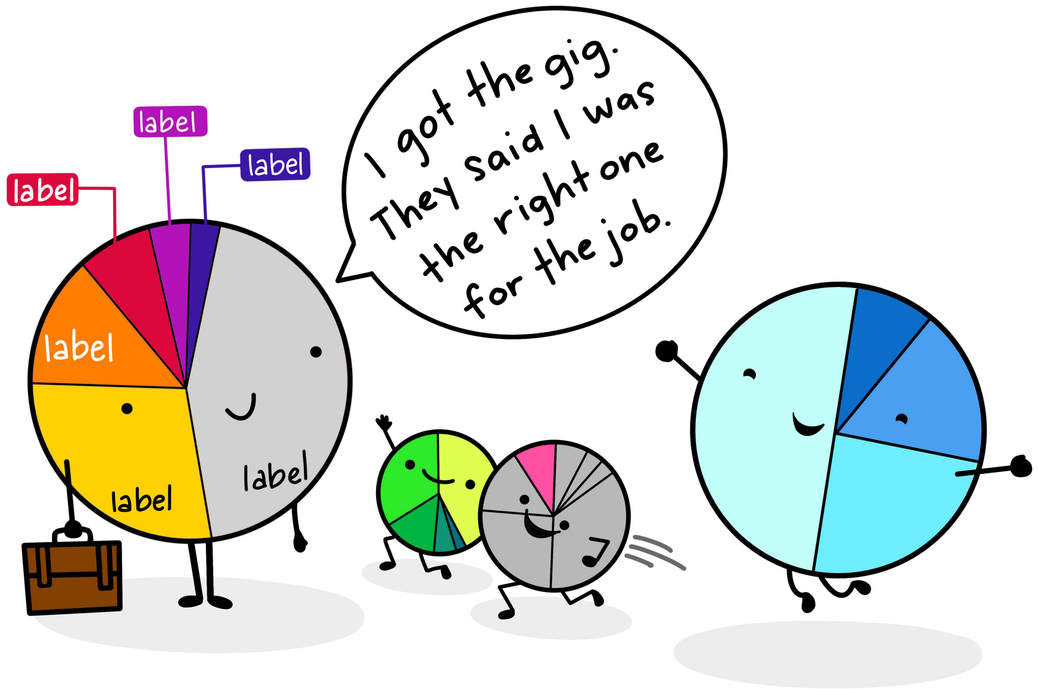
Design principles for making figures

Week 9 (11/26/25)



Artwork by Allison Horst

Stepfanie M. Aguillon

Outline of today's class

- Design strategies for making figures
  - Clarity
  - Color
  - Emphasis
  - Consistency

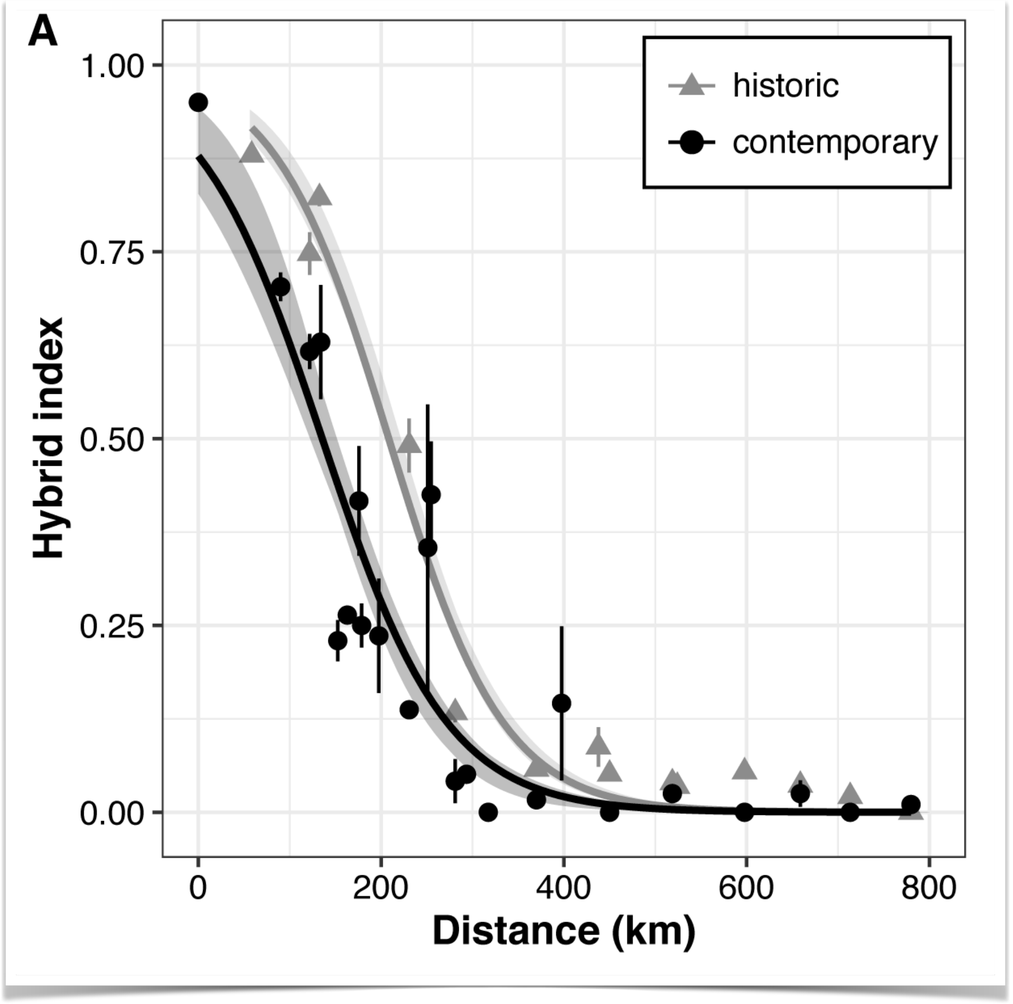
} "Three C's and an E"

Controversial Opinion

Figures are **the most** important part of any paper or presentation.

comparing the plumage scores with the image parameter values were strongly significant for all six plumage traits (Tables S4 and S5; Fig. S1).

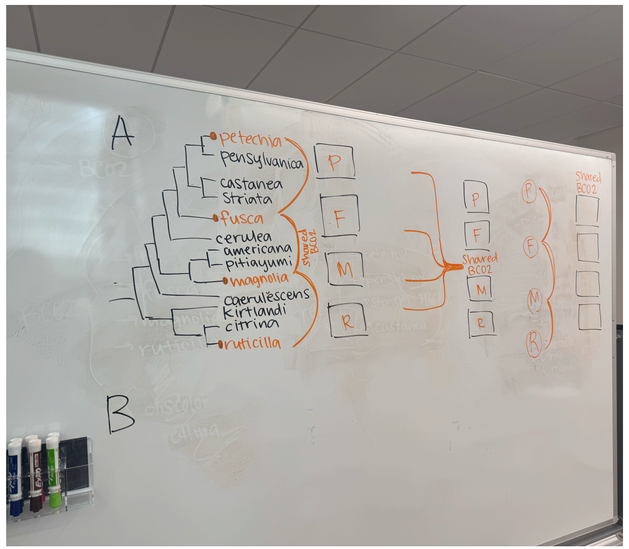
We detected a significant westward shift of ~73 km in the hybrid zone cline center between the historic and contemporary sampling periods for the plumage hybrid index (Fig. 2a; Table S6). The individual clines for the six plumage traits are broadly overlapping within both the historic (Fig. S2a) and contemporary (Fig. S2b) periods. The cline center from the historic sam-

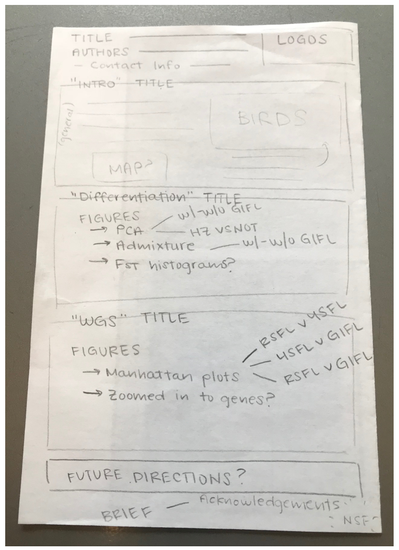


Aguillon & Rohwer 2022 *Evolution*

But before we even sit down at the computer...

The real first step is to “prioritize the information you want to share, **envision it**, and **design it**.”





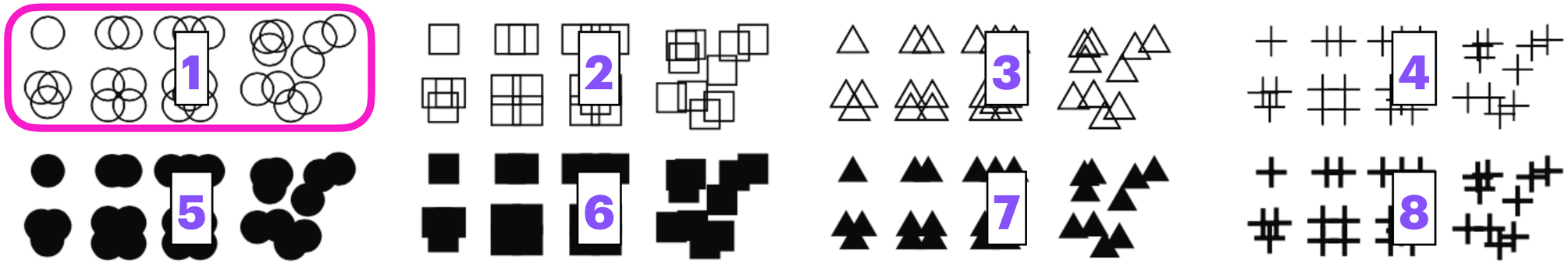
When you make a figure, your goal is to convey information as clearly, accurately, and efficiently as possible.

Clarity

Creating figures that are clear and easy to understand.

Symbol style: one data category

Which symbol is the best to use?

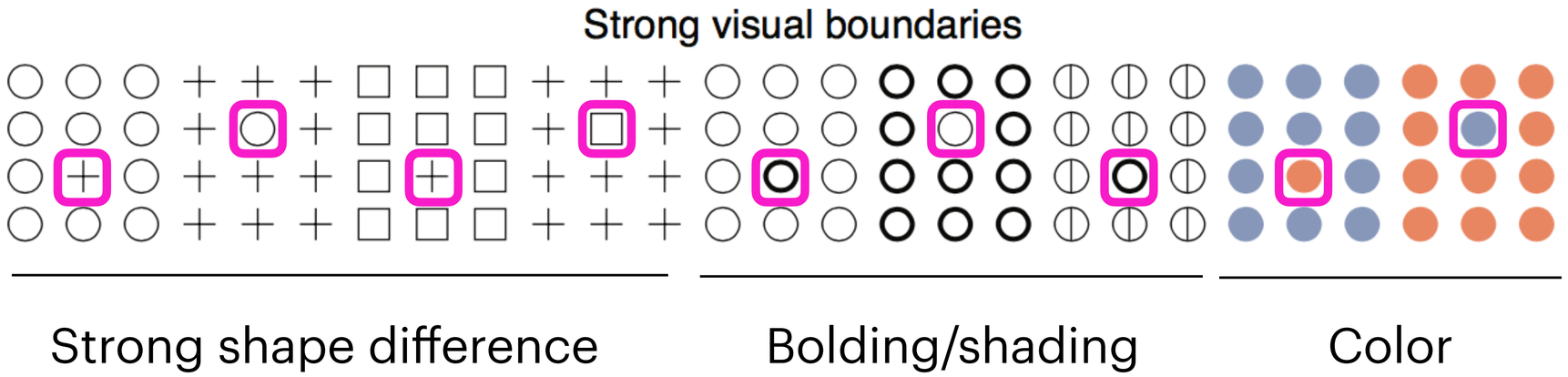


1. The intersection of the circles does not form an image
2. The overlap leads to regions with higher density

Krzywinski & Wong 2013, *Plotting symbols*

Symbol style: multiple data categories

Which symbol is the best to use?

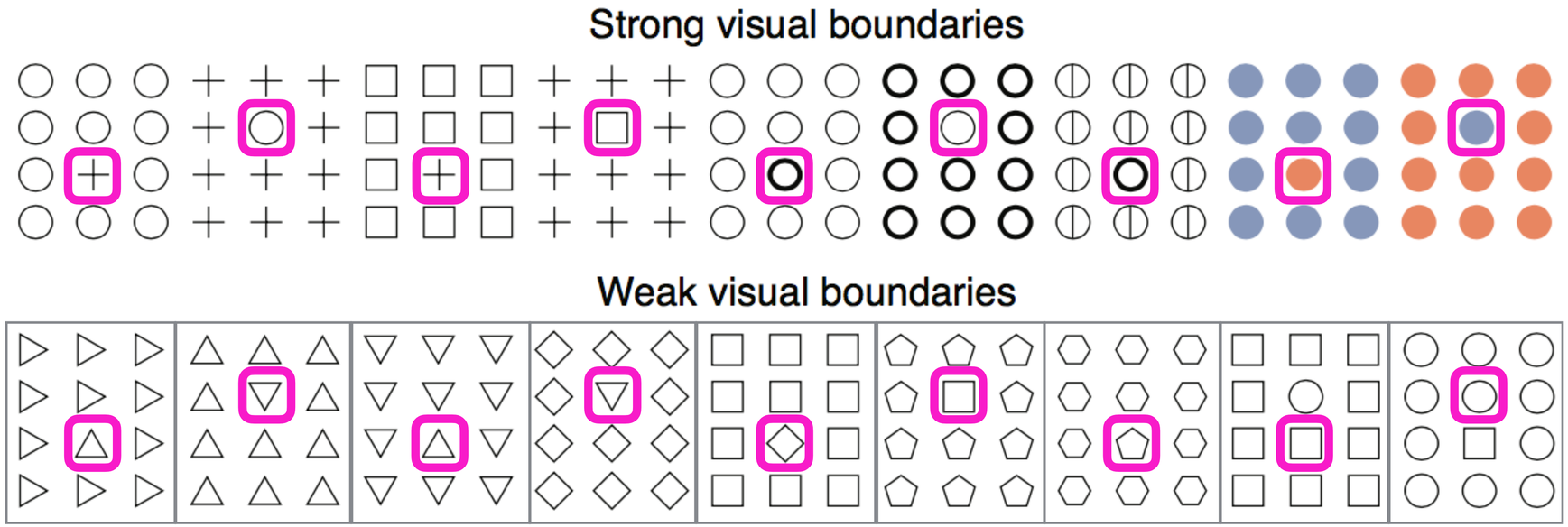


With multiple symbols, try for distinct forms that can be visualized quickly

Krzywinski & Wong 2013, *Plotting symbols*

Symbol style: multiple data categories

Which symbol is the best to use?

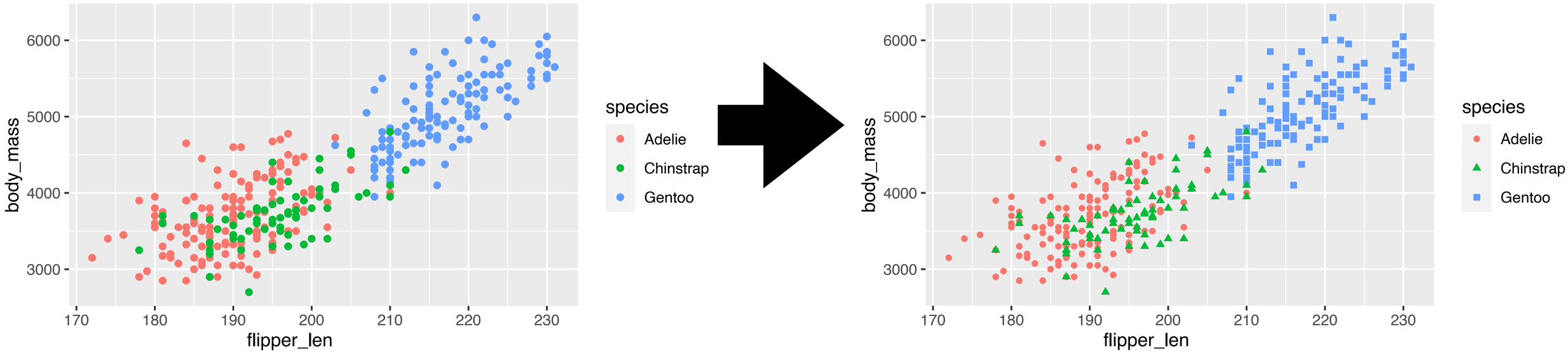


Krzywinski & Wong 2013, *Plotting symbols*

Changing symbols is easy in ggplot

Symbols are determined with the **shape** option

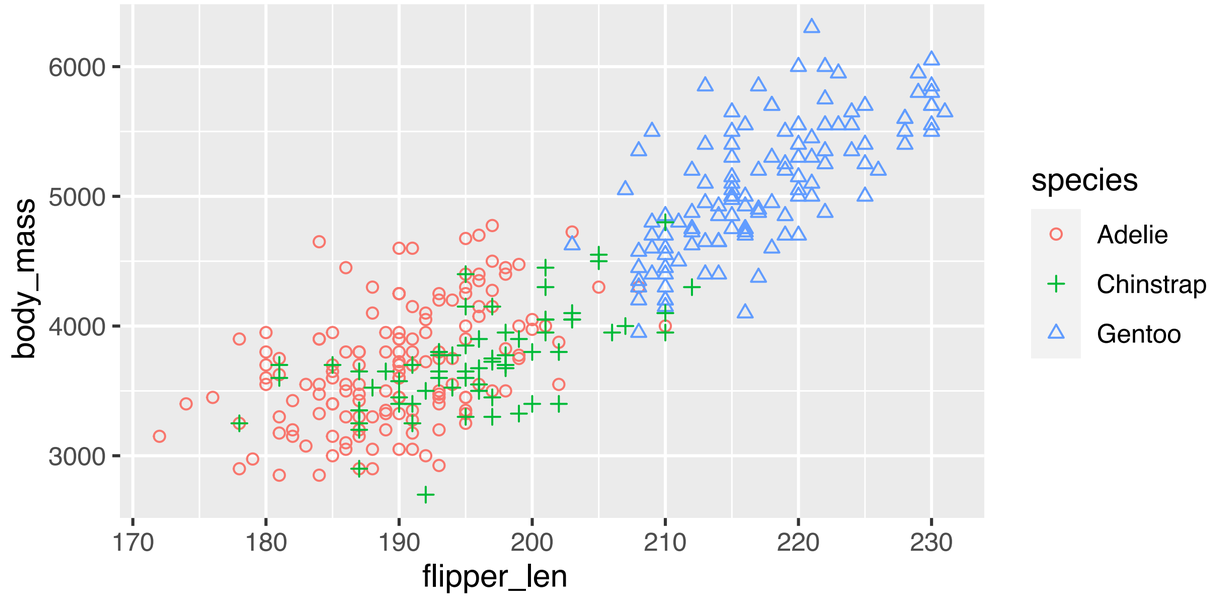
```
ggplot(penguins, aes(x = flipper_len, y = body_mass)) +
  geom_point(aes(color = species, shape = species))
```



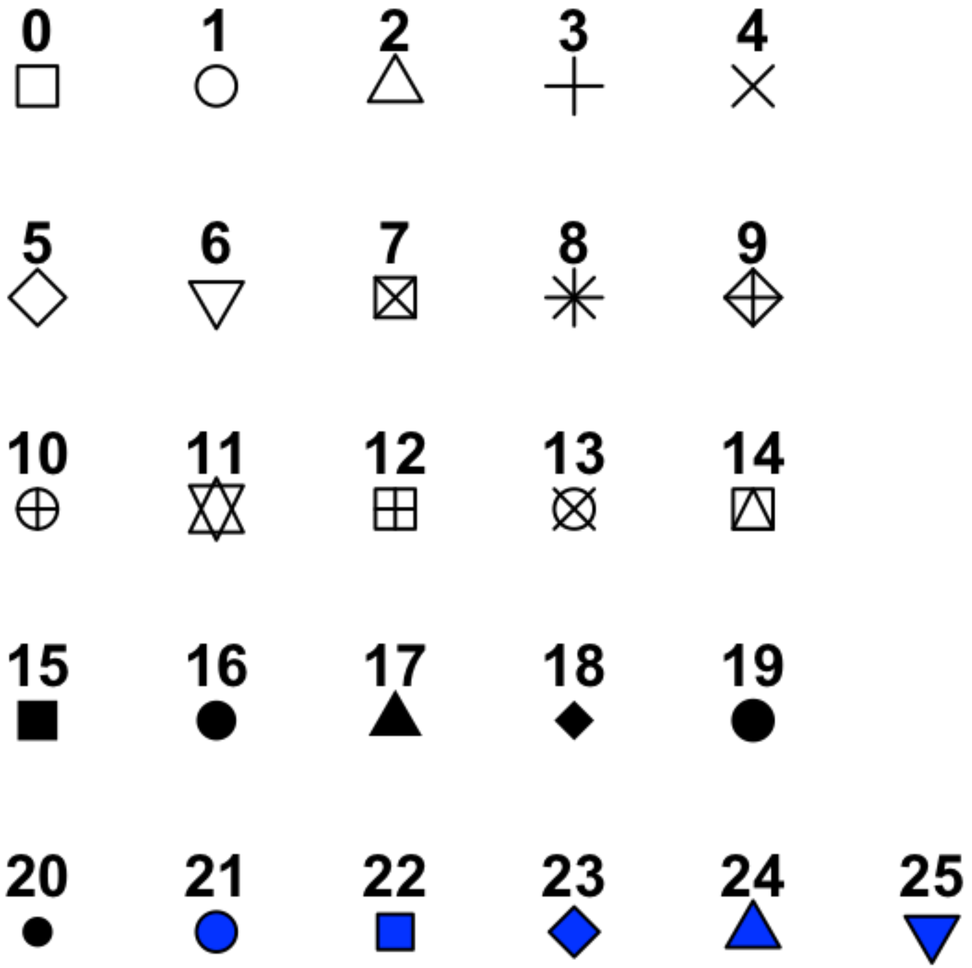
Changing symbols is easy in ggplot

You can choose the shape using `scale_shape_manual()`

```
ggplot(penguins, aes(x = flipper_len, y = body_mass)) +
  geom_point(aes(color = species, shape = species)) +
  scale_shape_manual(values = c(21, 3, 24))
```



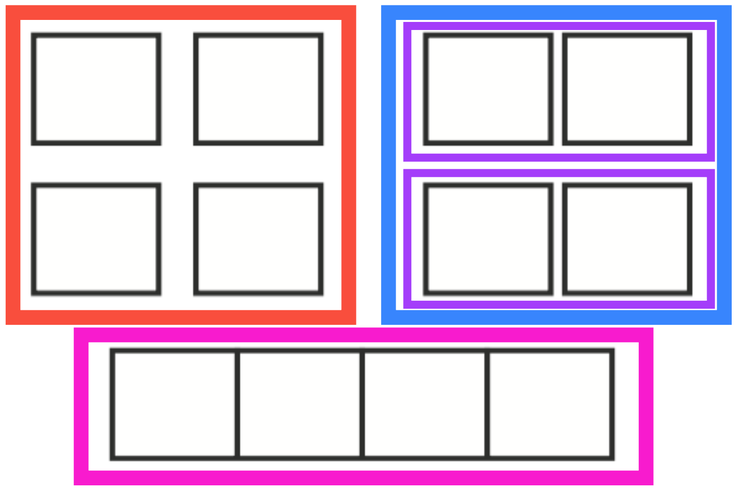
There are many symbol options in R



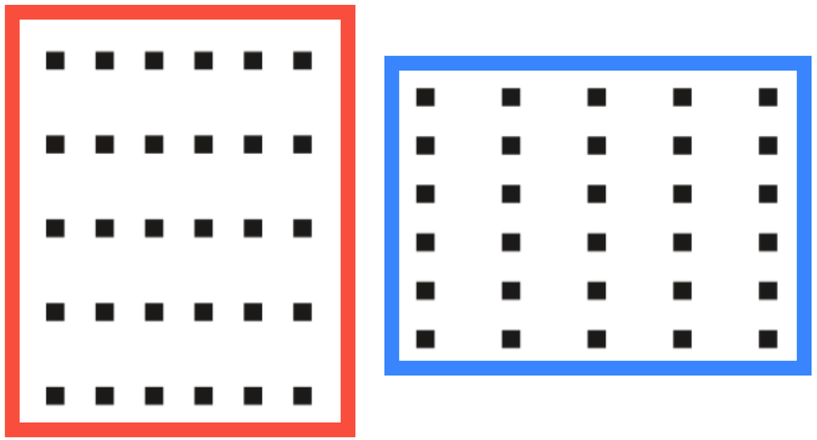
Grouping data together within a figure

We automatically “group” things in figures.

Proximity



Spacing



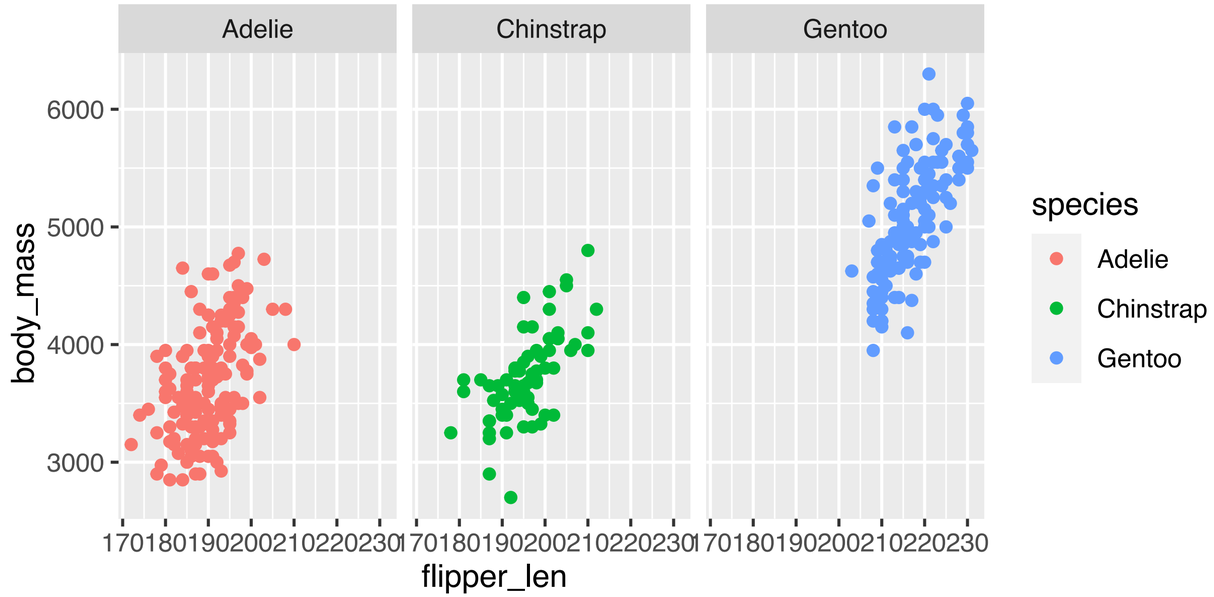
Use this to your advantage! OR confuse your reader!

Wong 2010, *Gestalt Principles (Part 1)*

Grouping can be easy in ggplot

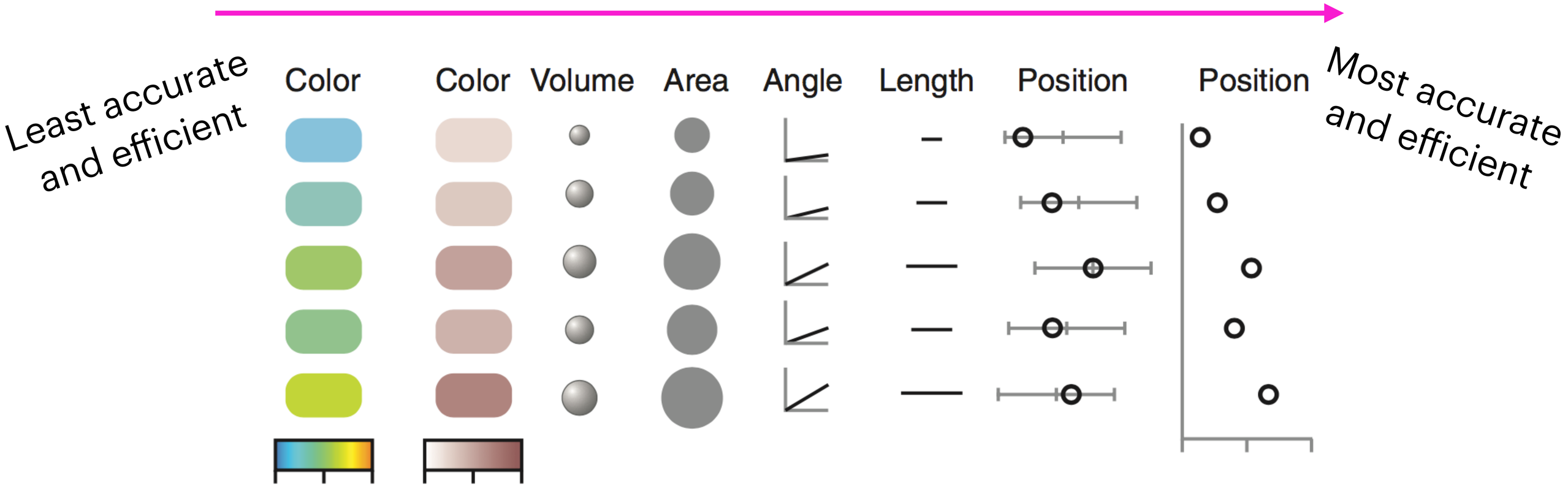
`facet_wrap()` provides an easy way to create a multi-panel figure

```
ggplot(penguins, aes(x = flipper_len, y = body_mass)) +
  geom_point(aes(color = species)) +
  facet_wrap(~species)
```



Picking the right type of figure

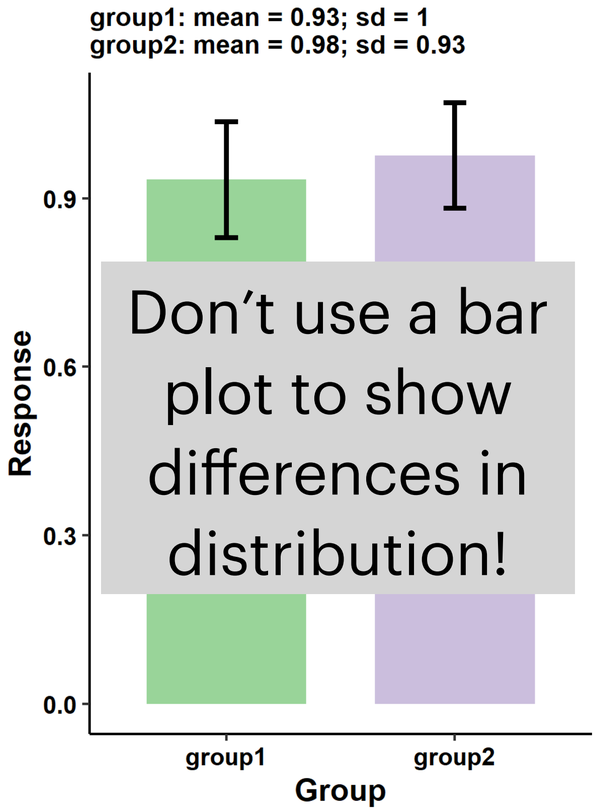
You want a highly **efficient** figure that is also **accurate**

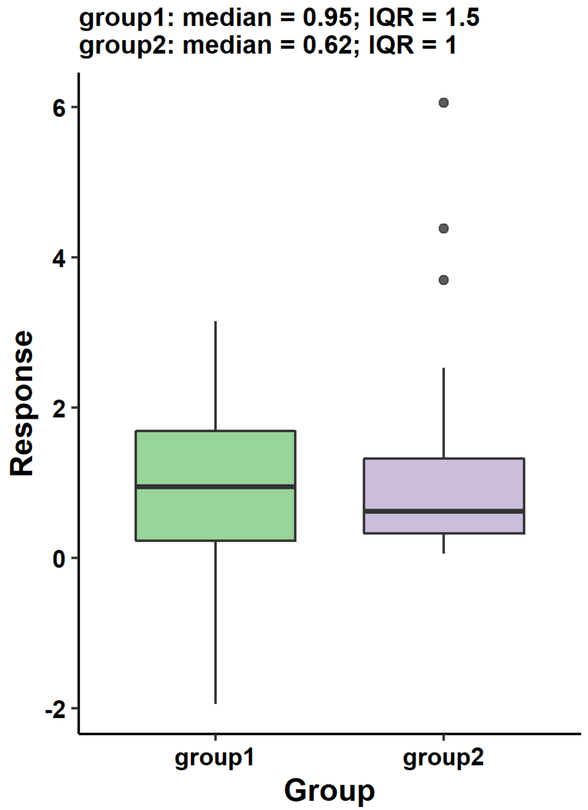


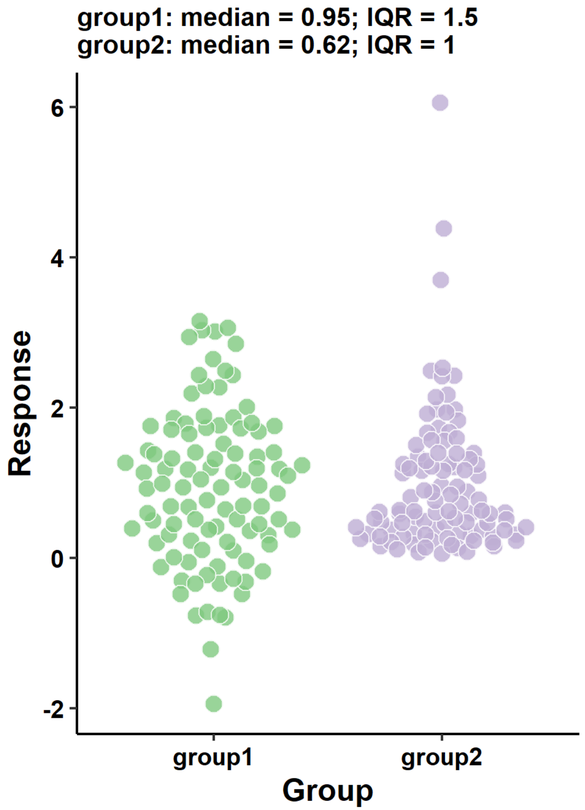
Wong 2010, *Design of data figures*

Picking the right type of figure

Accuracy also means not obscuring patterns in the data!



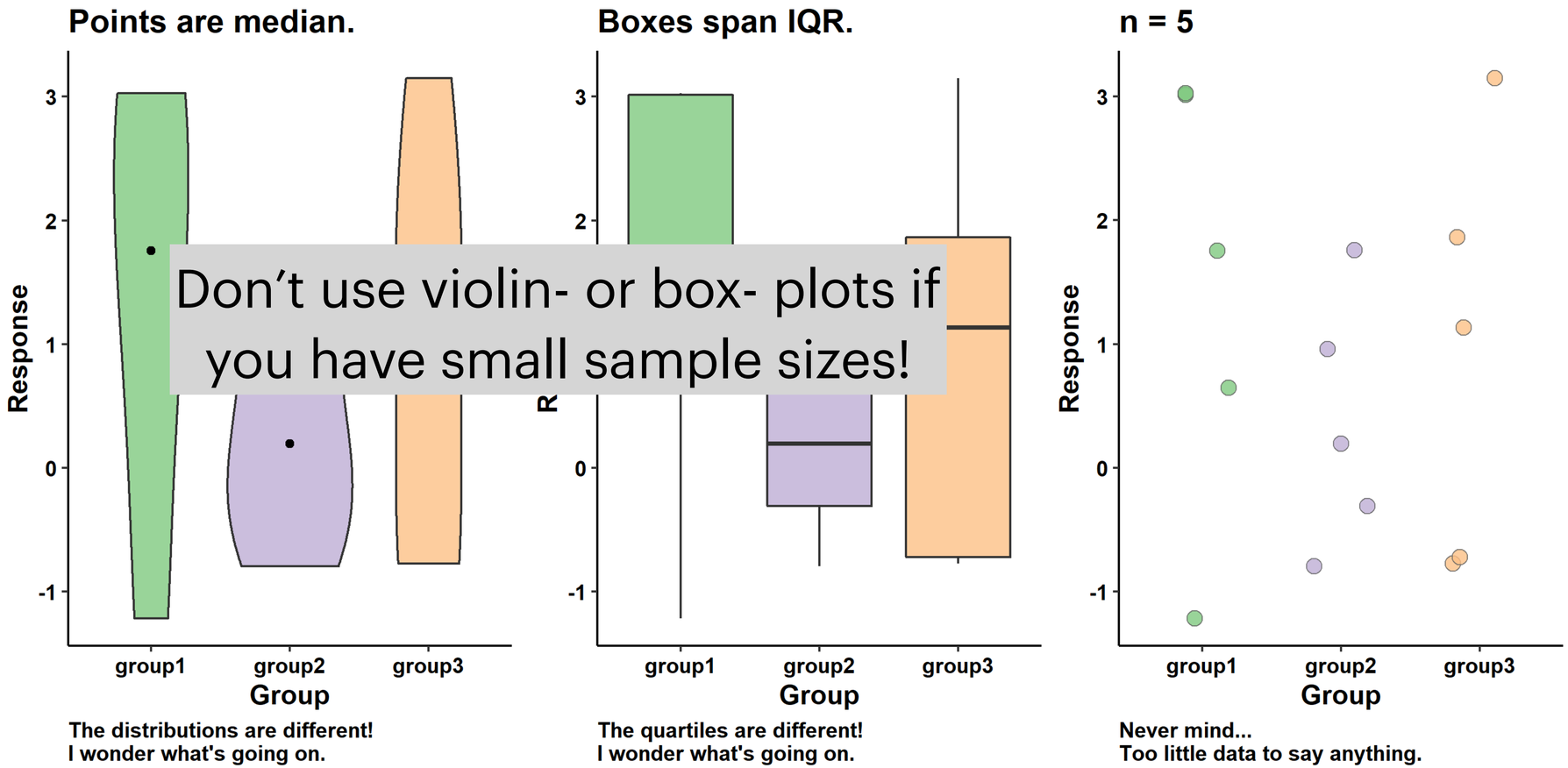




Friends Don’t Let Friends Make Bad Graphs

Picking the right type of figure

Accuracy also means not obscuring patterns in the data!

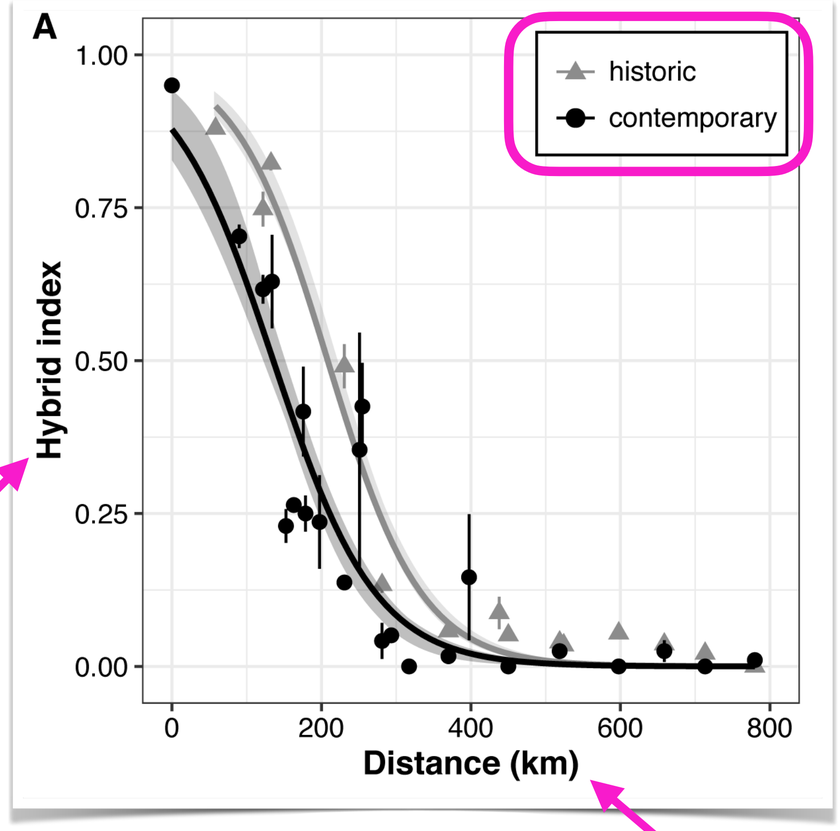


Don’t use violin- or box- plots if you have small sample sizes!

Friends Don’t Let Friends Make Bad Graphs

Use labels and legends within the figure

A good figure-making practice is to try to make your figure understandable *without* reading the caption.



Aguillon & Rohwer 2022 *Evolution*

Color

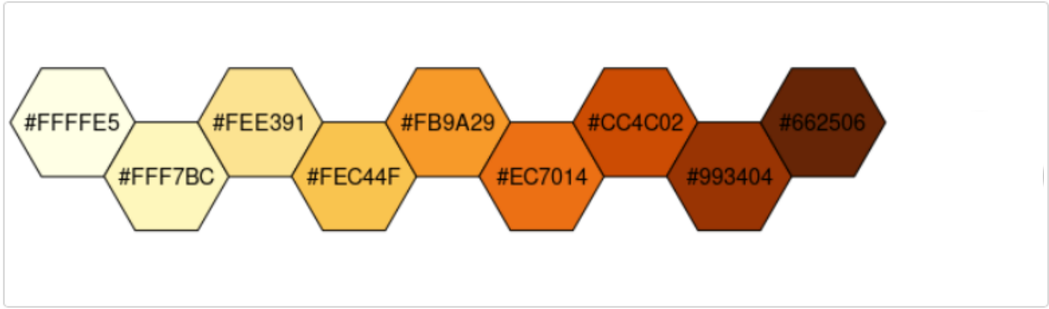
Color is a great tool for figures, but use caution!

Different kinds of color palettes

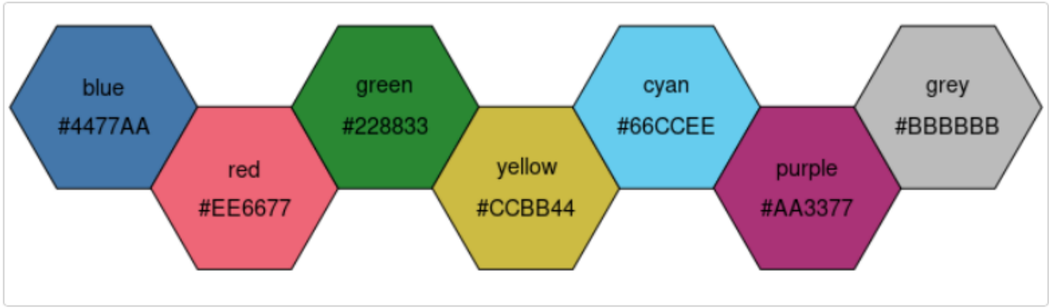
Which color palette is the best to use?

Trick question!
IT DEPENDS!

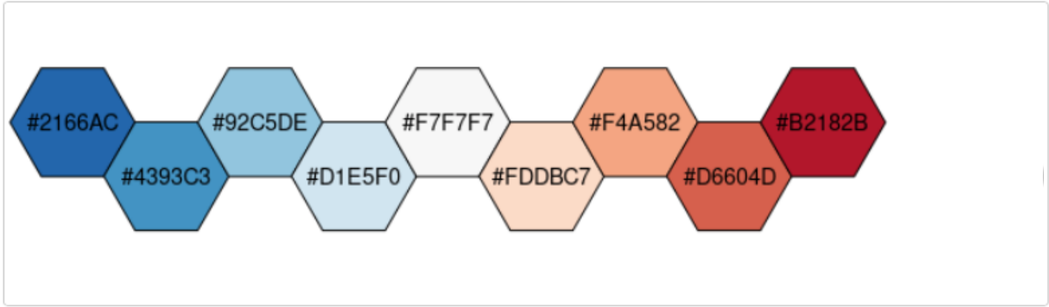
1



2



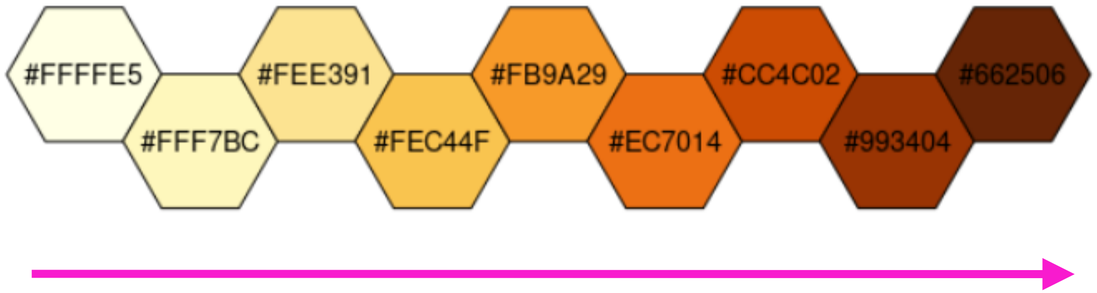
3

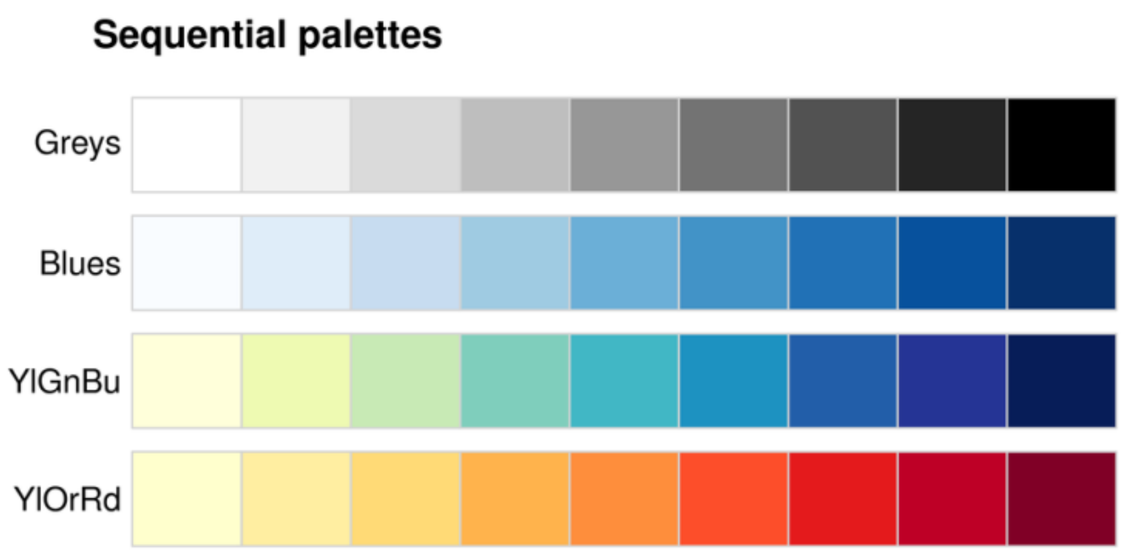


Paul Tol's Colour Schemes

Sequential color palettes

Arranged from “low” to “high” using the lightness/darkness of the color(s)

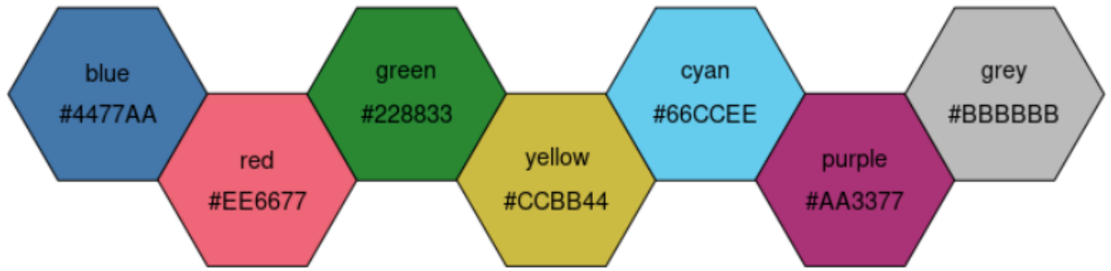


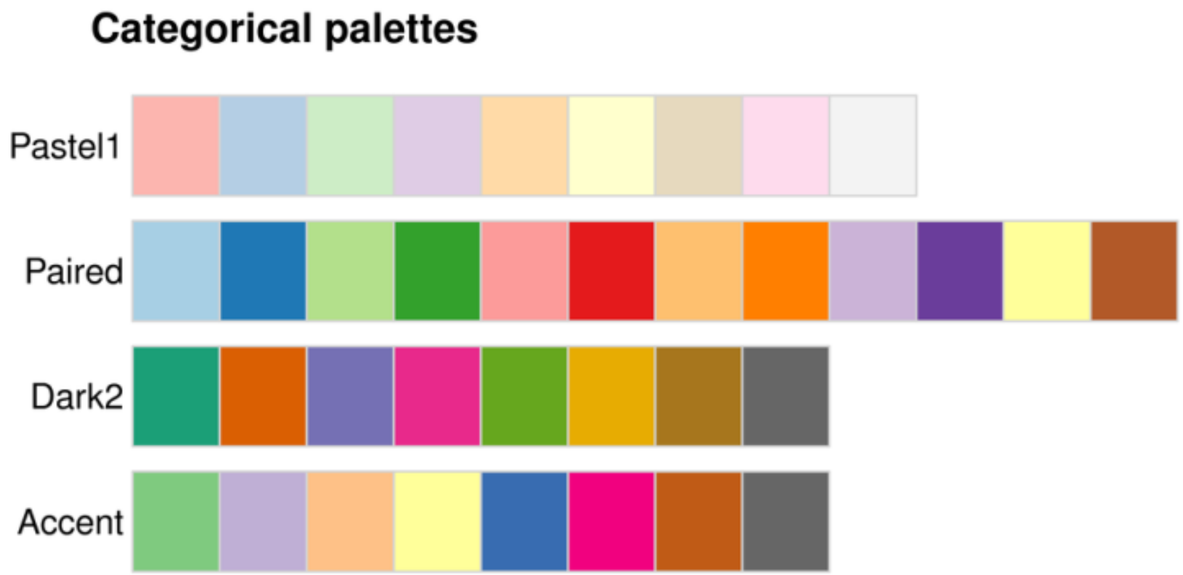


Paul Tol’s Colour Schemes; betterfigures.org

Categorical color palettes

A palette without an obvious “order” of the colors (always multiple colors)

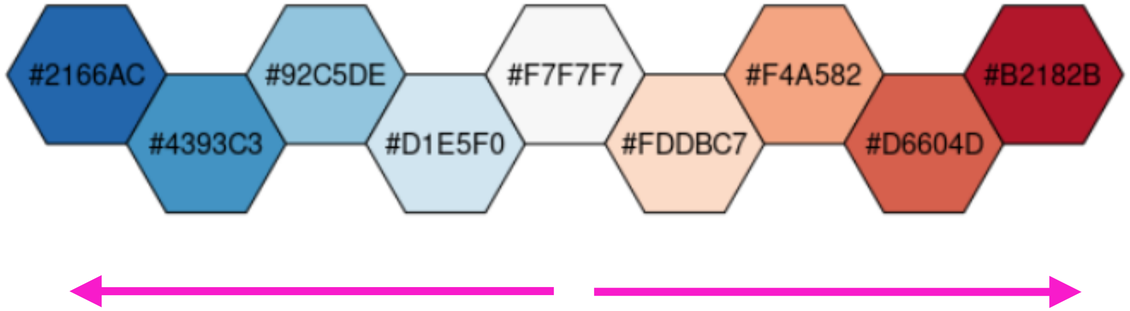


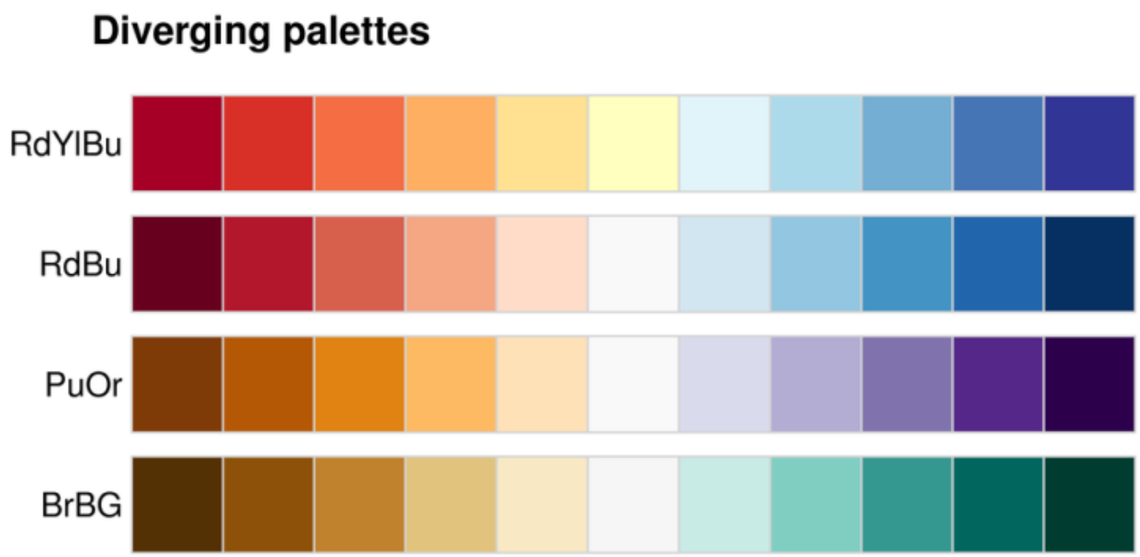


Paul Tol’s Colour Schemes; betterfigures.org

Diverging color palettes

A palette that includes two colors diverging from a “zero” value

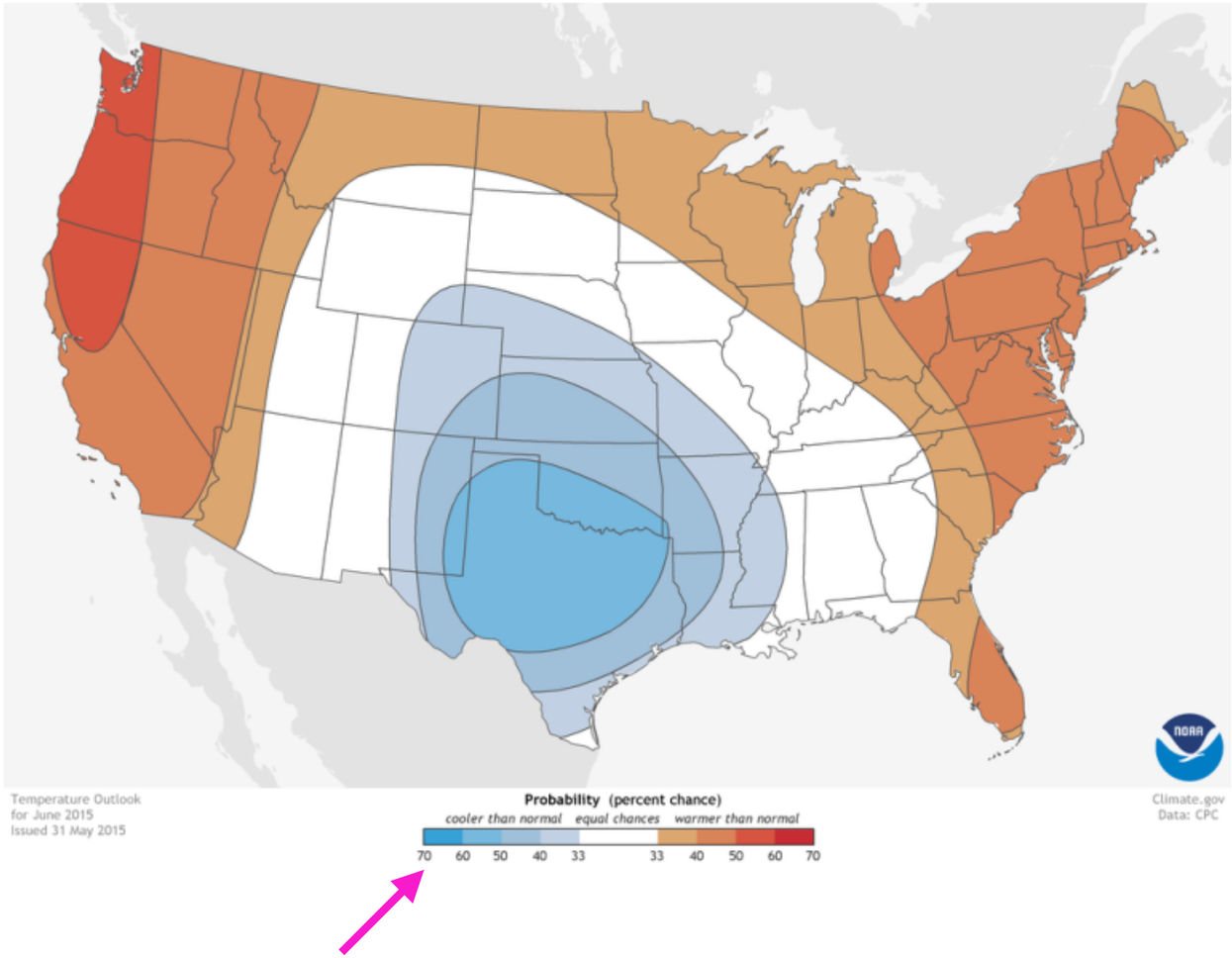




Paul Tol’s Colour Schemes; betterfigures.org

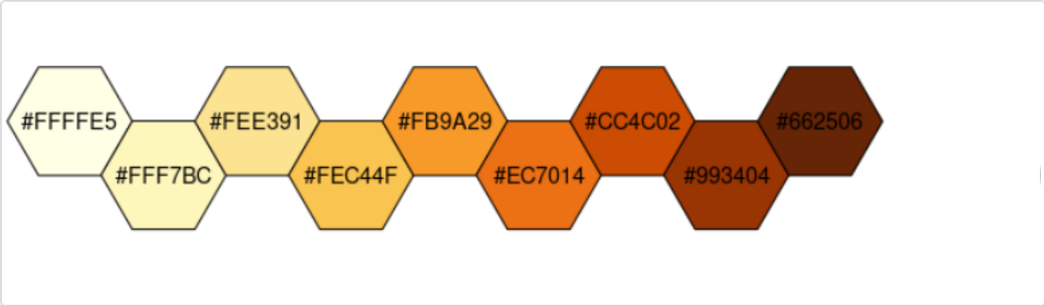
Diverging color palettes

Often used in visualizations of maps

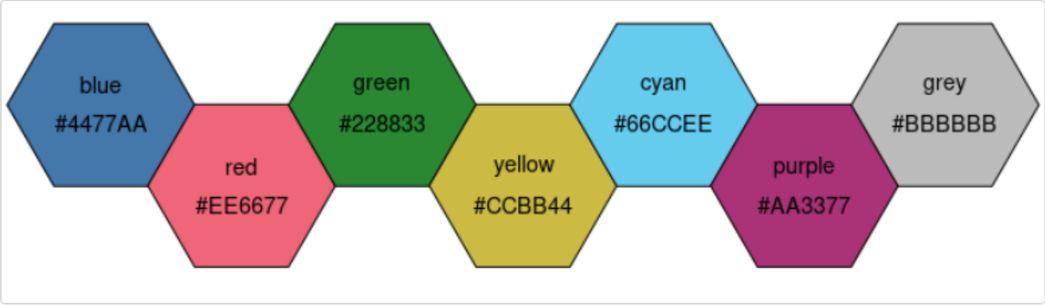


Different kinds of color palettes

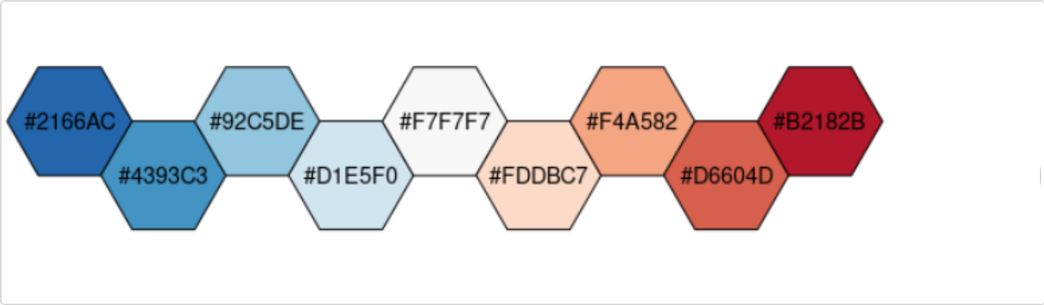
Which color palette is the best to use?



Sequential: when your data has an “order” (quantitative)



Categorical: when your data doesn’t have an “order” (qualitative)



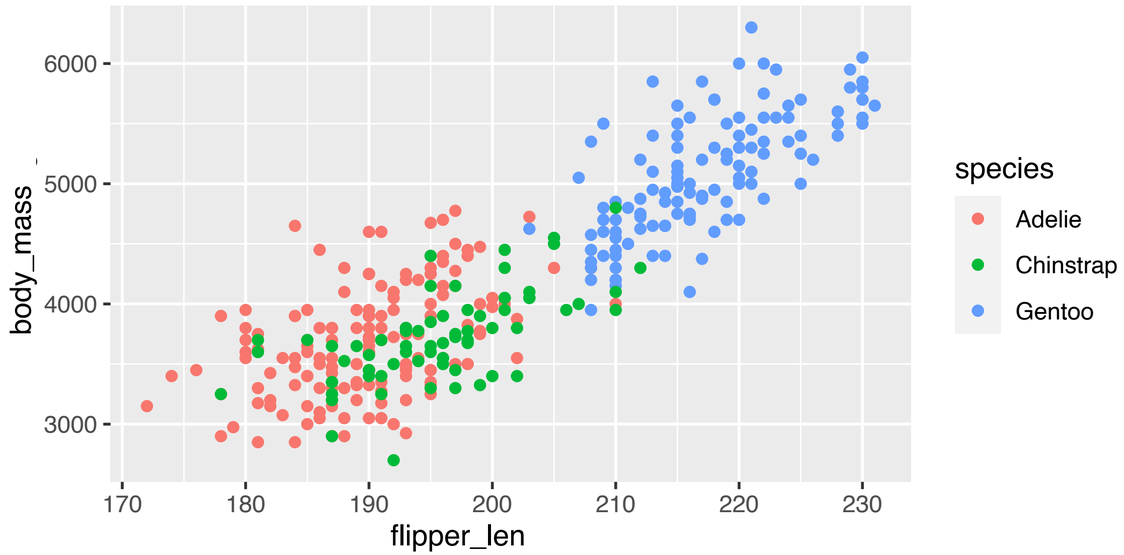
Diverging: when your data diverges from a reference “zero” value

Paul Tol’s Colour Schemes

Changing colors is easy in ggplot

Symbols are determined with the `color` or `fill` option

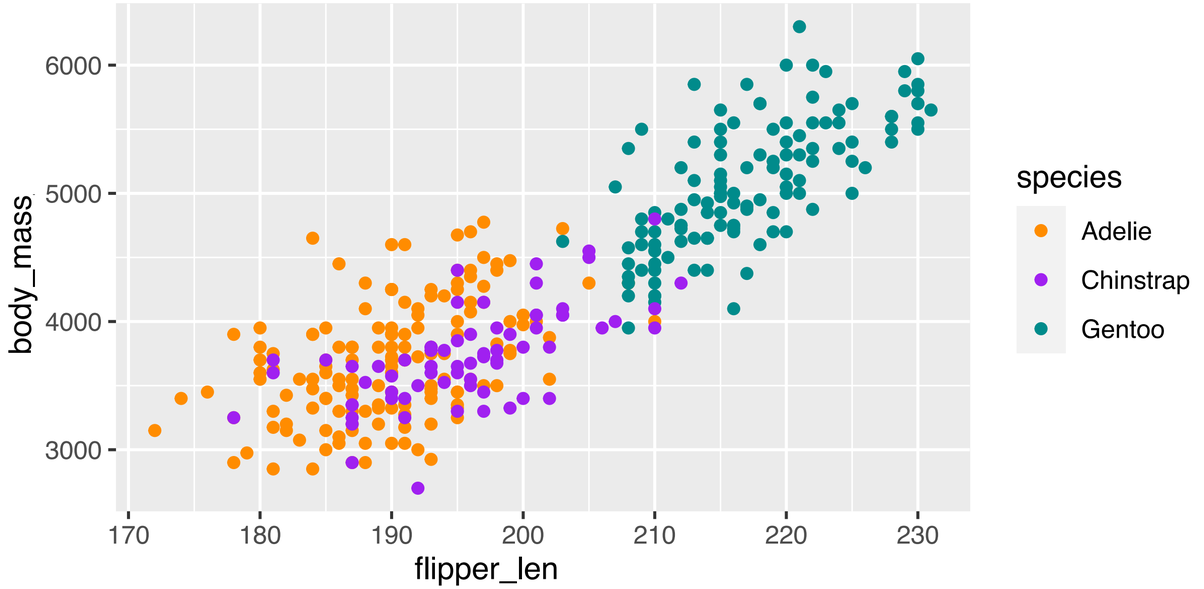
```
ggplot(penguins, aes(x = flipper_len, y = body_mass)) +
  geom_point(aes(color = species))
```

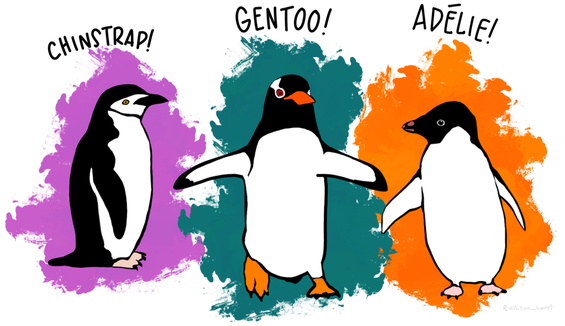


Changing colors is easy in ggplot

You can choose the shape using `scale_color_manual()` or `scale_fill_manual()`

```
ggplot(penguins, aes(x = flipper_len, y = body_mass)) +
  geom_point(aes(color = species)) +
  scale_color_manual(values = c("darkorange", "purple", "cyan4"))
```





Artwork by Allison Horst

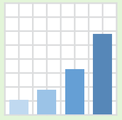
Changing colors is easy in ggplot

Alternatively, you can use pre-built palettes

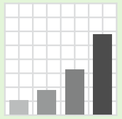
```
ggplot(penguins, aes(x = flipper_len, y = body_mass)) +
  geom_point(aes(color = species)) +
  scale_color_brewer(palette = "Set1")
```

There are many pre-set palettes in ggplot

COLOR AND FILL SCALES (DISCRETE)



n + scale_fill_brewer(palette = "Blues"**)**
For palette choices:
RColorBrewer::display.brewer.all()



n + scale_fill_grey(start = 0.2,
end = 0.8, na.value = "red"**)**

COLOR AND FILL SCALES (CONTINUOUS)

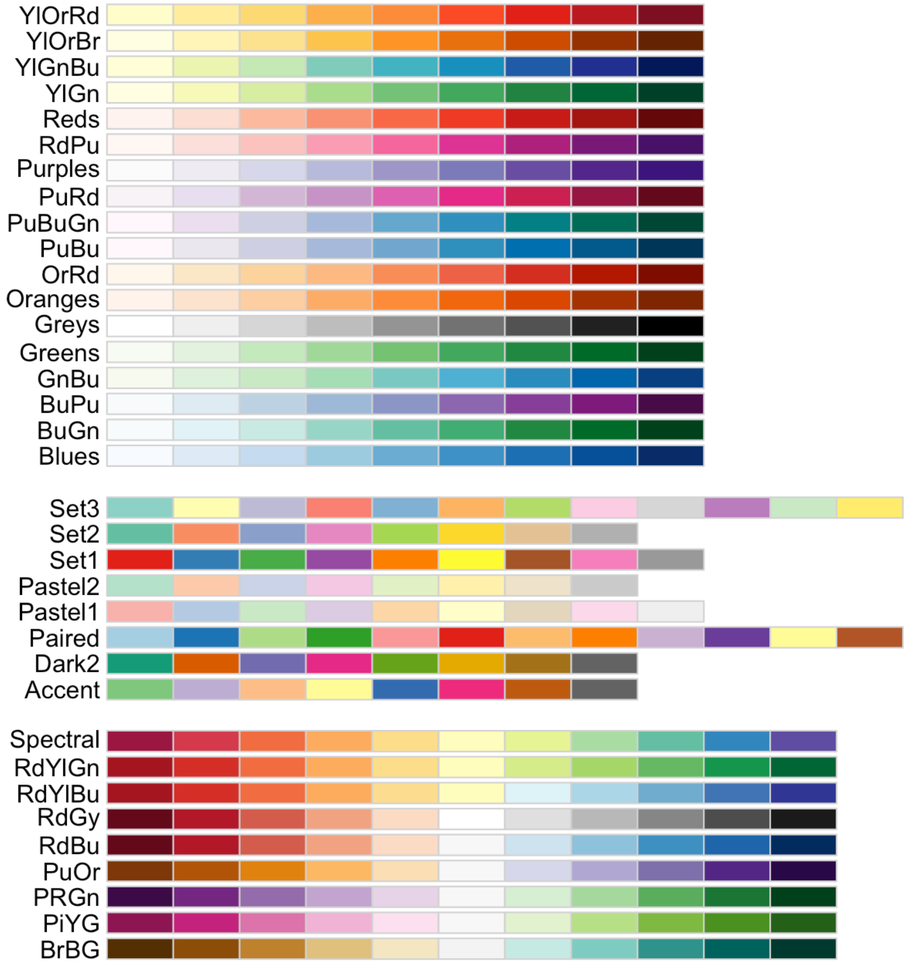
o <− c + geom_dotplot(aes(fill = x))

o + scale_fill_distiller(palette = “Blues”**)**

o + scale_fill_gradient(low="red", high=“yellow"**)**

o + scale_fill_gradient2(low = "red", high = “blue”,
mid = "white", midpoint = 25**)**

o + scale_fill_gradientn(colors = topo.colors(6)**)**
Also: rainbow(), heat.colors(), terrain.colors(),
cm.colors(), RColorBrewer::brewer.pal()



see also scale_color_viridis() options!

There are many colors available in R

Many preset color names

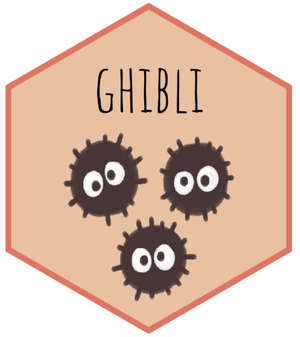
white	coral4	deepskyblue	gray28	gray88	grey40
aliceblue	cornflowerblue	deepskyblue1	gray29	gray89	grey41
antiquewhite	cornsilk	deepskyblue2	gray30	gray90	grey42
antiquewhite1	cornsilk1	deepskyblue3	gray31	gray91	grey43
antiquewhite2	cornsilk2	deepskyblue4	gray32	gray92	grey44
antiquewhite3	cornsilk3	dimgray	gray33	gray93	grey45
antiquewhite4	cornsilk4	dimgrey	gray34	gray94	grey46
aquamarine	cyan	dodgerblue	gray35	gray95	grey47
aquamarine1	cyan1	dodgerblue1	gray36	gray96	grey48
aquamarine2	cyan2	dodgerblue2	gray37	gray97	grey49
aquamarine3	cyan3	dodgerblue3	gray38	gray98	grey50
aquamarine4	cyan4	dodgerblue4	gray39	gray99	grey51
azure	darkblue	firebrick	gray40	gray100	grey52
azure1	darkcyan	firebrick1	gray41	green	grey53
azure2	darkgoldenrod	firebrick2	gray42	green1	grey54
azure3	darkgoldenrod1	firebrick3	gray43	green2	grey55
azure4	darkgoldenrod2	firebrick4	gray44	green3	grey56
beige	darkgoldenrod3	floralwhite	gray45	green4	grey57
bisque	darkgoldenrod4	forestgreen	gray46	greenyellow	grey58
bisque1	darkgray	gainsboro	gray47	grey	grey59
bisque2	darkgreen	ghostwhite	gray48	grey0	grey60
bisque3	darkgrey	gold	gray49	grey1	grey61
bisque4	darkkhaki	gold1	gray50	grey2	grey62
black	darkmagenta	gold2	gray51	grey3	grey63
blanchedalmon	darkolivegreen	gold3	gray52	grey4	grey64
blue	darkolivegreen1	gold4	gray53	grey5	grey65
blue1	darkolivegreen2	goldenrod	gray54	grey6	grey66
blue2	darkolivegreen3	goldenrod1	gray55	grey7	grey67
blue3	darkolivegreen4	goldenrod2	gray56	grey8	grey68
blue4	darkorange	goldenrod3	gray57	grey9	grey69
blueviolet	darkorange1	goldenrod4	gray58	grey10	grey70
brown	darkorange2	gray	gray59	grey11	grey71
brown1	darkorange3	gray0	gray60	grey12	grey72
brown2	darkorange4	gray1	gray61	grey13	grey73
brown3	darkorchid	gray2	gray62	grey14	grey74
brown4	darkorchid1	gray3	gray63	grey15	grey75
burlywood	darkorchid2	gray4	gray64	grey16	grey76
burlywood1	darkorchid3	gray5	gray65	grey17	grey77
burlywood2	darkorchid4	gray6	gray66	grey18	grey78
burlywood3	darkred	gray7	gray67	grey19	grey79

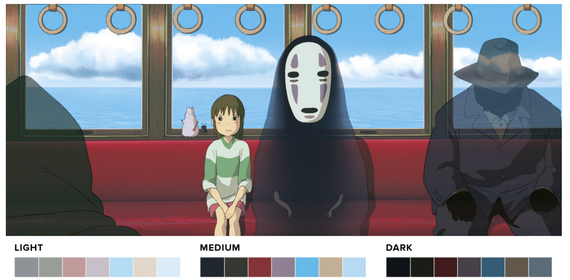
Can use hex codes

#018571 #4DAC26 #5E3C99 #0571B0 #404040

https://www.colorhexa.com/

Many separate packages





timcdlucas/
palettetown

Pokemon themed colour schemes for R.

1 Contributor · 5 Issues · 70 Stars · 5 Forks

gglgbtq

Color

Color is a great tool for figures, but use caution!

Caution #1: Using the wrong palette for your data

sequential dataset

categorical palette

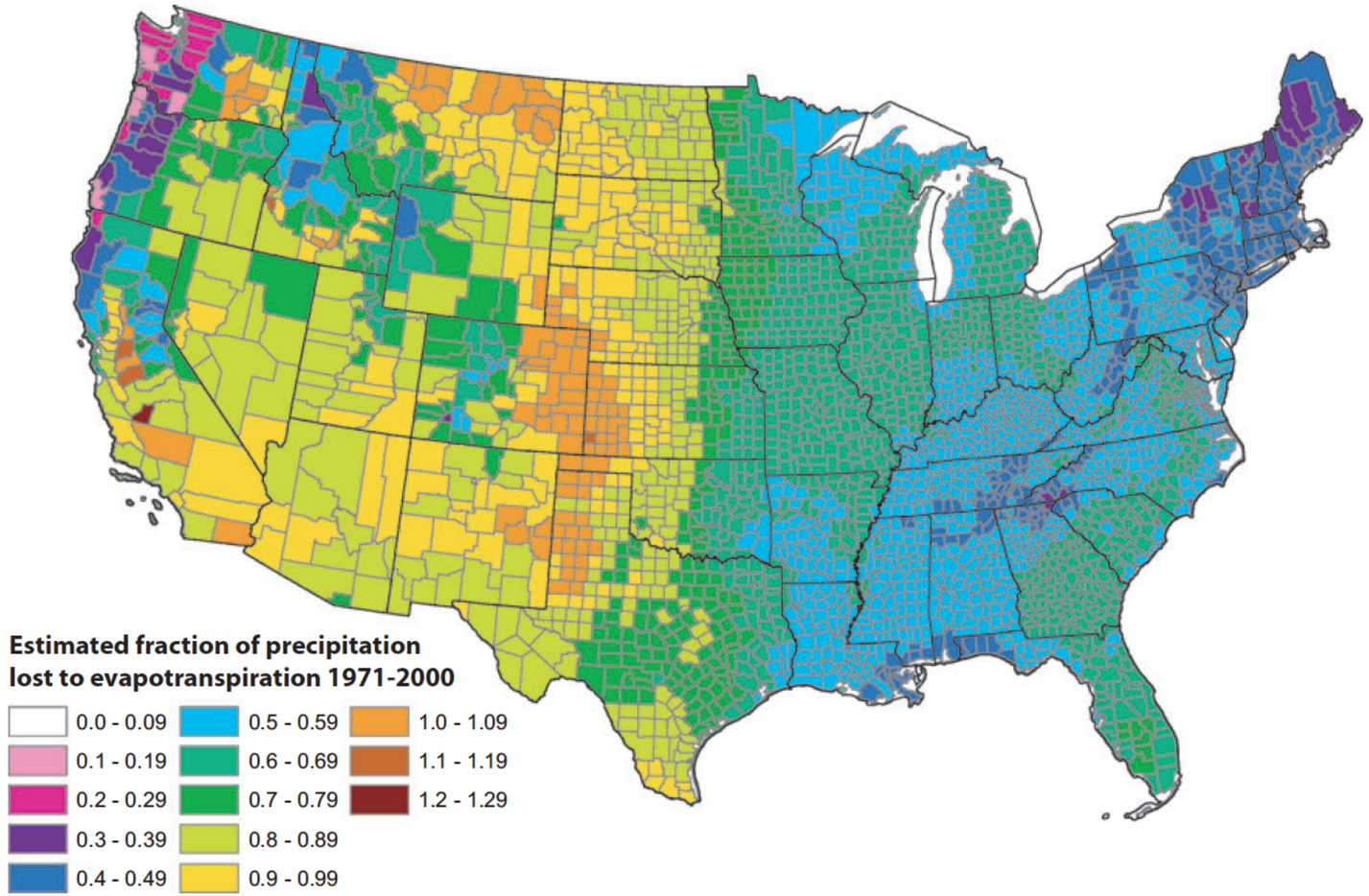
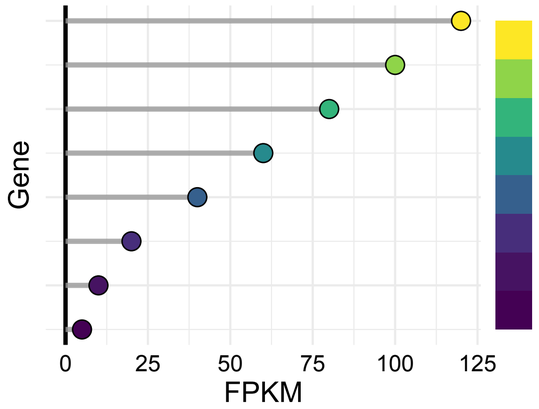


FIGURE 13. Estimated Mean Annual Ratio of Actual Evapotranspiration (ET) to Precipitation (*P*) for the Conterminous U.S. for the Period 1971-2000. Estimates are based on the regression equation in Table 1 that includes land cover. Calculations of ET/*P* were made first at the 800-m resolution of the PRISM climate data. The mean values for the counties (shown) were then calculated by averaging the 800-m values within each county. Areas with fractions >1 are agricultural counties that either import surface water or mine deep groundwater.

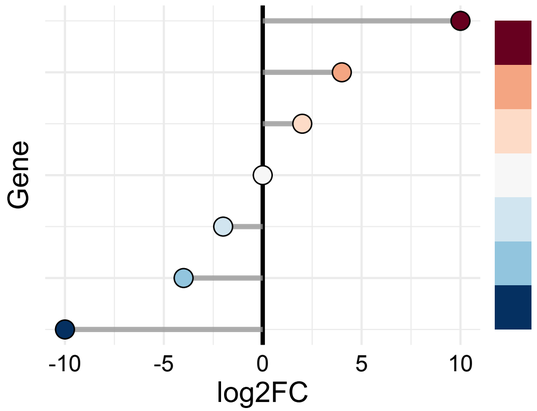
Caution #1: Using the wrong palette for your data

Darkest color = Min
Lightest color = Max



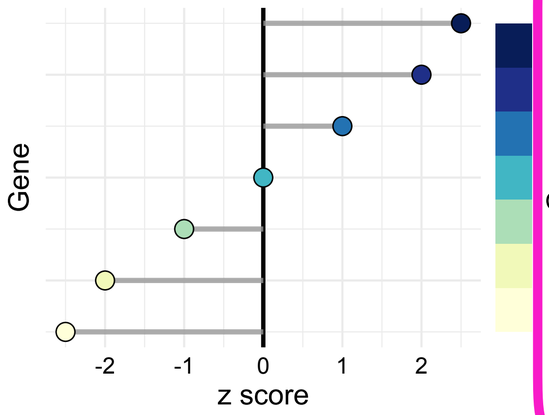
This is good.

Lightest color = 0
Darkest colors = Max absolutes



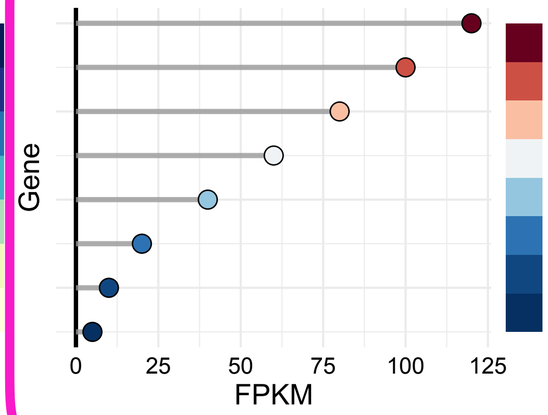
This is good.

Darkest color = Max
Lightest color = Min



This is good.

Lighest color means nothing
(neither mean nor median).

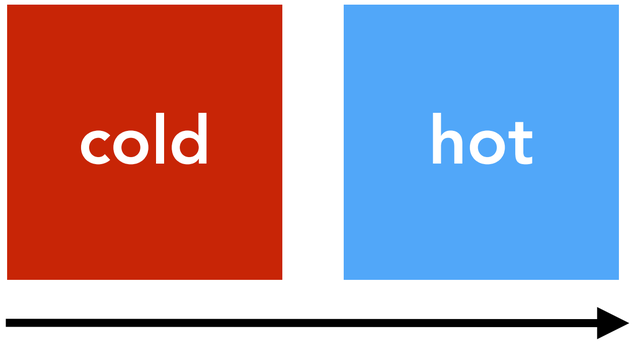


A data visualization sin

Friends Don't Let Friends Make Bad Graphs

Caution #2: Pre-conceived notions about color

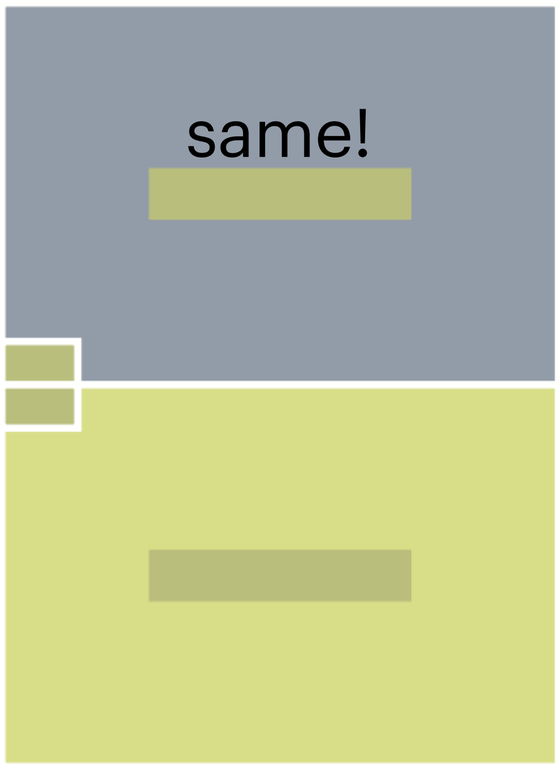
Temperature

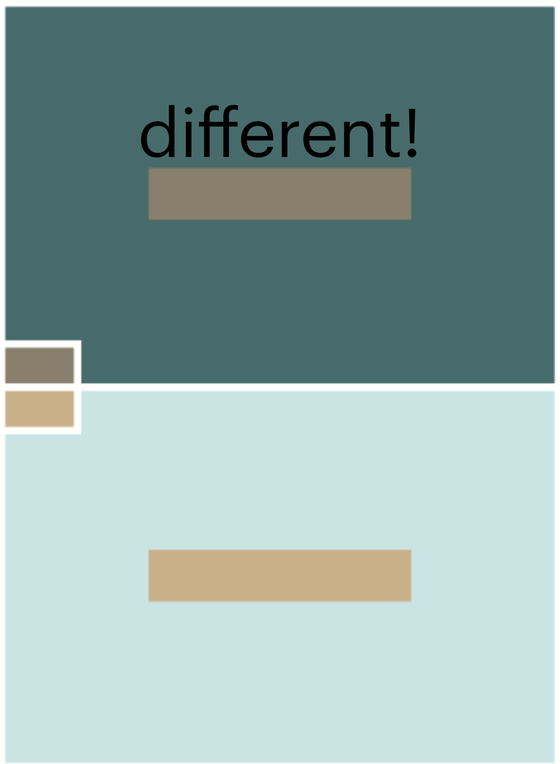


Concentration

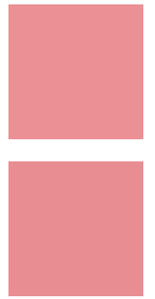
Caution #3: Proximity can change perception

Are these colors the same or different?



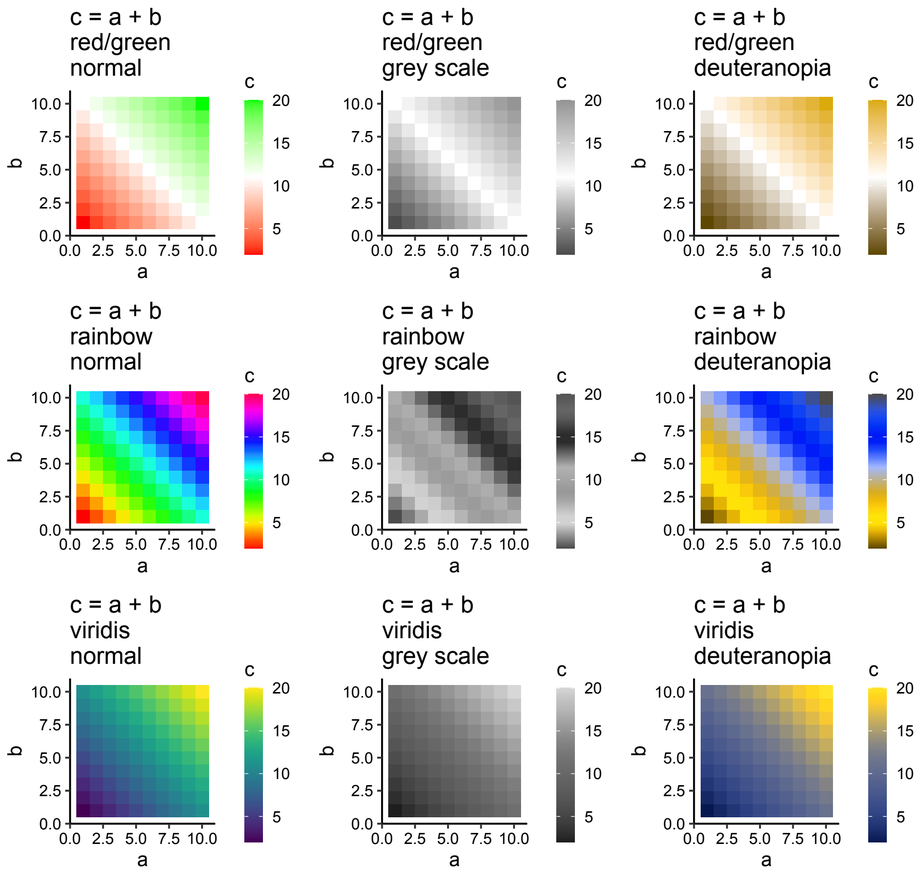


same!

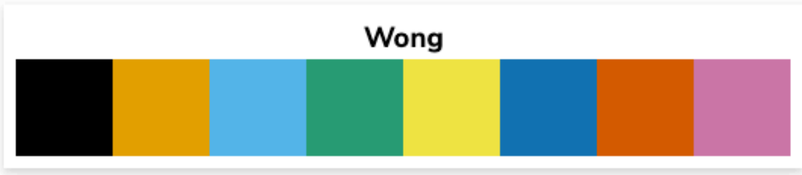


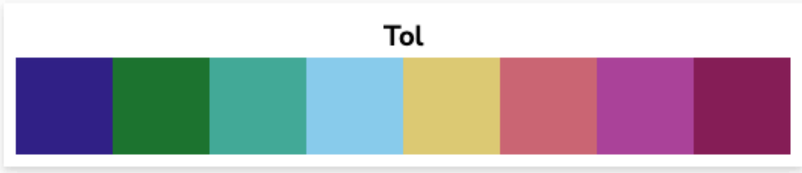
Wong 2010, *Color coding*

Caution #4: Color-blindness is pretty common



A number of color palettes have been developed with the intention of being accessible to people who are colorblind. Three of them appear below, from the IBM Design Library, Bang Wong, and Paul Tol respectively. Click on any of them to load it into the color palette selection tool above.





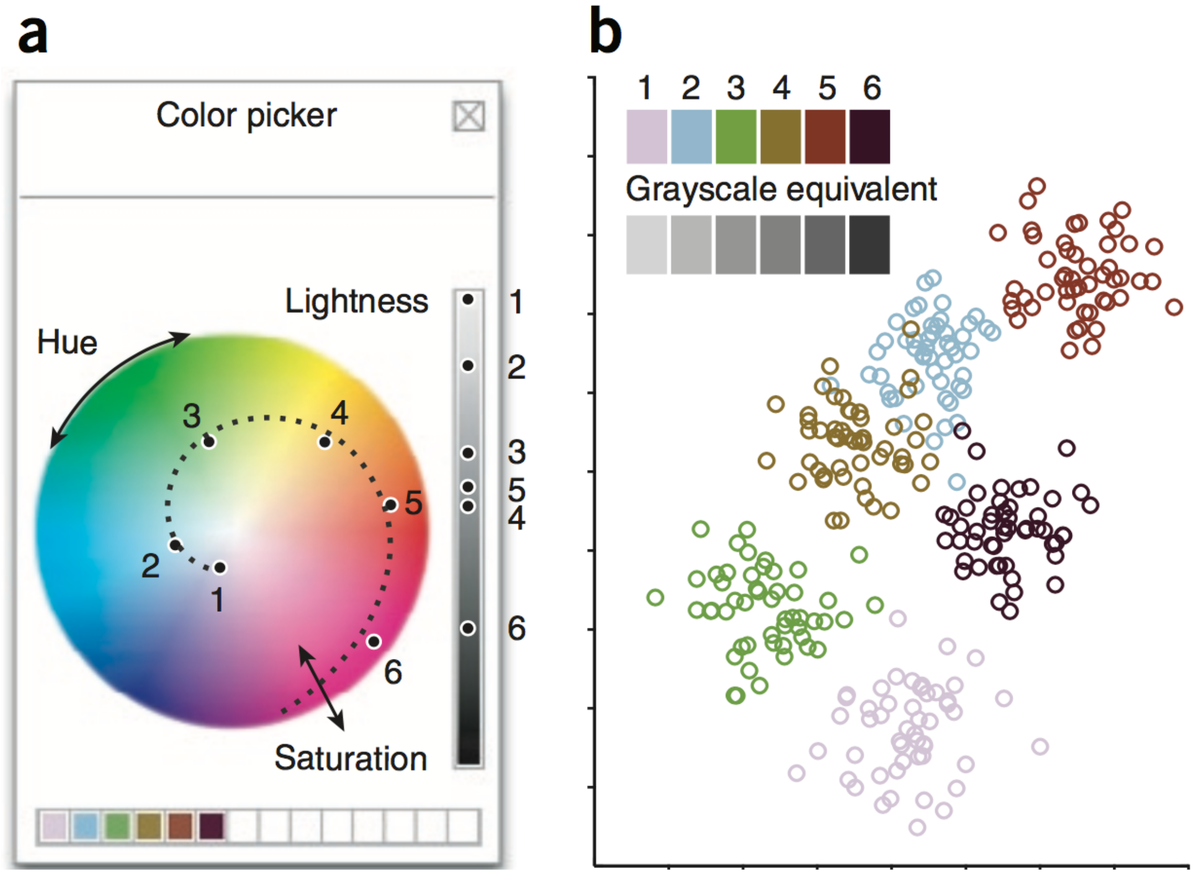
Friends Don't Let Friends Make Bad Graphs

davidmathlogic.com/colorblind/

If you make your own palettes...

be sure to choose colors that switch nicely to grayscale

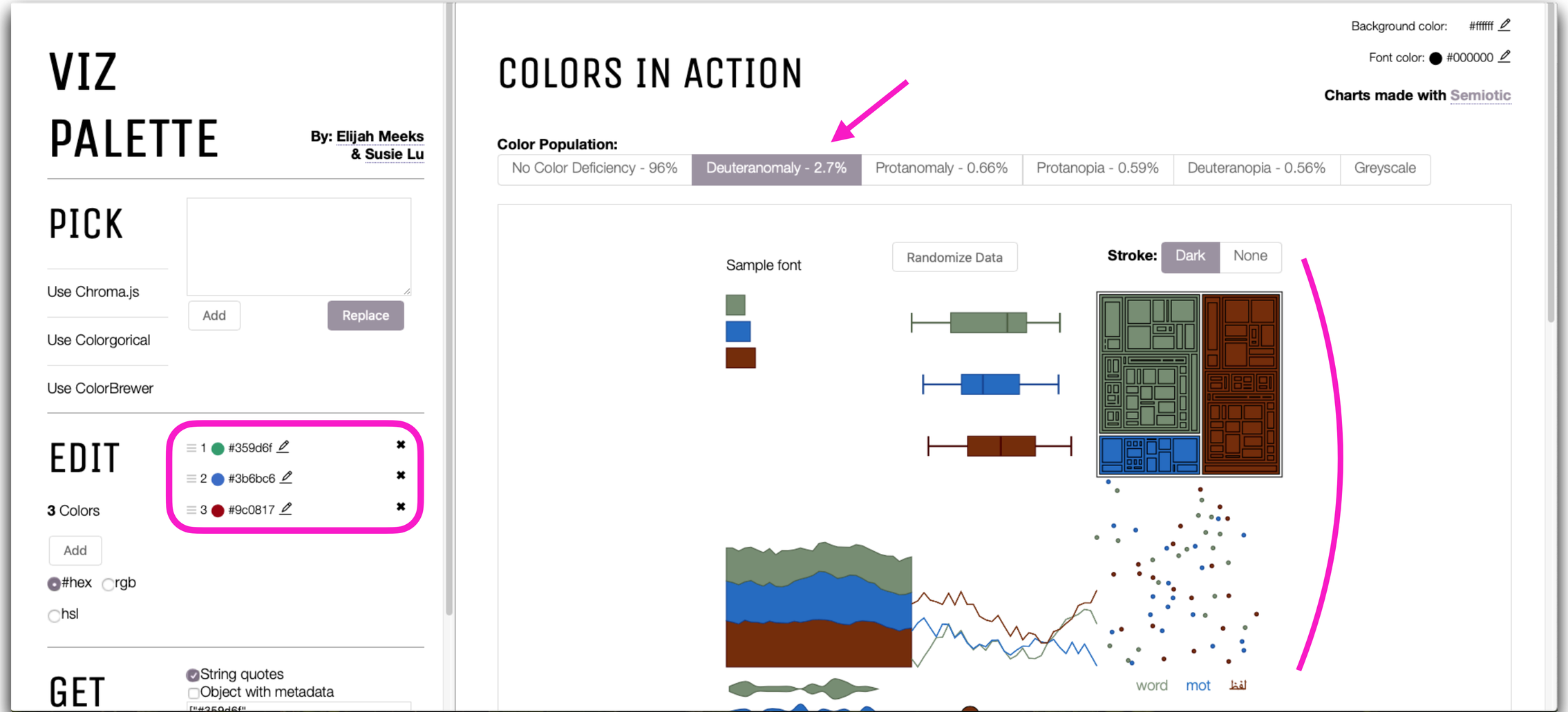
Hue
Saturation
Lightness



Wong 2010, *Color coding*

If you make your own palettes...

test out colors using Viz Palette



Emphasis

Adding special importance or prominence in your figures.

Emphasis sets an object apart

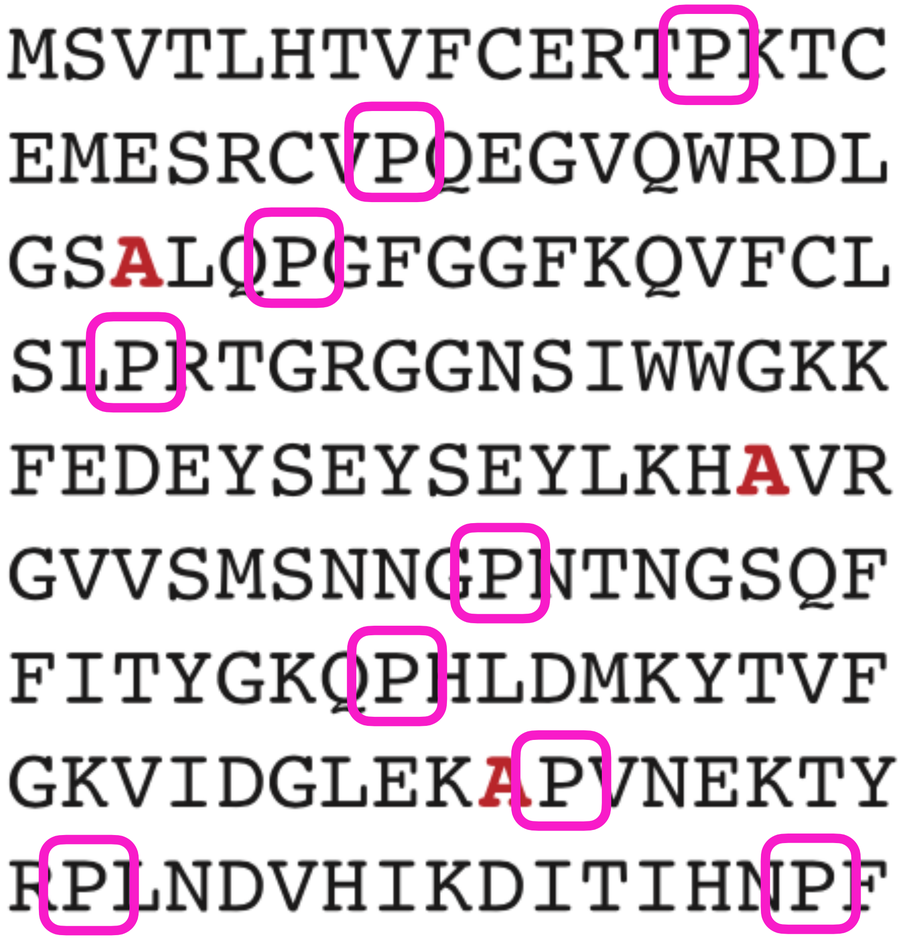
Easy

A

Difficult

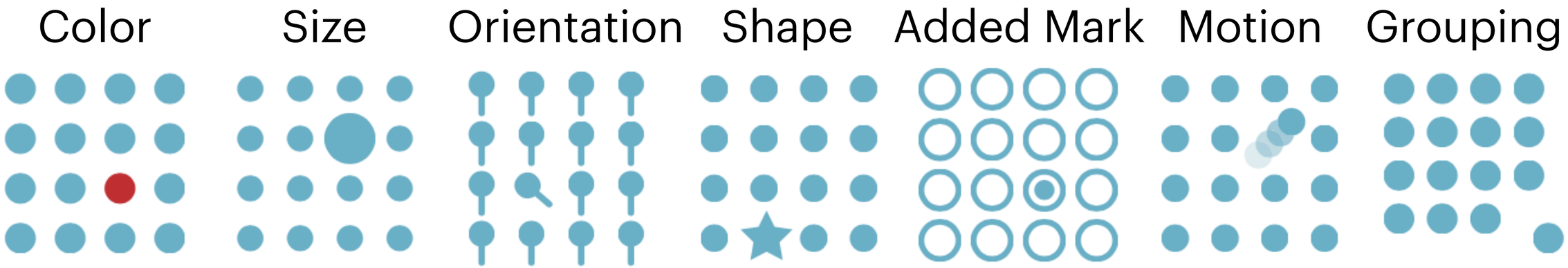
P

actually 3x as many!!



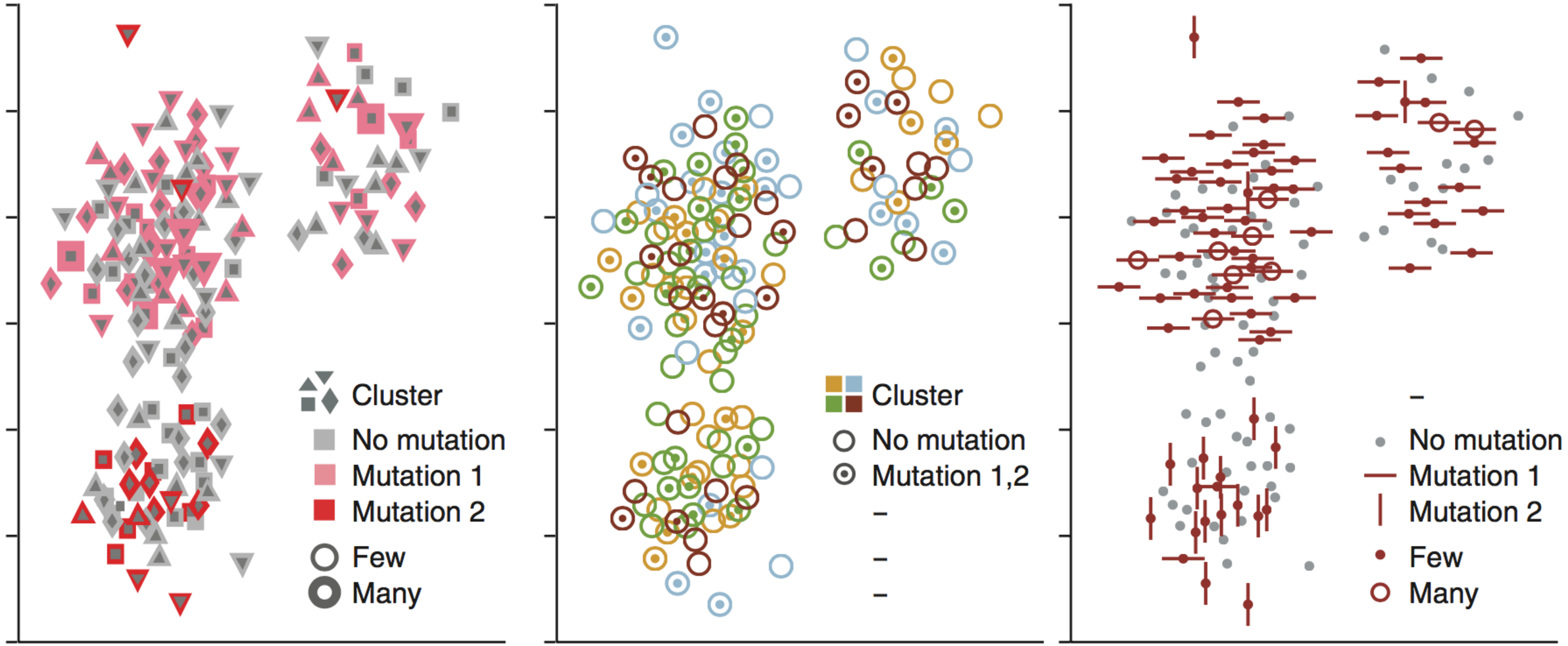
Wong 2010, *Salience*

There are many ways to add emphasis



Wong 2010, *Salience*

But you can't emphasize everything!

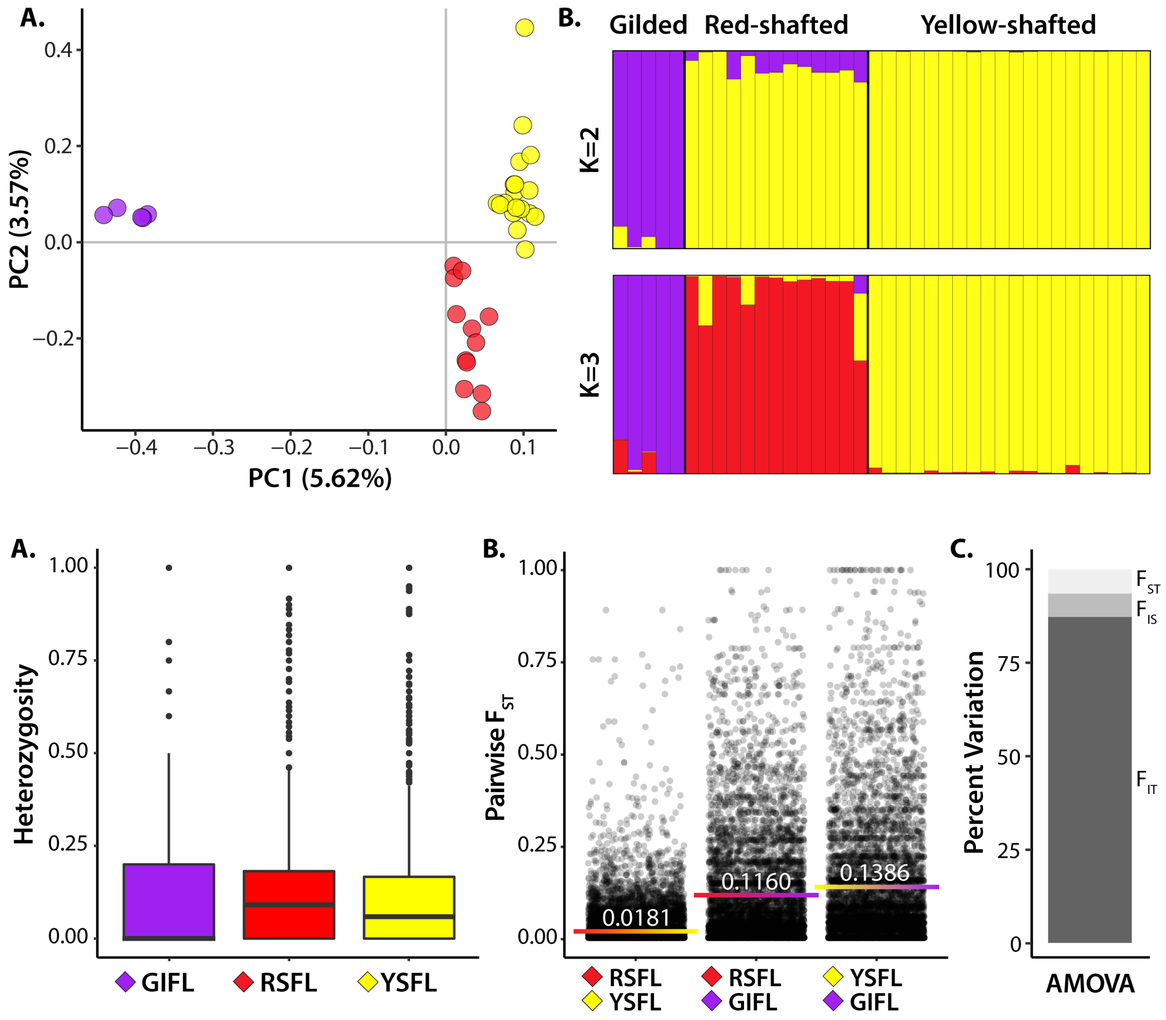


Wong 2010, *Salience*

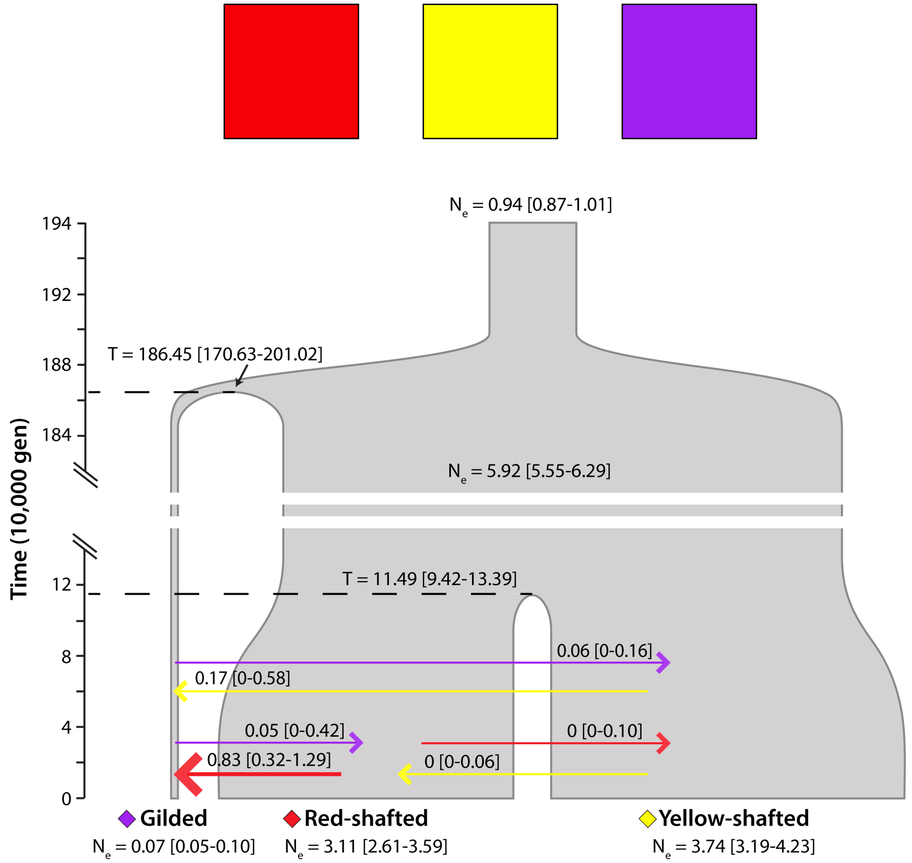
Consistency

Making sure all your figures “agree.”

Colors and symbols should mean the same thing

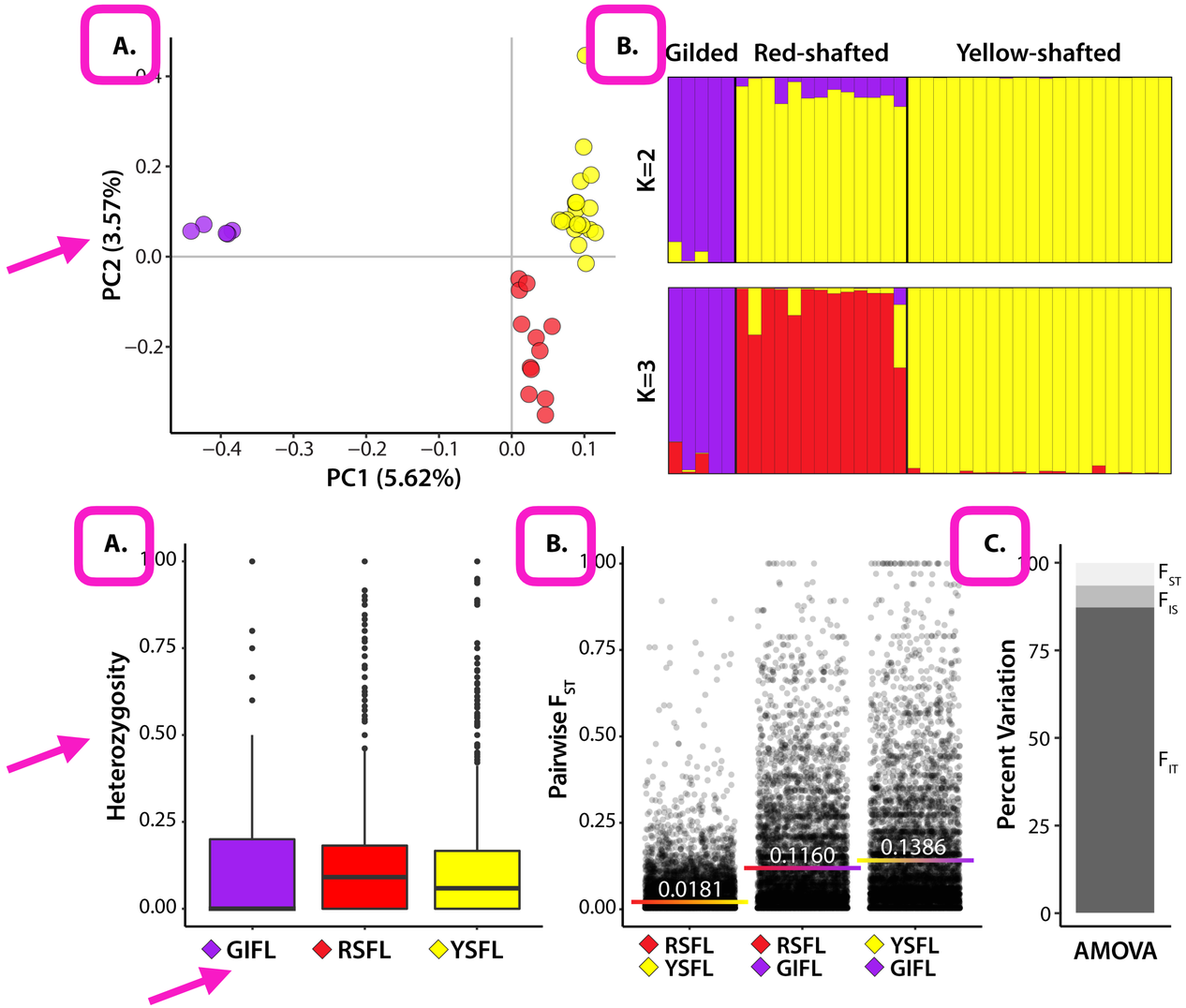


Three colors always mean the same thing!



Aguillon et al. 2018 *The Auk*

Use the same (readable) font throughout



Stay consistent in...

panel labels

axis labels

font style

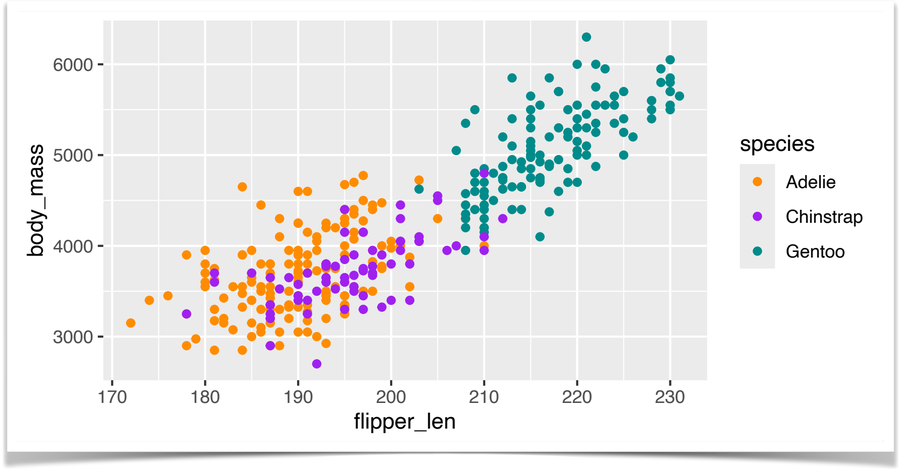
font size

Aguillon et al. 2018 *The Auk*

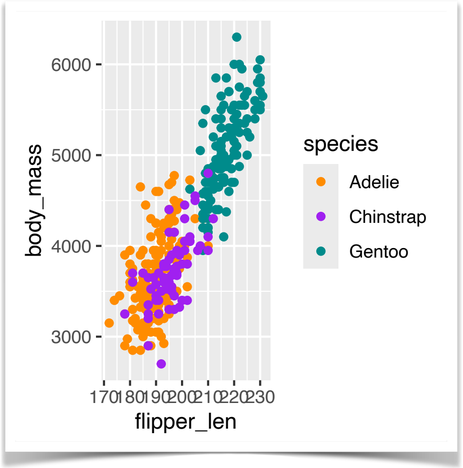
Save figures in their final dimensions

```
ggsave("name_of_figure.pdf", width = <value>,
height = <value>, units = <"in", "cm", "mm">)
```

```
ggsave("penguins1.pdf", width = 6,
height = 3, units = "in")
```




```
ggsave("penguins1.pdf", width = 3,
height = 3, units = "in")
```



Save figures in their final dimensions

Automatically saves the last plot

```
ggsave("name_of_figure.pdf", width = <value>,
height = <value>, units = <"in", "cm", "mm">)
```

But you can also indicate *which* plot to save

```
ggsave("name_of_figure.pdf", <plot_name>, width
= <value>, height = <value>, units = <"in",
"cm", "mm">)
```

Four basic design principles

- Clarity
- Color
- Emphasis
- Consistency

} “Three C’s and an E”

When you make a figure, your goal is to convey information as clearly, accurately, and efficiently as possible.

Further reading

- Midway 2020. Principles of Effective Data Visualization. *Patterns*
- Wilke 2018. Fundamentals of Data Visualization
- Better Posters Blog
- Bang Wong's "Points of View" series in Nature Methods
- Weissgerber et al. 2015. Beyond Bar and Line Graphs: Time for a New Data Presentation Program. *PLoS Biology*