

ggplot2 ecosystem & designing visualizations

Lecture 10

Dr. Colin Rundel

The wider ggplot2 ecosystem

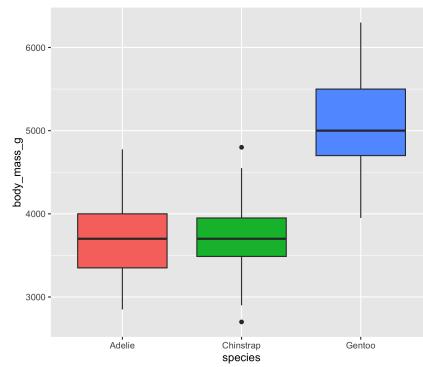
ggthemes

ggplot2 themes

```
1 g = ggplot( palmerpenguins::penguins, aes(x=species, y=body_mass_g, fill=species)) +  
2   geom_boxplot()
```

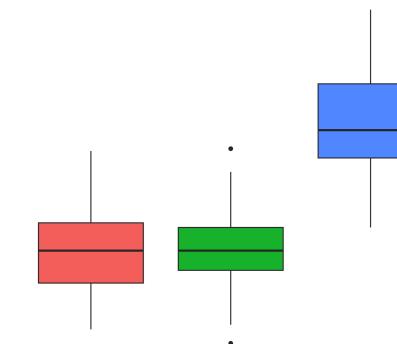
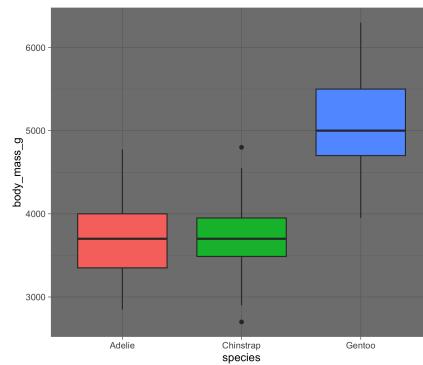
```
1 g
```

```
1 g + theme_minimal()
```



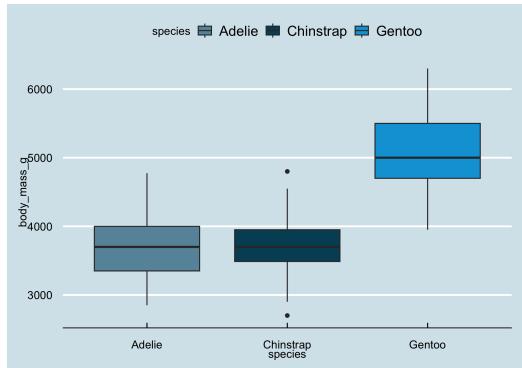
```
1 g + theme_dark()
```

```
1 g + theme_void()
```

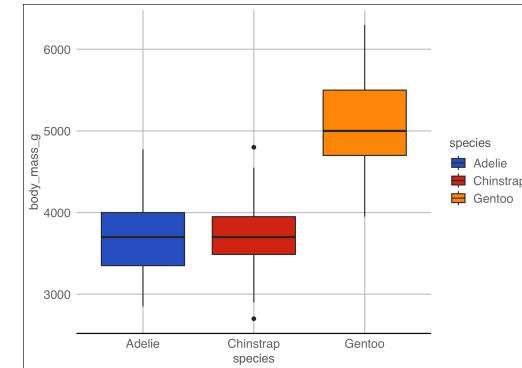


ggthemes

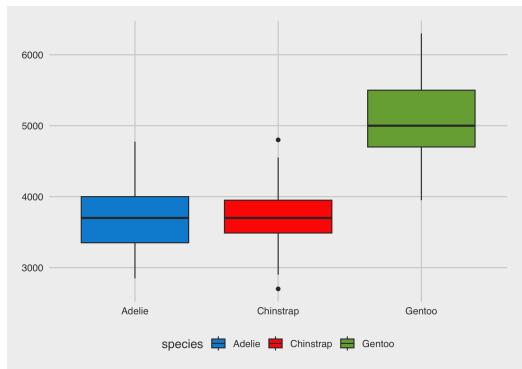
```
1 g + ggthemes::theme_economist() +  
2 ggthemes::scale_fill_economist()
```



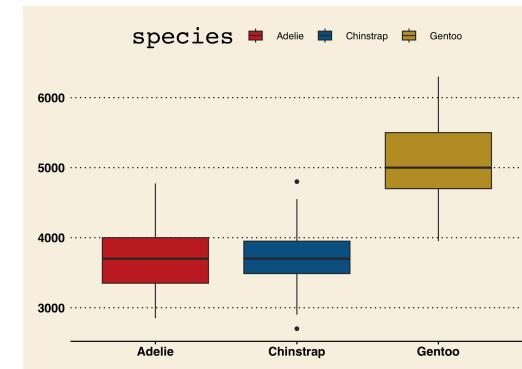
```
1 g + ggthemes::theme_gdocs() +  
2 ggthemes::scale_fill_gdocs()
```



```
1 g + ggthemes::theme_fivethirtyeight() +  
2 ggthemes::scale_fill_fivethirtyeight()
```

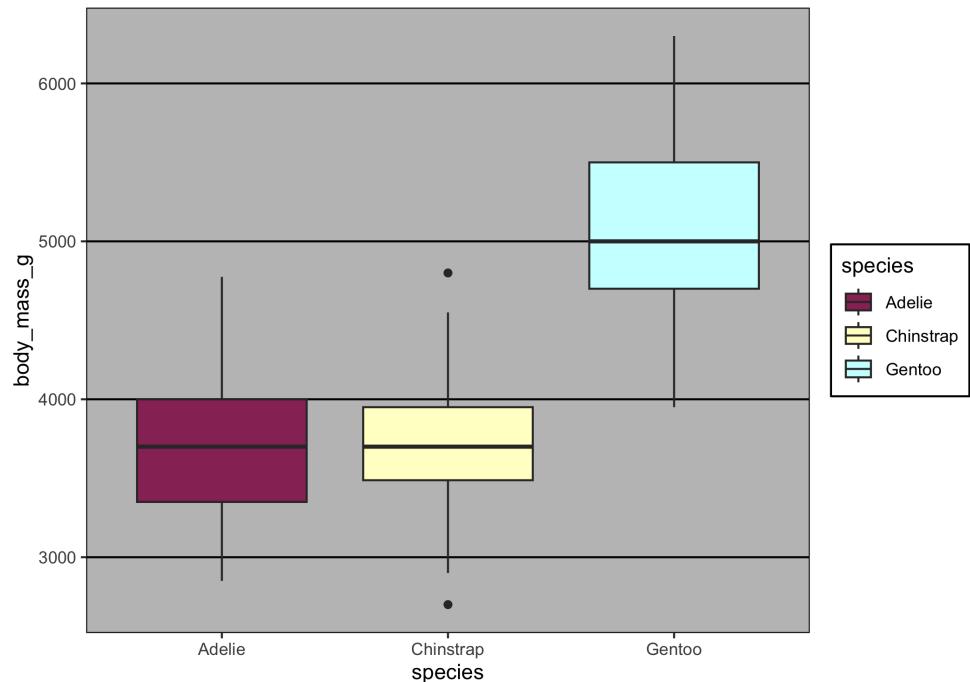


```
1 g + ggthemes::theme_wsj() +  
2 ggthemes::scale_fill_wsj()
```

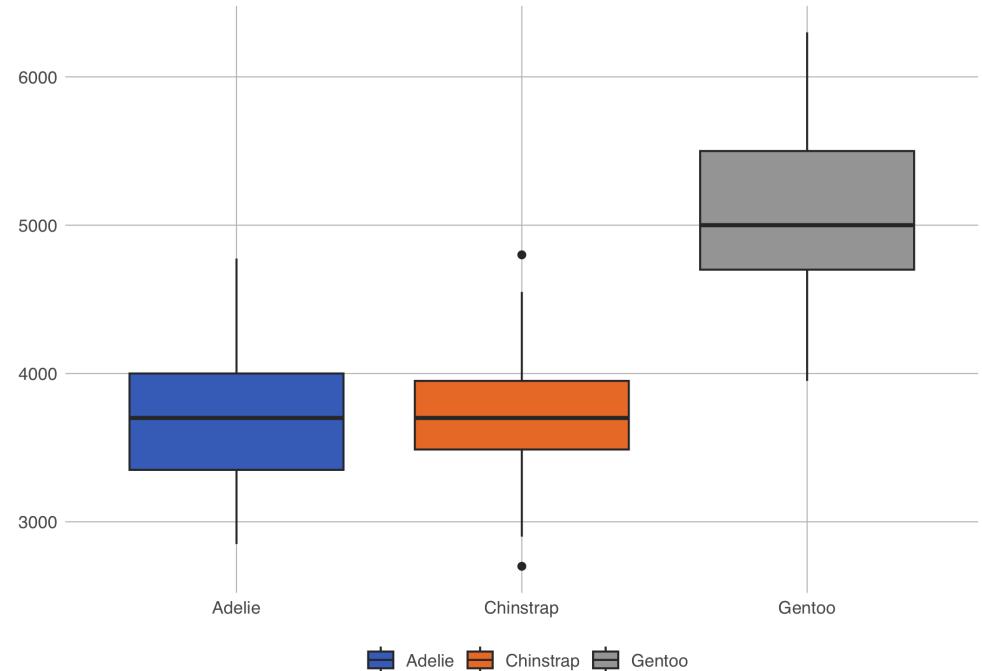


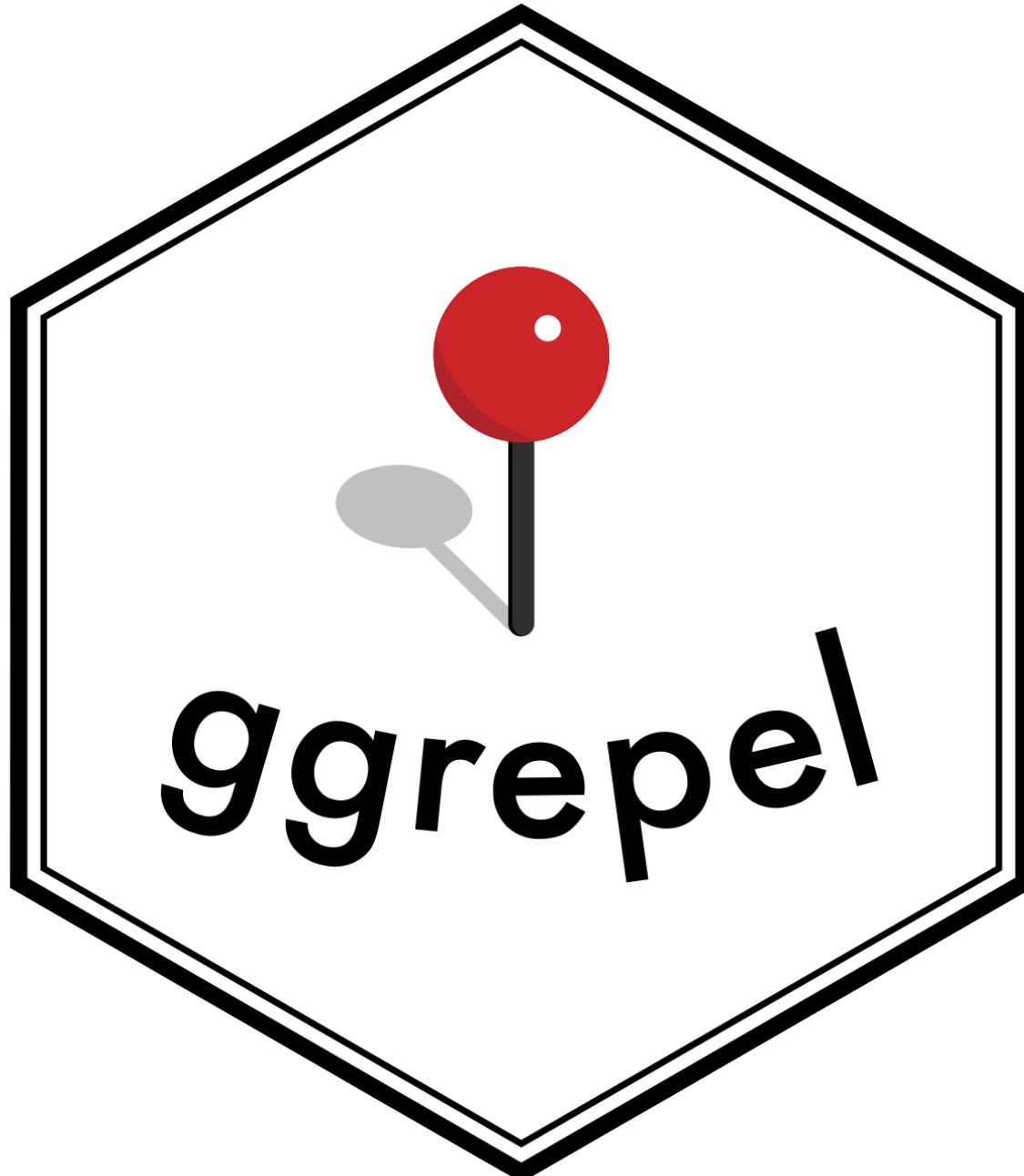
And for those who miss Excel

```
1 g + ggthemes::theme_excel() +  
2 ggthemes::scale_fill_excel()
```



```
1 g + ggthemes::theme_excel_new() +  
2 ggthemes::scale_fill_excel_new()
```





```

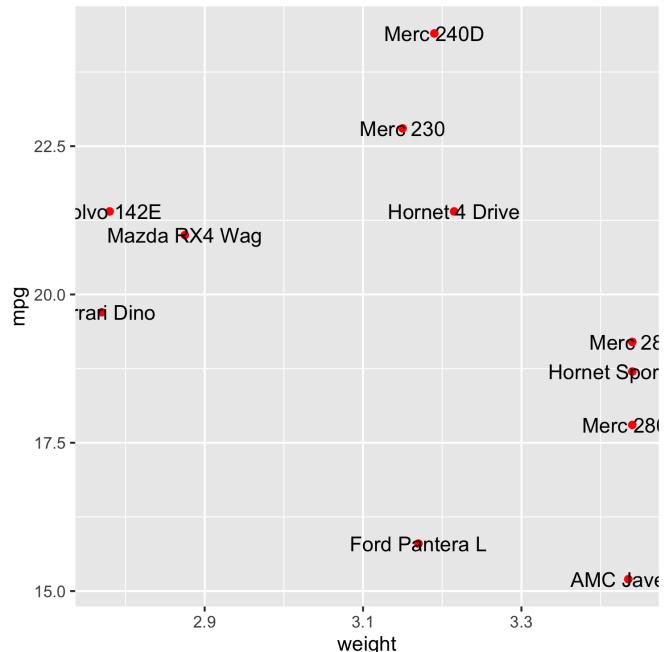
1 d = tibble(
2   car = rownames(mtcars),
3   weight = mtcars$wt,
4   mpg = mtcars$mpg
5 ) %>%
6 filter(weight > 2.75, weight < 3.45)

```

```

1 ggplot(d, aes(x=weight, y=mpg)) +
2   geom_point(color="red") +
3   geom_text(
4     aes(label = car)
5 )

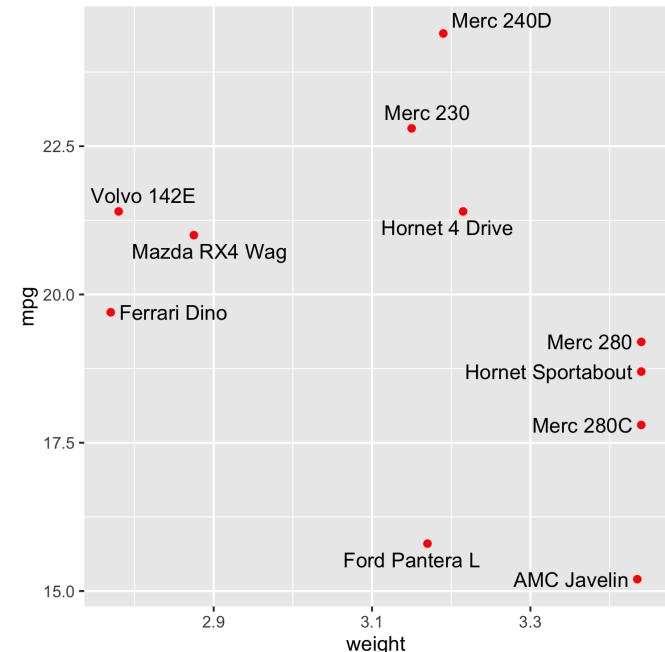
```



```

1 ggplot(d, aes(x=weight, y=mpg)) +
2   geom_point(color="red") +
3   ggrepel::geom_text_repel(
4     aes(label = car)
5 )

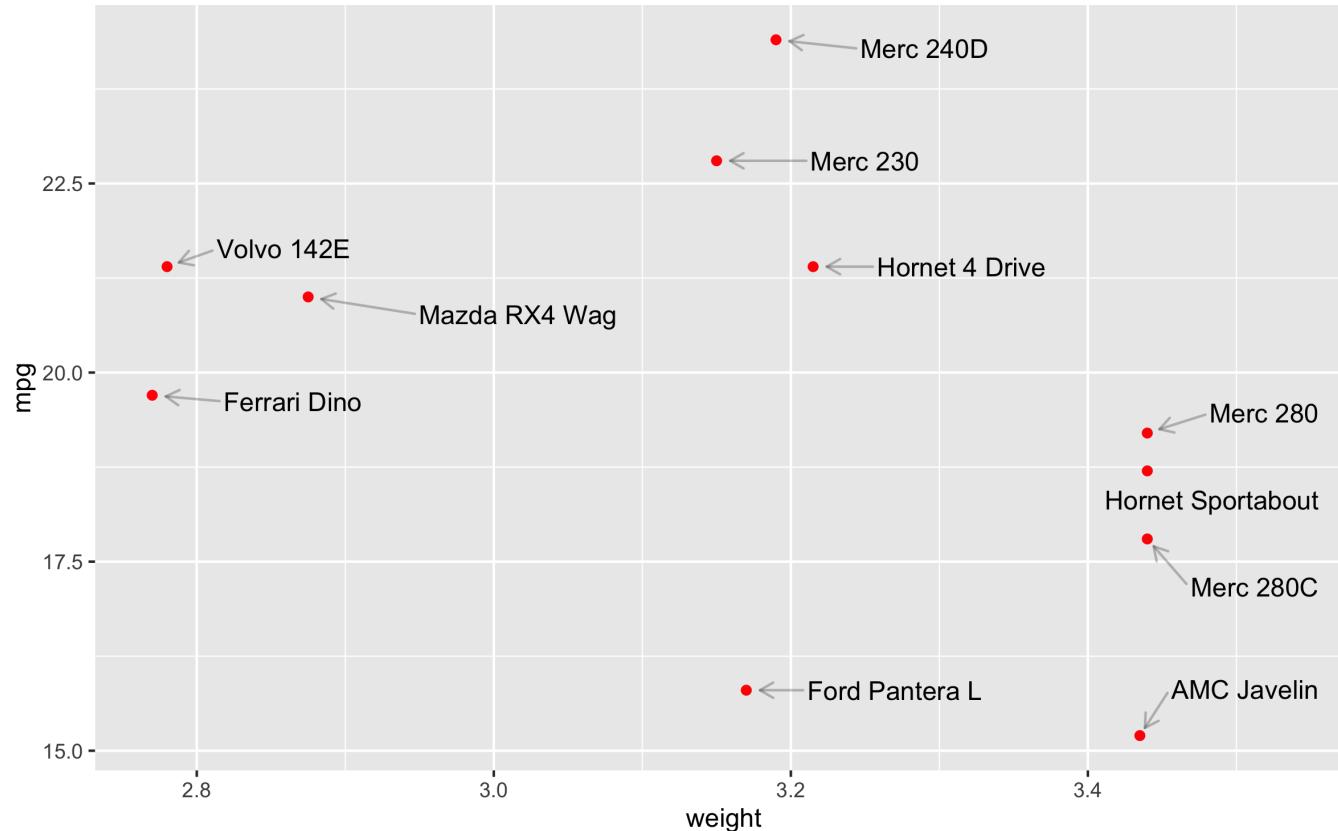
```



```

1 ggplot(d, aes(x=weight, y=mpg)) +
2   geom_point(color="red") +
3   ggrepel::geom_text_repel(
4     aes(label = car),
5     nudge_x = .1, box.padding = 1, point.padding = 0.6,
6     arrow = arrow(length = unit(0.02, "npc")), segment.alpha = 0.25
7 )

```





Sta 523 - Fall 2023

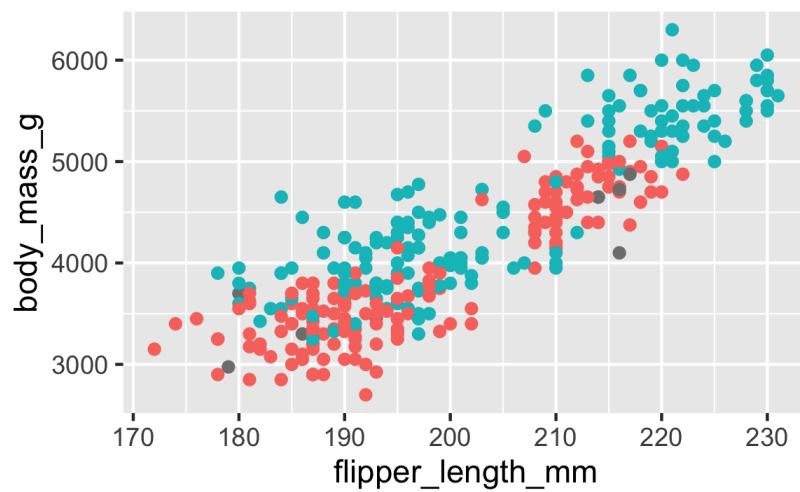
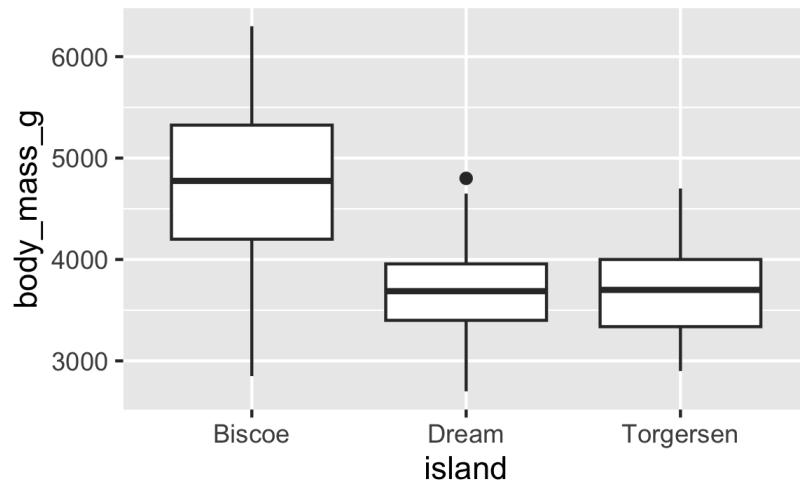
ggplot objects

```
1 library(patchwork)
2
3 p1 = ggplot(palmerpenguins::penguins) +
4   geom_boxplot(aes(x = island, y = body_mass_g))
5
6 p2 = ggplot(palmerpenguins::penguins) +
7   geom_boxplot(aes(x = species, y = body_mass_g))
8
9 p3 = ggplot(palmerpenguins::penguins) +
10  geom_point(aes(x = flipper_length_mm, y = body_mass_g, color = sex))
11
12 p4 = ggplot(palmerpenguins::penguins) +
13  geom_point(aes(x = bill_length_mm, y = body_mass_g, color = sex))
```

```
1 class(p1)
```

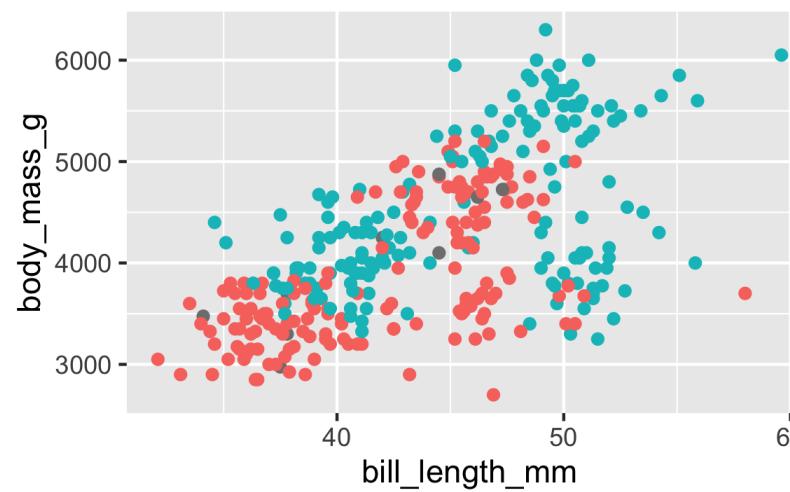
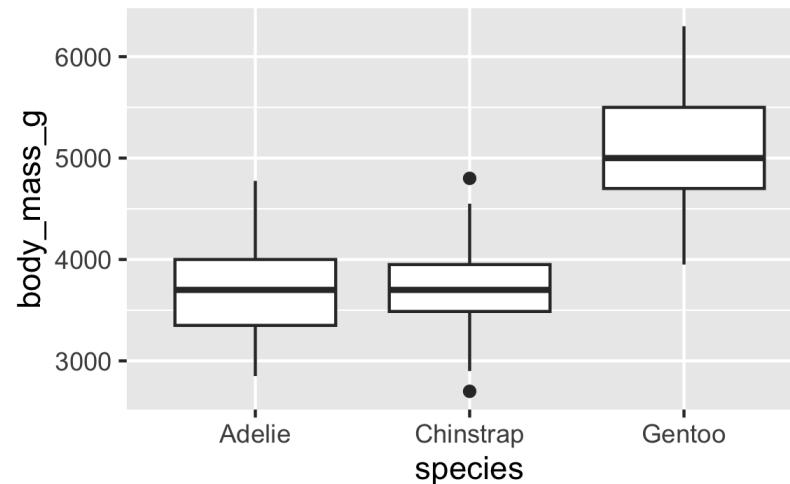
```
[1] "gg"      "ggplot"
```

1 p1 + p2 + p3 + p4



sex

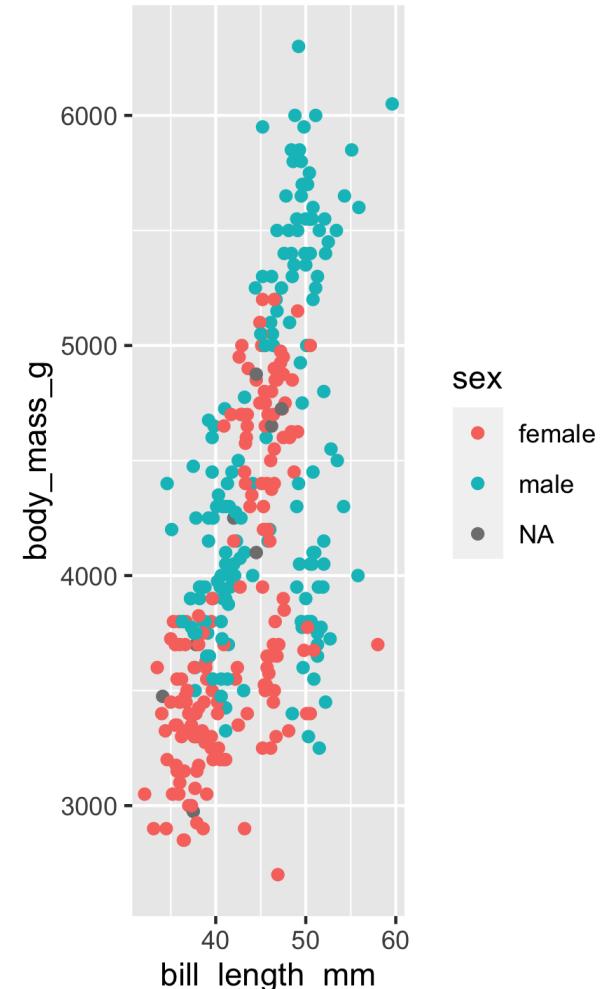
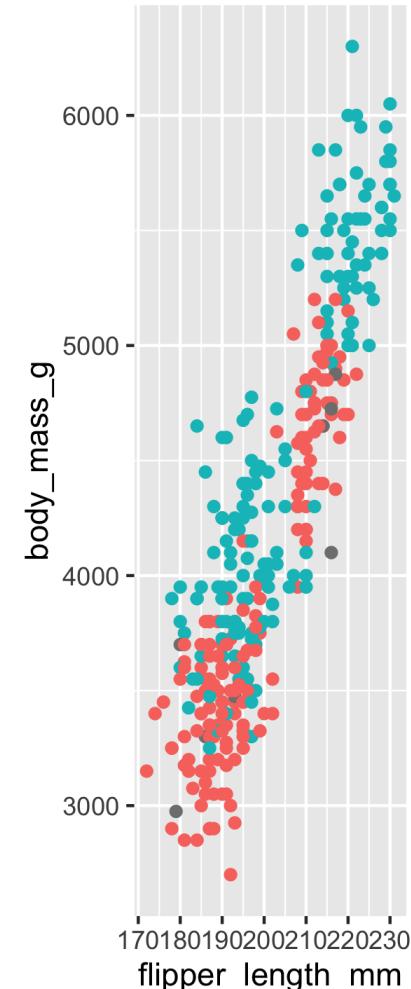
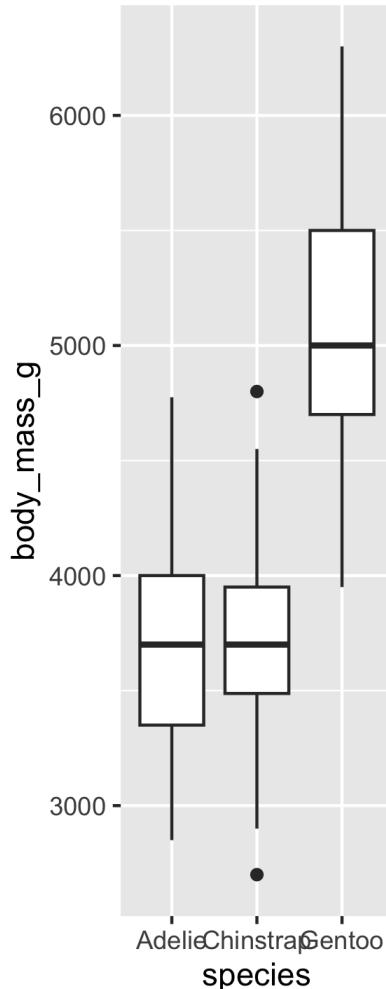
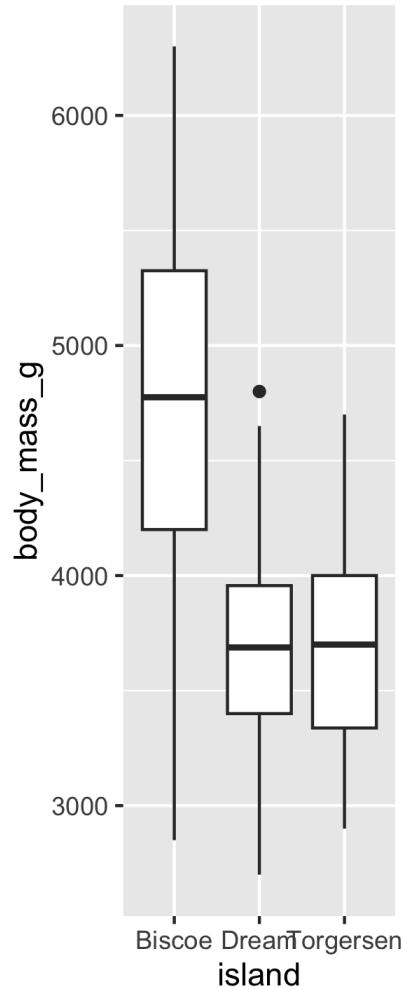
- female
- male
- NA



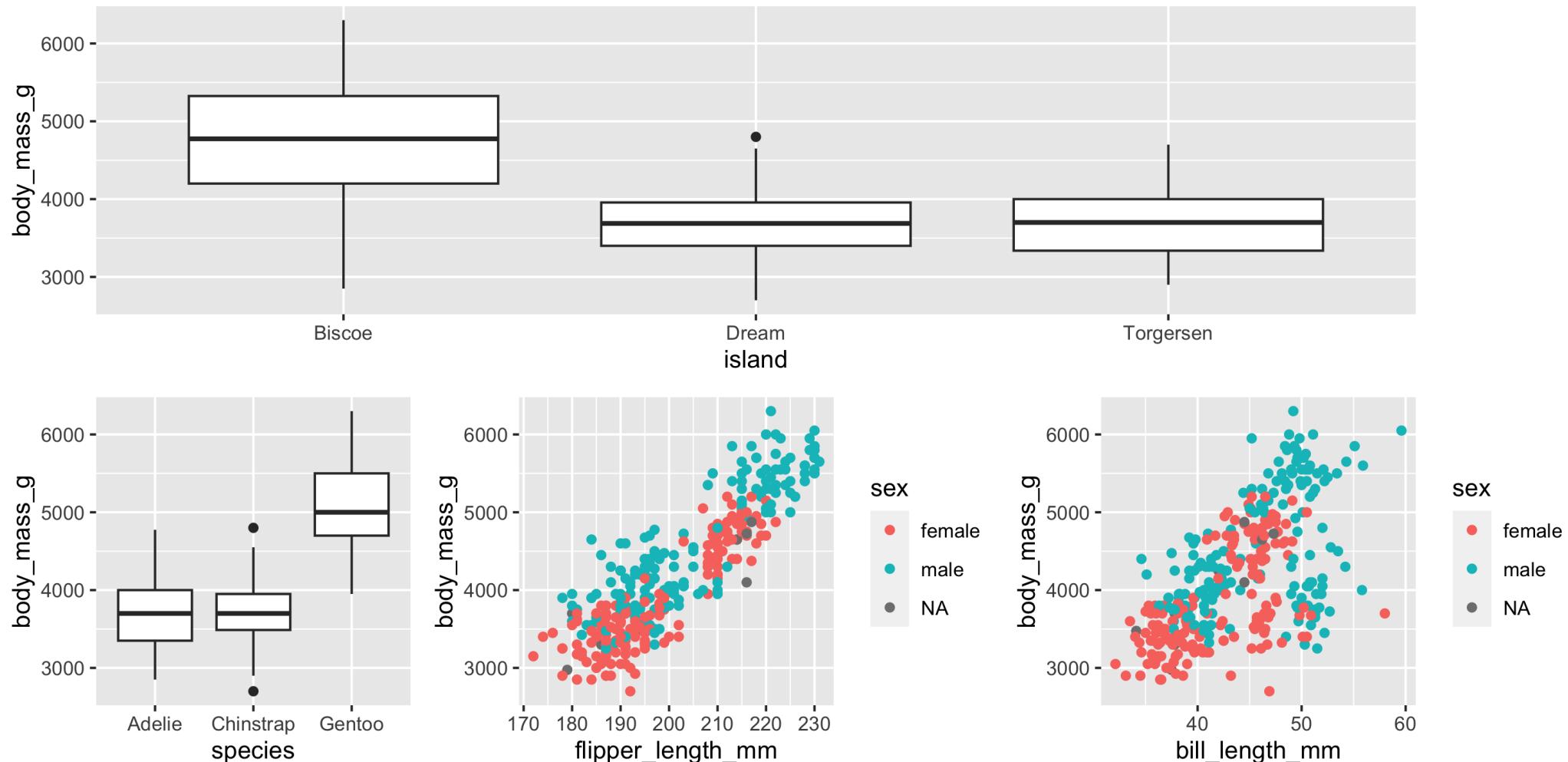
sex

- female
- male
- NA

```
1 p1 + p2 + p3 + p4 + plot_layout(nrow=1)
```



$1 \ p1 \ / \ (p2 + p3 + p4)$



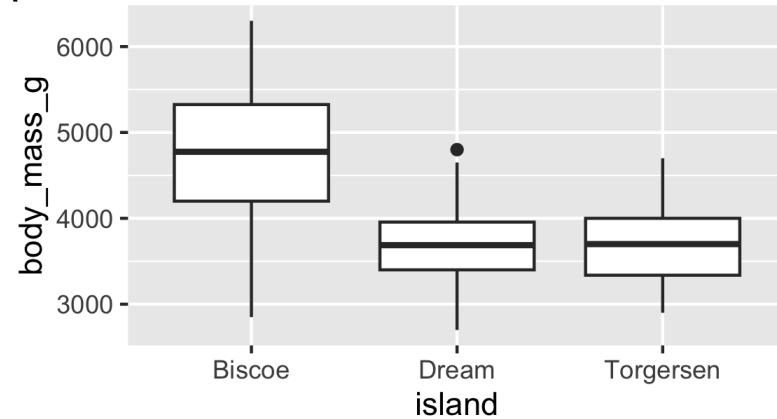
```

1 p1 + p2 + p3 + p4 +
2 plot_annotation(title = "Palmer Penguins", tag_levels = c("A"))

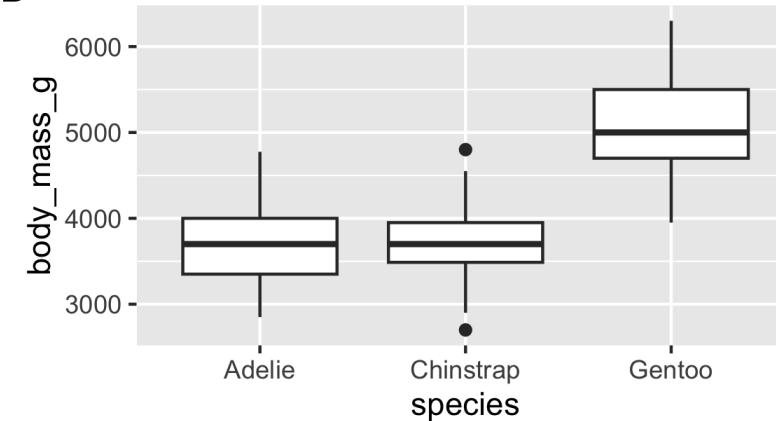
```

Palmer Penguins

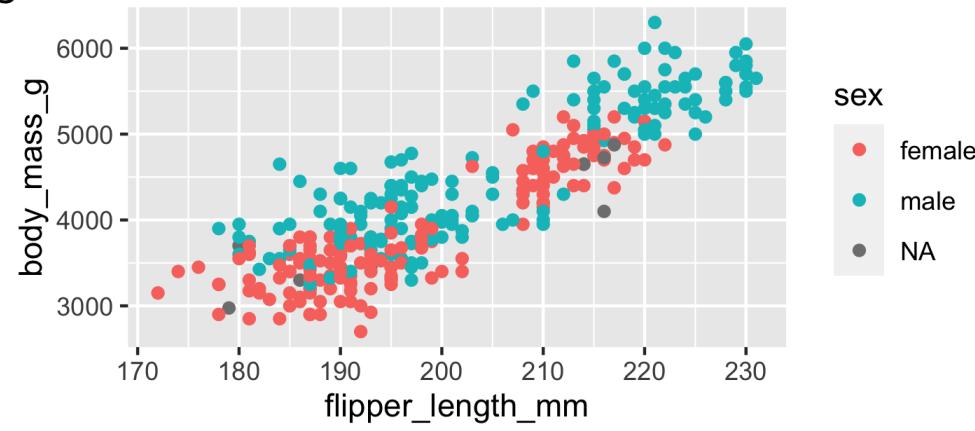
A



B



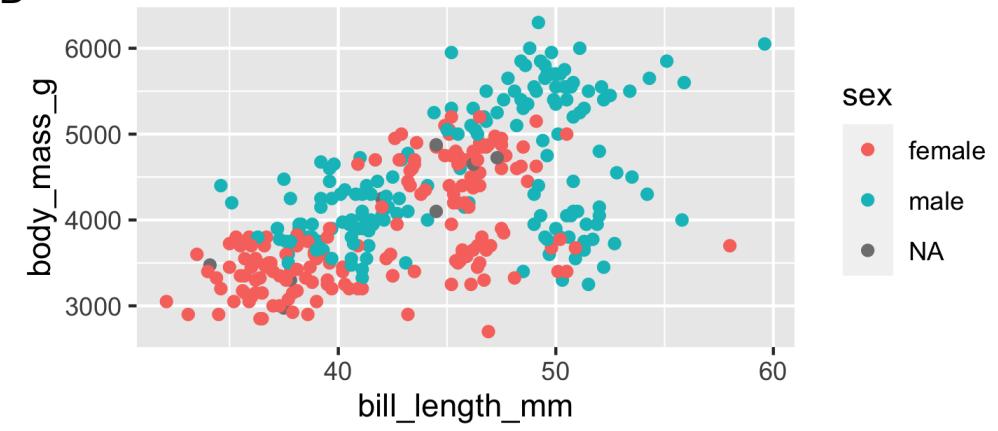
C



sex

- female
- male
- NA

D



sex

- female
- male
- NA

```

1 p1 + {
2   p2 + {
3     p3 + p4 + plot_layout(ncol = 1) + plot_layout(tag_level = 'new')
4   }
5 } +
6 plot_layout(ncol = 1) +
7 plot_annotation(tag_levels = c("1", "a"), tag_prefix = "Fig ")

```

Fig 1

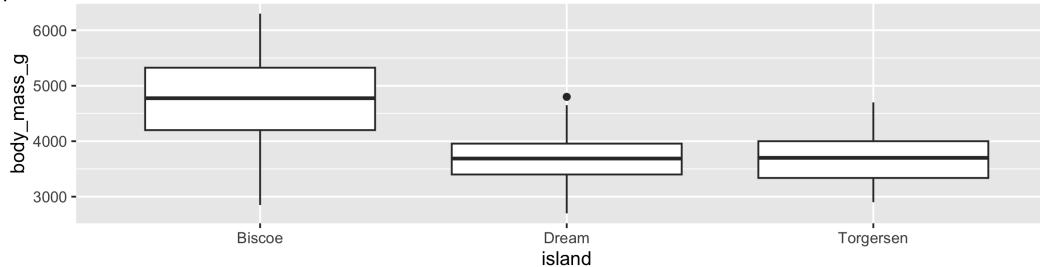


Fig 2

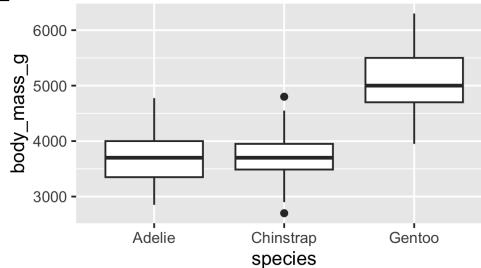


Fig 3a

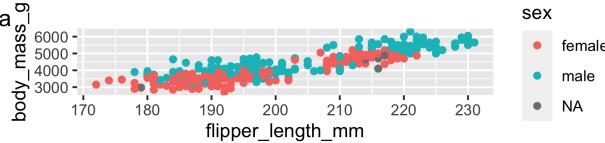
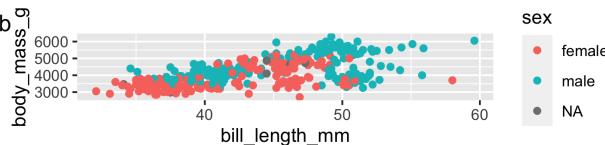
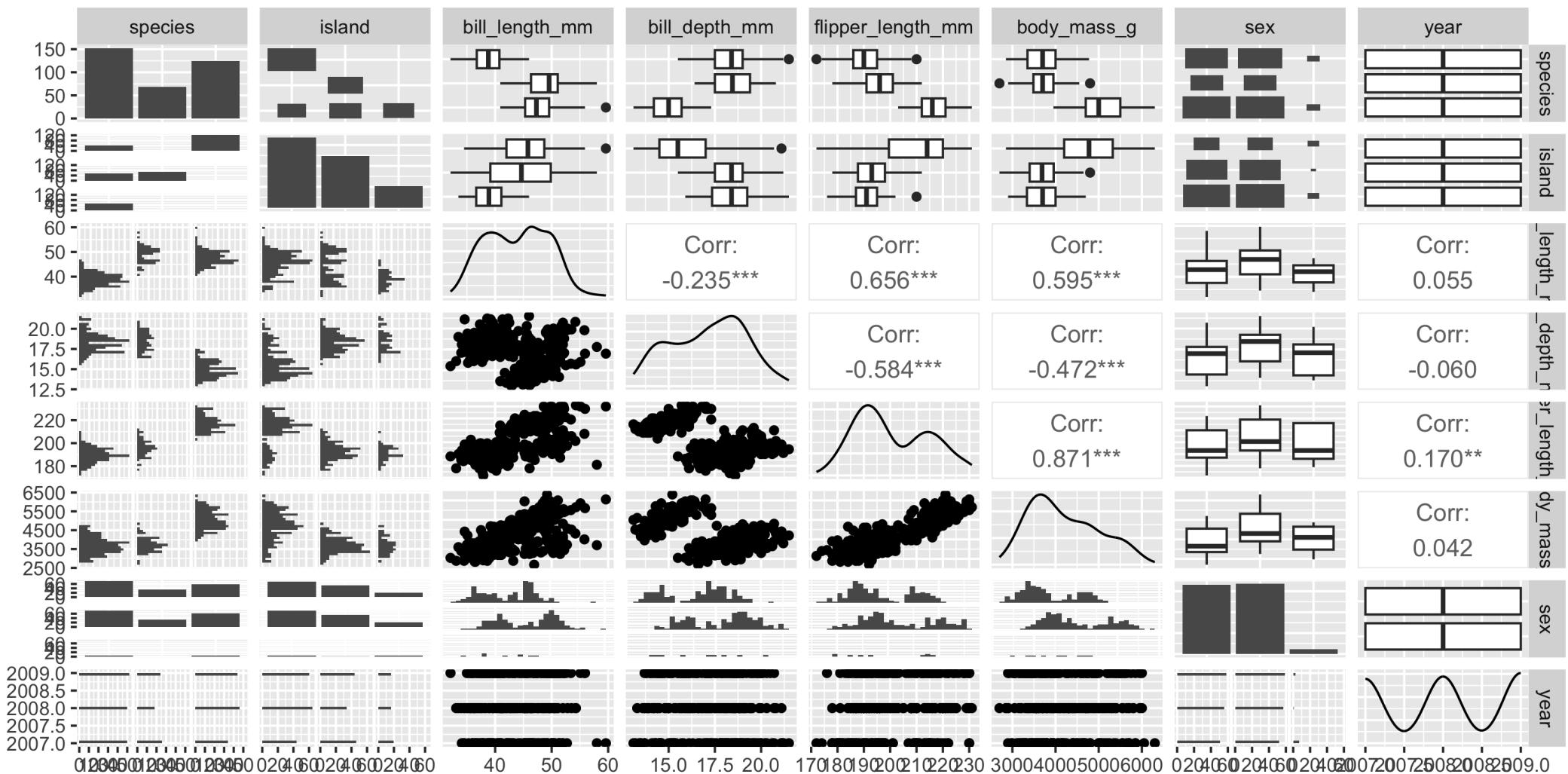


Fig 3b

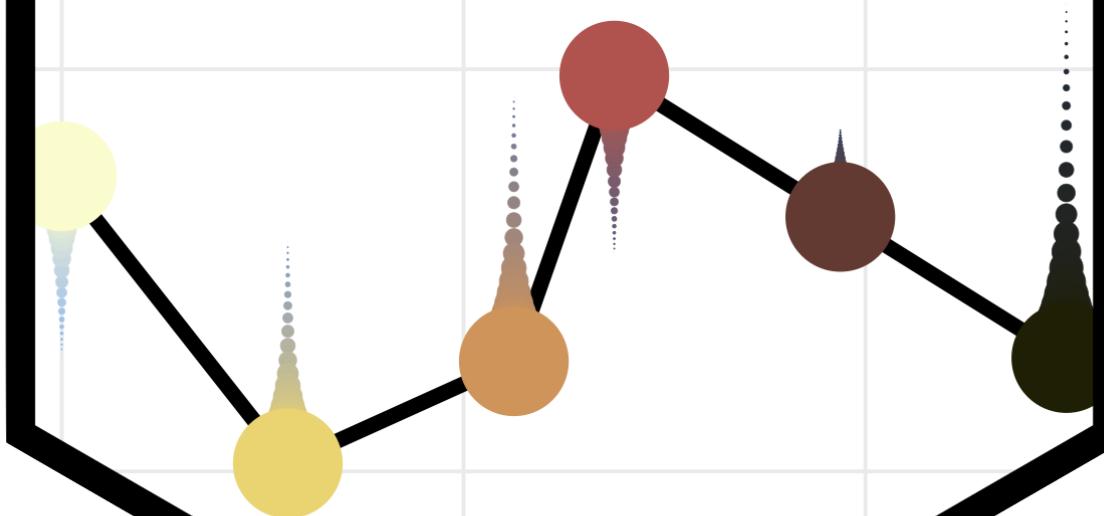


GGally

1 GGallery::ggpairs(palmerpenguins::penguins)



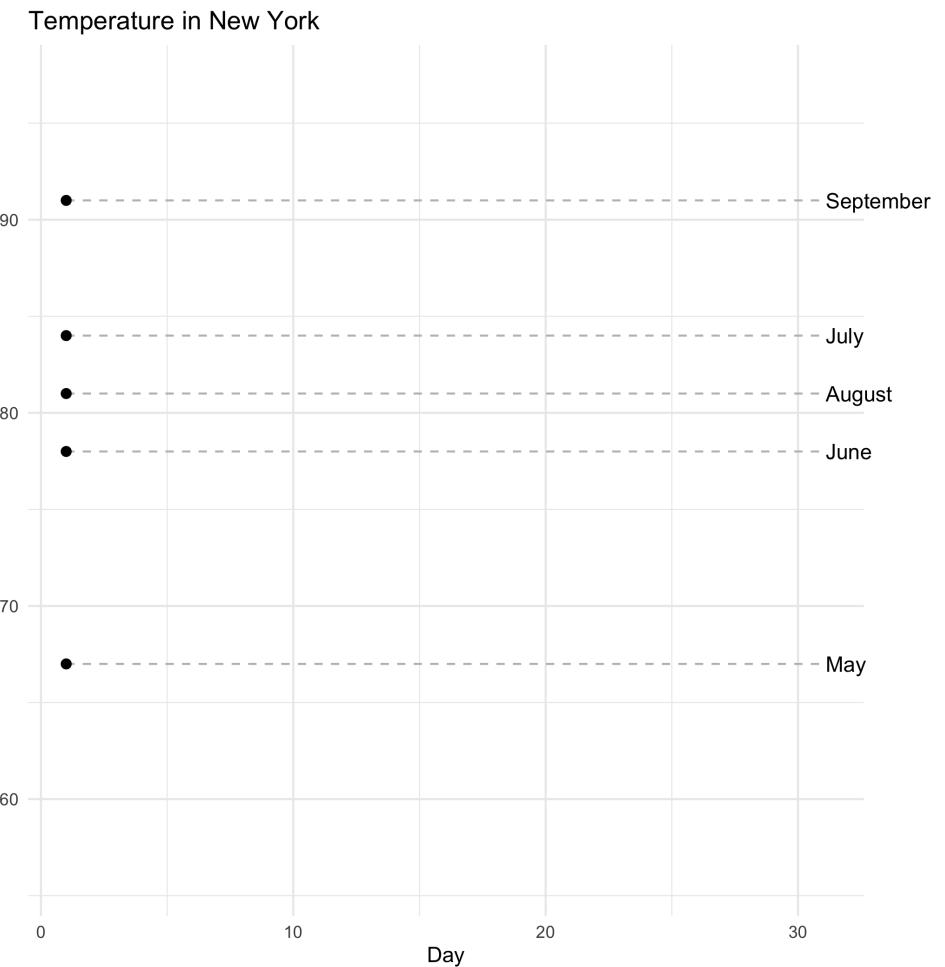
ganimate



```

1 airq = airquality
2 airq$Month = month.name[airq$Month]
3
4 ggplot(
5   airq,
6   aes(Day, Temp, group = Month)
7 ) +
8   geom_line() +
9   geom_segment(
10    aes(xend = 31, yend = Temp),
11    linetype = 2,
12    colour = 'grey'
13 ) +
14   geom_point(size = 2) +
15   geom_text(
16    aes(x = 31.1, label = Month),
17    hjust = 0
18 ) +
19   gganimate::transition_reveal(Day) +
20   coord_cartesian(clip = 'off') +
21   labs(
22     title = 'Temperature in New York',
23     y = 'Temperature (°F)'

```



More extensions

exts.ggplot2.tidyverse.org/gallery/

ggplot2 extensions - gallery Add Your Extension! exts.ggplot2.tidyverse.org

Sort Text Filter Author Filter Tag Filter CRAN Only

Github stars ▼ search name, autho ▼

Showing 86 of 101

The screenshot shows the 'ggplot2 extensions' gallery interface. At the top, there are filters for 'Sort' (set to 'Github stars'), 'Text Filter' (empty), 'Author Filter' (empty), 'Tag Filter' (empty), and a 'CRAN Only' toggle switch (on). Below these are dropdown menus for 'Github stars' (set to 'search name, autho') and 'Tag Filter' (empty). The main area displays 86 of 101 registered extensions. Three examples are shown in detail:

- patchwork** (Star 1932): A package for easy composition of ggplot plots using arithmetic operators. It includes a histogram of 'carb' values, a scatter plot of 'disp' vs 'mpg', and a density plot of 'qsec'.
- gganimate** (Star 1709): A Grammar of Animated Graphics. It shows a grid of five panels representing different regions (Africa, Americas, Asia, Europe, Oceania) over time (Year: 1958), with points representing GDP per capita.
- ggstatsplot** (Star 1283): Provides a collection of functions to enhance ggplot2 plots with results from statistical tests. It features a violin plot for 'Sepal.Length' across Iris species, showing results for pairwise comparisons using the Games-Howell test.

Why do we visualize?

Anscombe's Quartet

```
1 datasets::anscombe %>% as_tibble()
```

```
# A tibble: 11 × 8
```

| | x1 | x2 | x3 | x4 | y1 | y2 | y3 | y4 |
|----|-------|-------|-------|-------|-------|-------|-------|-------|
| | <dbl> |
| 1 | 10 | 10 | 10 | 8 | 8.04 | 9.14 | 7.46 | 6.58 |
| 2 | 8 | 8 | 8 | 8 | 6.95 | 8.14 | 6.77 | 5.76 |
| 3 | 13 | 13 | 13 | 8 | 7.58 | 8.74 | 12.7 | 7.71 |
| 4 | 9 | 9 | 9 | 8 | 8.81 | 8.77 | 7.11 | 8.84 |
| 5 | 11 | 11 | 11 | 8 | 8.33 | 9.26 | 7.81 | 8.47 |
| 6 | 14 | 14 | 14 | 8 | 9.96 | 8.1 | 8.84 | 7.04 |
| 7 | 6 | 6 | 6 | 8 | 7.24 | 6.13 | 6.08 | 5.25 |
| 8 | 4 | 4 | 4 | 19 | 4.26 | 3.1 | 5.39 | 12.5 |
| 9 | 12 | 12 | 12 | 8 | 10.8 | 9.13 | 8.15 | 5.56 |
| 10 | 7 | 7 | 7 | 0 | 4.92 | 7.26 | 6.12 | 7.01 |

Tidy anscombe

```
1 tidy_anscombe = datasets::anscombe %>%
2   pivot_longer(everything(), names_sep = 1, names_to = c("var", "group")) %>%
3   pivot_wider(id_cols = group, names_from = var,
4               values_from = value, values_fn = list(value = list)) %>%
5   unnest(cols = c(x,y)))
```

```
# A tibble: 44 × 3
```

| | group | x | y |
|------------------|-------|-------|-------|
| | <chr> | <dbl> | <dbl> |
| 1 | 1 | 10 | 8.04 |
| 2 | 1 | 8 | 6.95 |
| 3 | 1 | 13 | 7.58 |
| 4 | 1 | 9 | 8.81 |
| 5 | 1 | 11 | 8.33 |
| 6 | 1 | 14 | 9.96 |
| 7 | 1 | 6 | 7.24 |
| 8 | 1 | 4 | 4.26 |
| 9 | 1 | 12 | 10.8 |
| 10 | 1 | 7 | 4.82 |
| # i 34 more rows | | | |

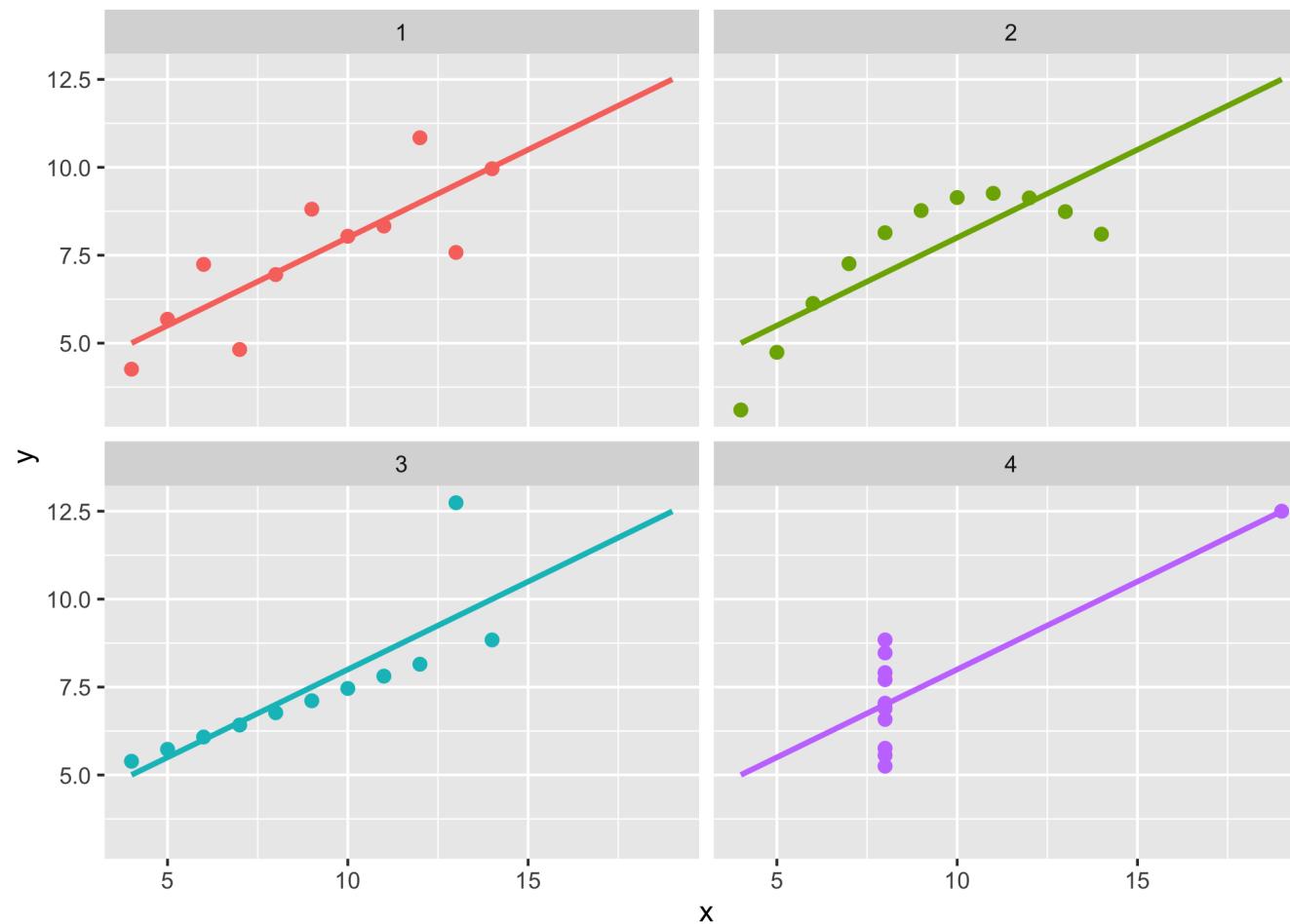
```
1 tidy_anscombe %>%
2   group_by(group) %>%
3   summarize(
4     mean_x = mean(x), mean_y = mean(y),
5     sd_x = sd(x), sd_y = sd(y),
6     cor = cor(x,y), .groups = "drop"
7   )
```

```
# A tibble: 4 × 6
  group mean_x mean_y  sd_x  sd_y    cor
  <chr>  <dbl>  <dbl> <dbl> <dbl> <dbl>
1 1        9     7.50  3.32  2.03  0.816
2 2        9     7.50  3.32  2.03  0.816
3 3        9     7.5    3.32  2.03  0.816
4 4        9     7.50  3.32  2.03  0.817
```

```

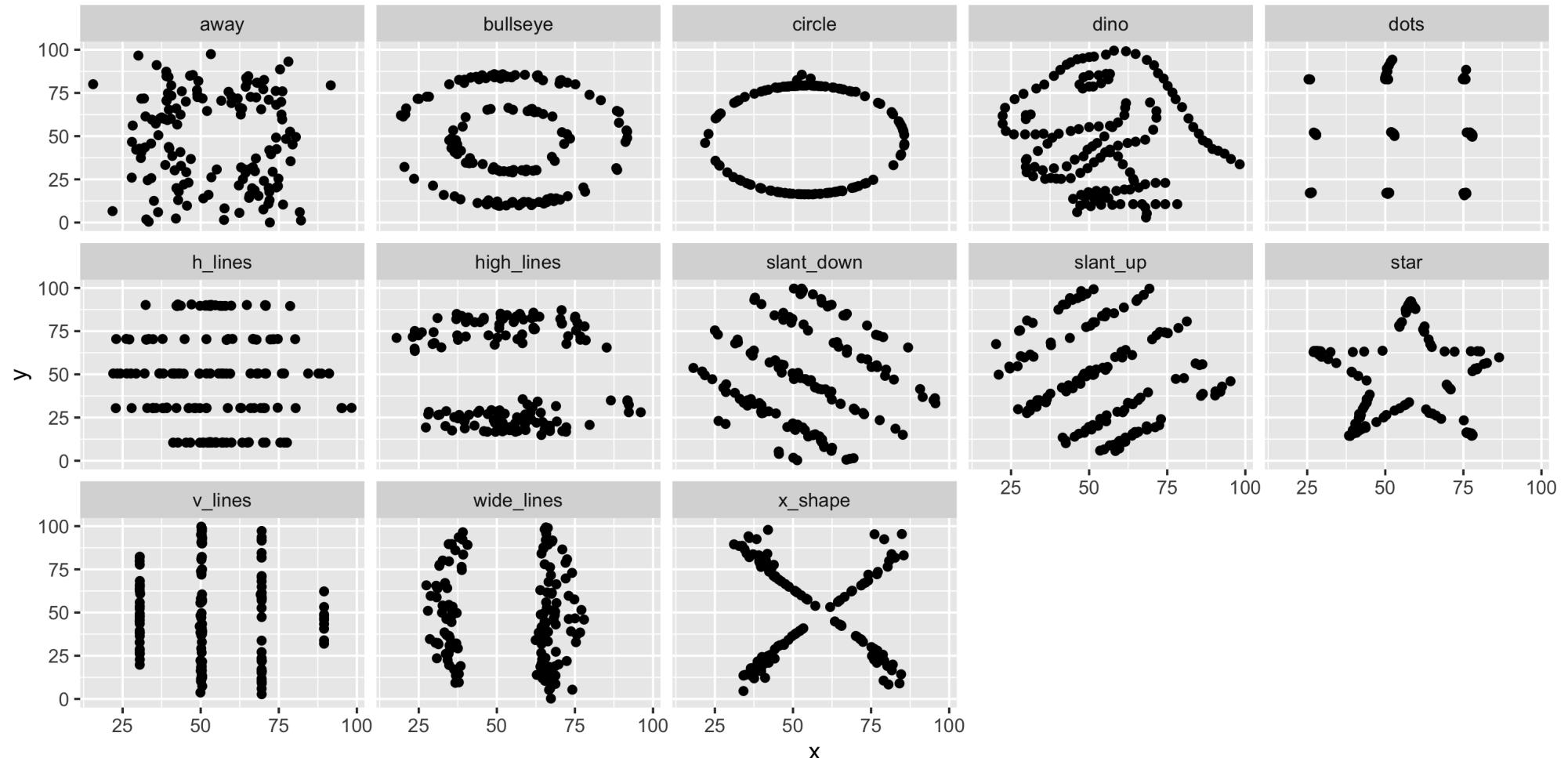
1 ggplot(tidy_anscombe, aes(x = x, y = y, color = as.factor(group))) +
2   geom_point(size=2) +
3   facet_wrap(~group) +
4   geom_smooth(method="lm", se=FALSE, fullrange=TRUE, formula = y~x) +
5   guides(color="none")

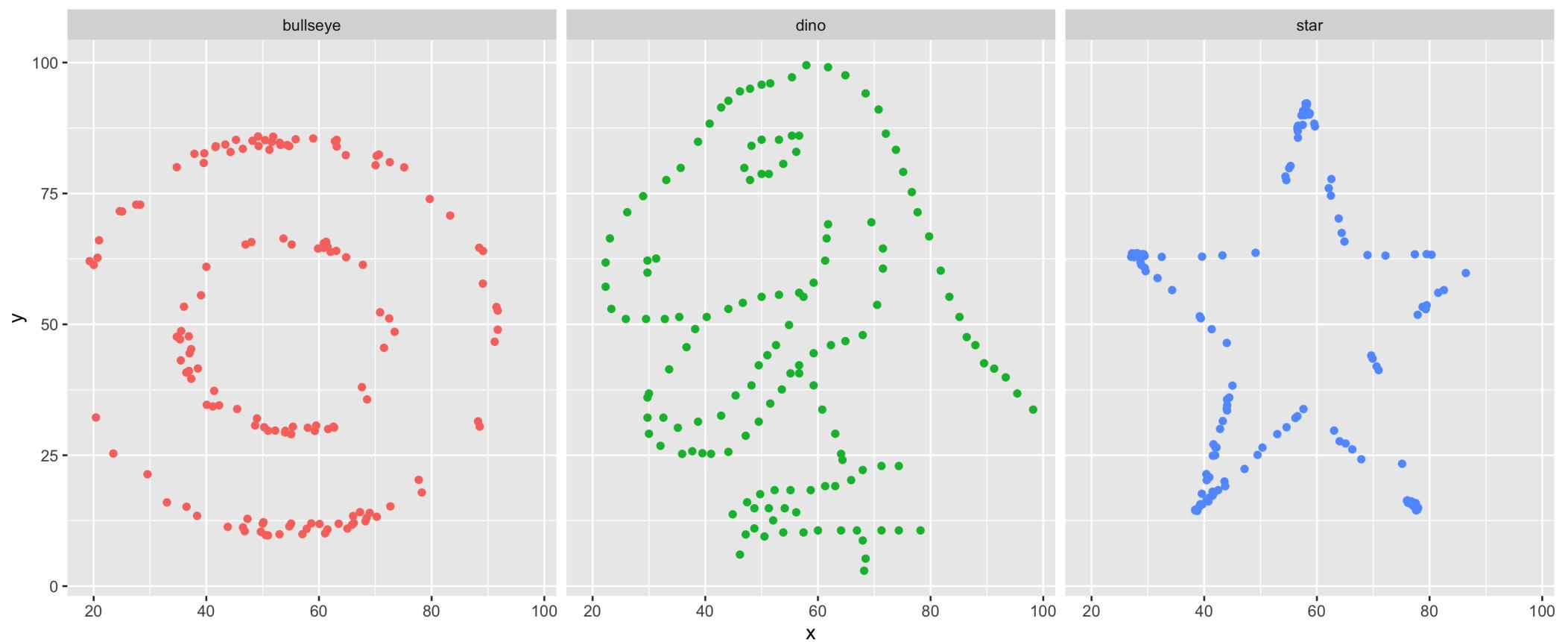
```



DatasauRus

```
1 ggplot(datasauRus::datasaurus_dozen, aes(x = x, y = y))  
2 ) +  
3 geom_point() +  
4 facet_wrap(~dataset, ncol=5)
```





```
1 datasauRus::datasaurus_dzen
```

```
# A tibble: 1,846 × 3
```

| | dataset | x | y |
|----|---------|-------|-------|
| | <chr> | <dbl> | <dbl> |
| 1 | dino | 55.4 | 97.2 |
| 2 | dino | 51.5 | 96.0 |
| 3 | dino | 46.2 | 94.5 |
| 4 | dino | 42.8 | 91.4 |
| 5 | dino | 40.8 | 88.3 |
| 6 | dino | 38.7 | 84.9 |
| 7 | dino | 35.6 | 79.9 |
| 8 | dino | 33.1 | 77.6 |
| 9 | dino | 29.0 | 74.5 |
| 10 | dino | 26.2 | 71.4 |

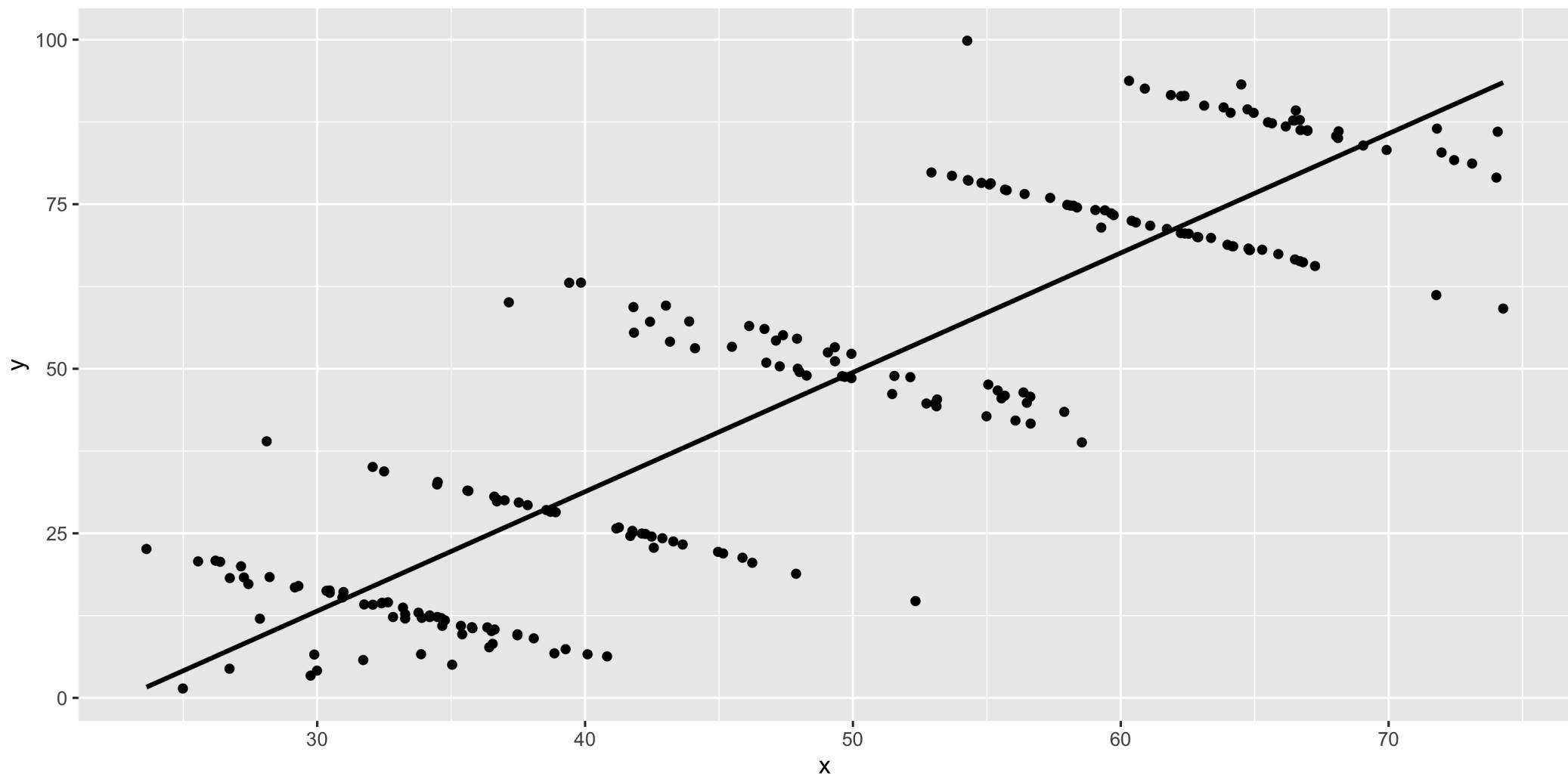
```
# i 1,836 more rows
```

```
1 datasauRus::datasaurus_dzen %>%  
2   group_by(dataset) %>%  
3   summarize(mean_x = mean(x), mean_y = mean(y),  
4             sd_x = sd(x), sd_y = sd(y),  
5             cor = cor(x,y), .groups = "drop")
```

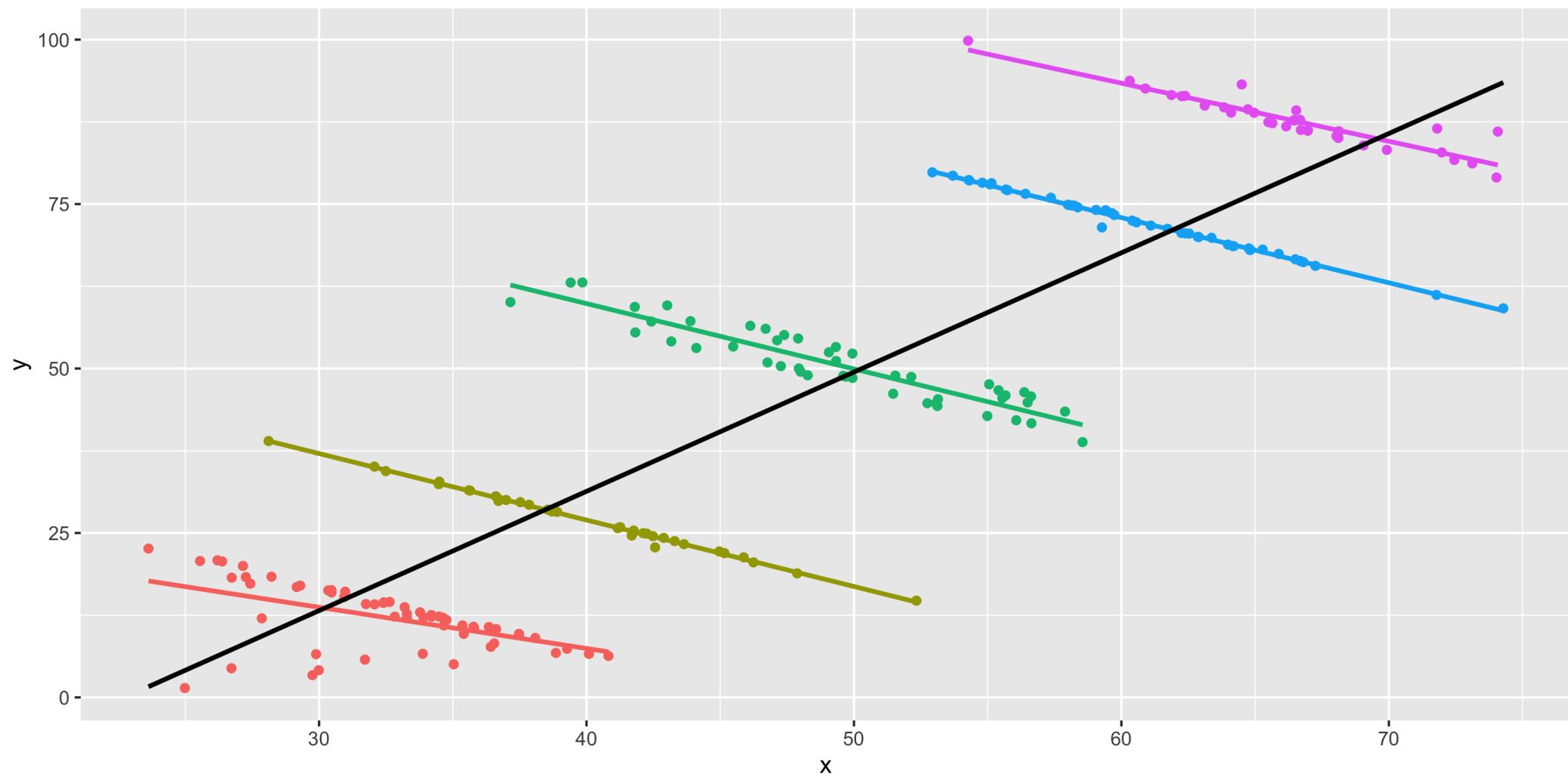
```
# A tibble: 13 × 6
```

| | dataset | mean_x | mean_y | sd_x | sd_y | cor |
|----|------------|--------|--------|-------|-------|---------|
| | <chr> | <dbl> | <dbl> | <dbl> | <dbl> | <dbl> |
| 1 | away | 54.3 | 47.8 | 16.8 | 26.9 | -0.0641 |
| 2 | bullseye | 54.3 | 47.8 | 16.8 | 26.9 | -0.0686 |
| 3 | circle | 54.3 | 47.8 | 16.8 | 26.9 | -0.0683 |
| 4 | dino | 54.3 | 47.8 | 16.8 | 26.9 | -0.0645 |
| 5 | dots | 54.3 | 47.8 | 16.8 | 26.9 | -0.0603 |
| 6 | h_lines | 54.3 | 47.8 | 16.8 | 26.9 | -0.0617 |
| 7 | high_lines | 54.3 | 47.8 | 16.8 | 26.9 | -0.0685 |
| 8 | slant_down | 54.3 | 47.8 | 16.8 | 26.9 | -0.0690 |
| 9 | slant_up | 54.3 | 47.8 | 16.8 | 26.9 | -0.0686 |
| 10 | star | 54.3 | 47.8 | 16.8 | 26.9 | -0.0630 |
| 11 | v_lines | 54.3 | 47.8 | 16.8 | 26.9 | -0.0694 |
| 12 | wide_lines | 54.3 | 47.8 | 16.8 | 26.9 | -0.0666 |
| 13 | x_shape | 54.3 | 47.8 | 16.8 | 26.9 | -0.0656 |

Simpson's Paradox



Simpson's Paradox

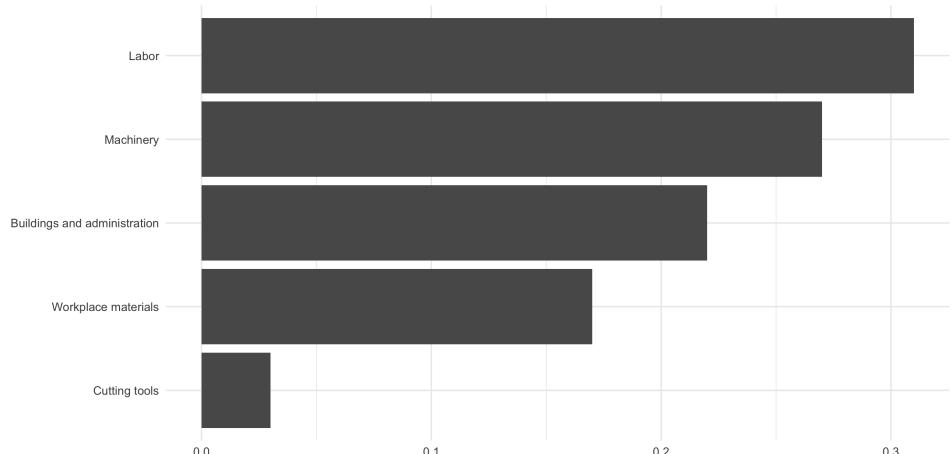
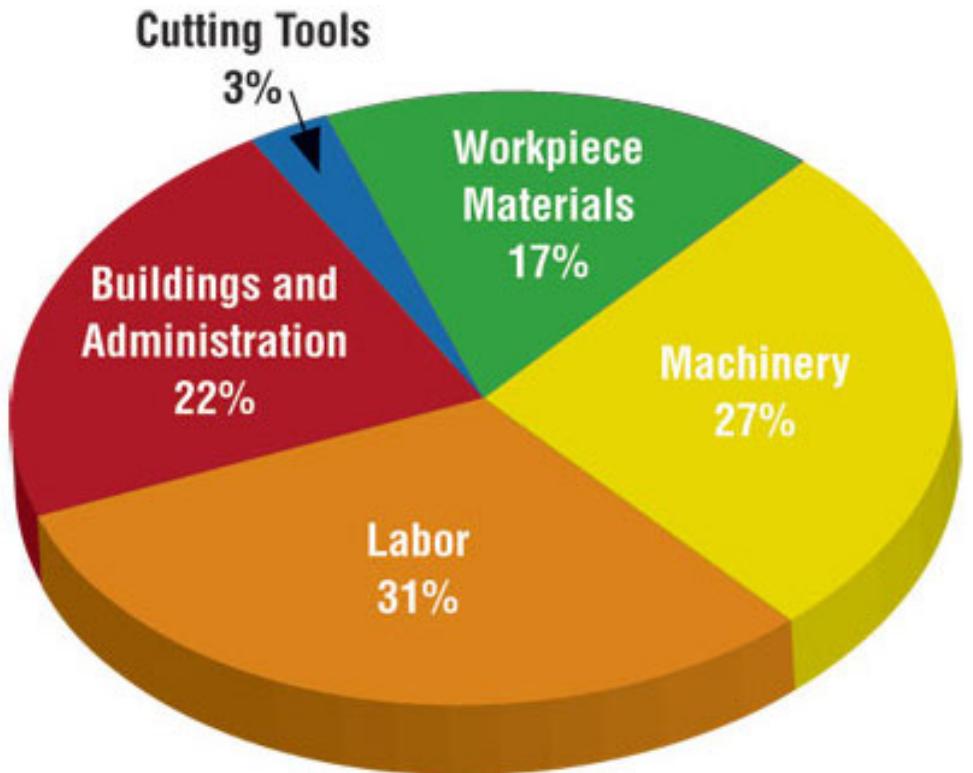


Designing effective visualizations

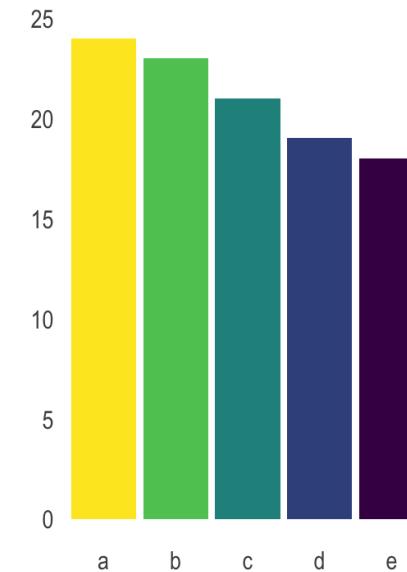
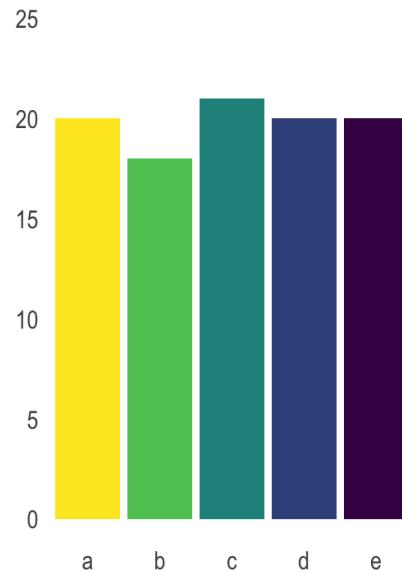
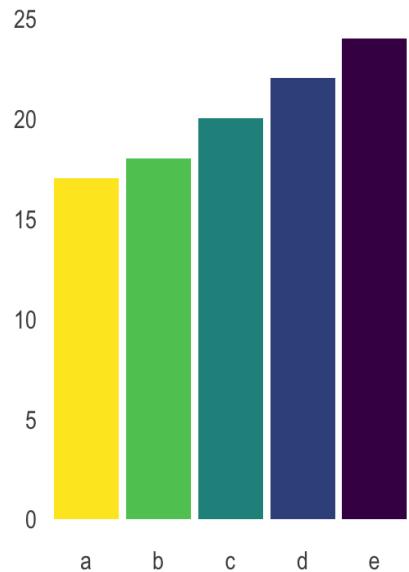
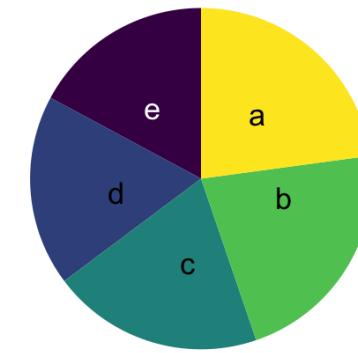
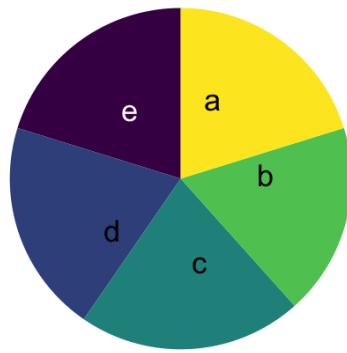
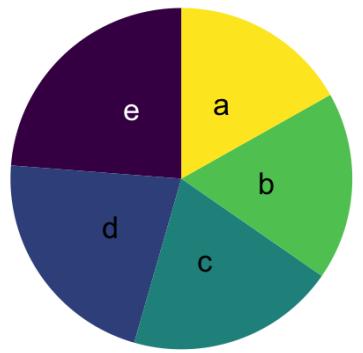
Gapminder

www.youtube.com/embed/OwII-dwh-bk

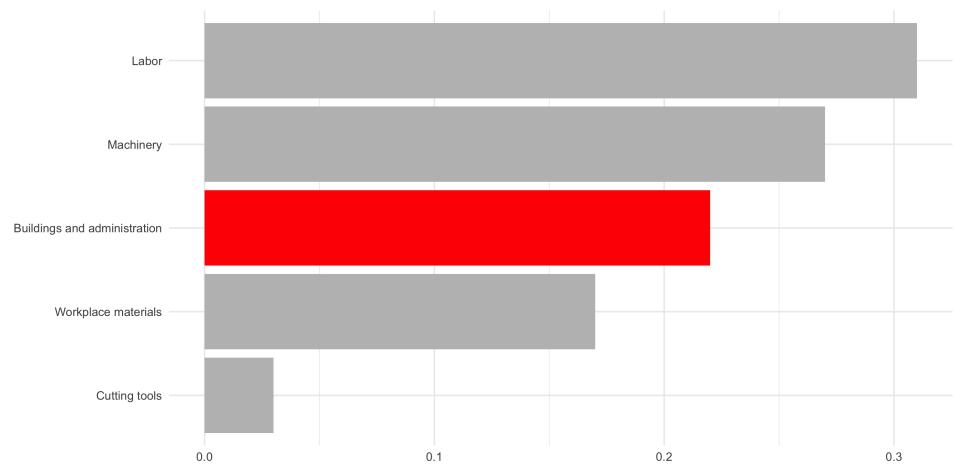
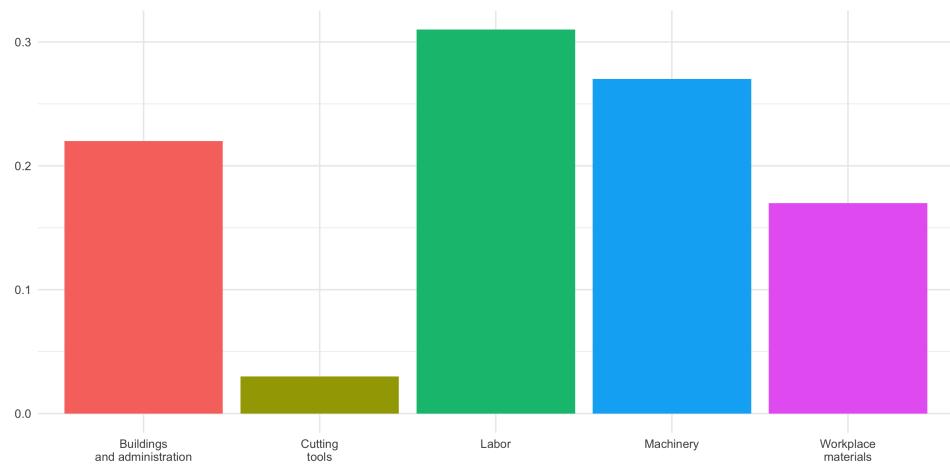
Keep it simple



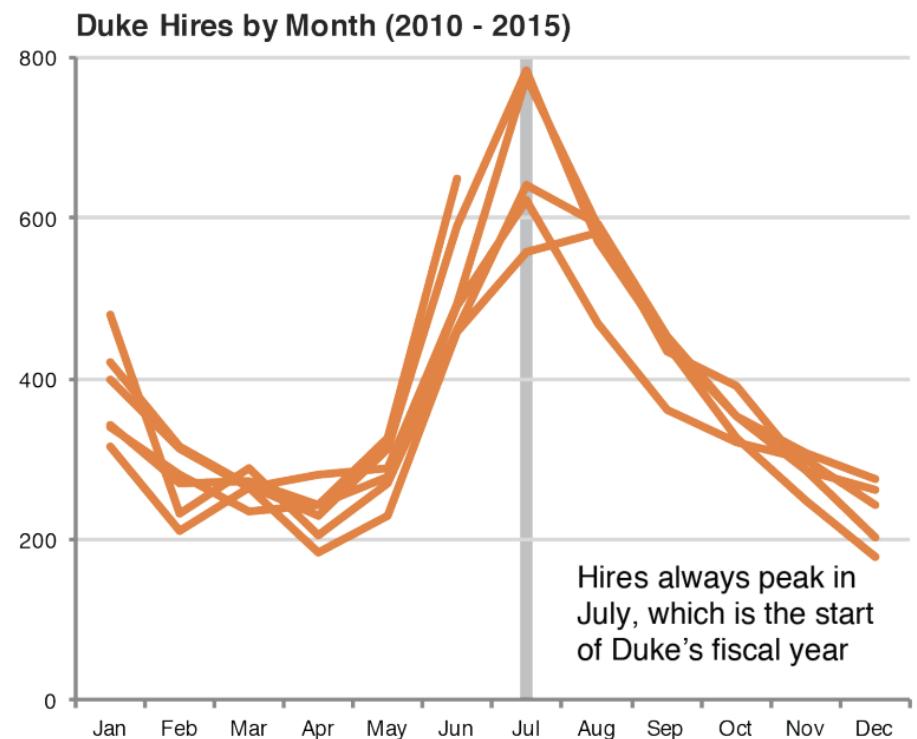
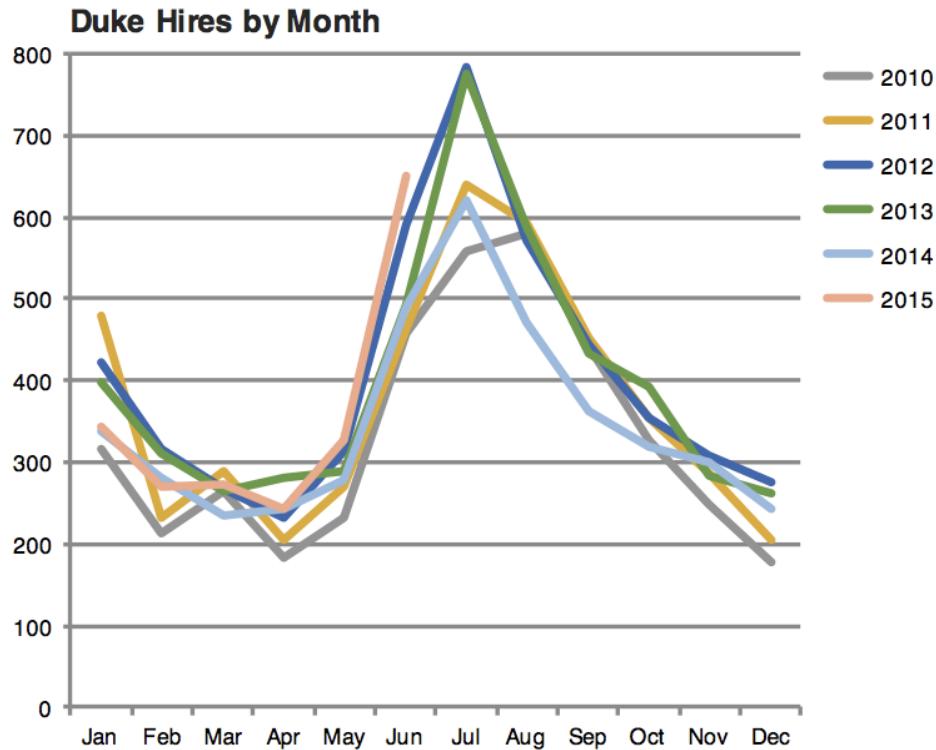
Judging relative area



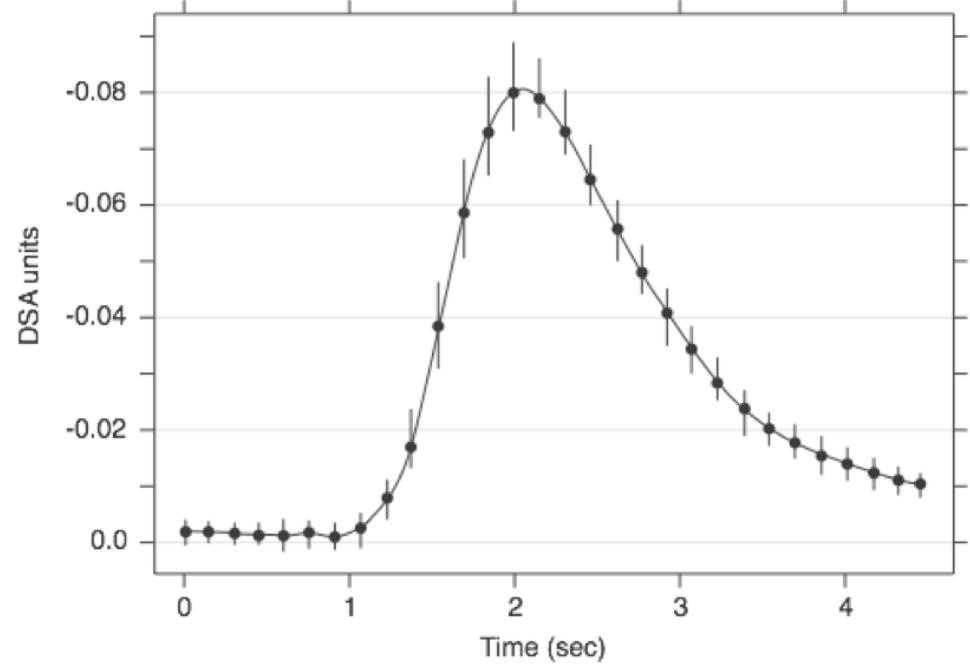
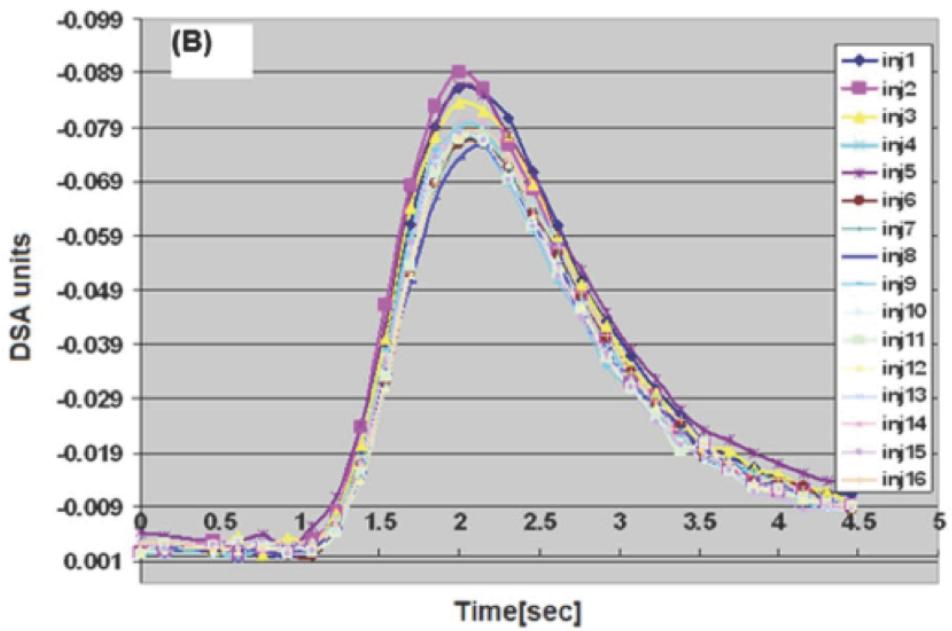
Use color to draw attention



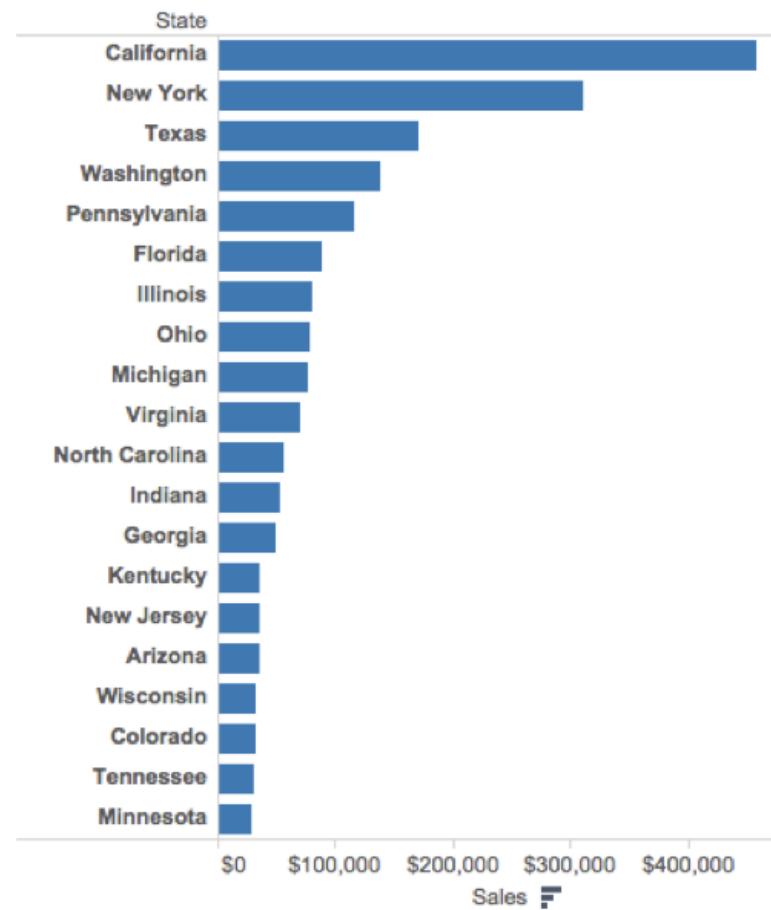
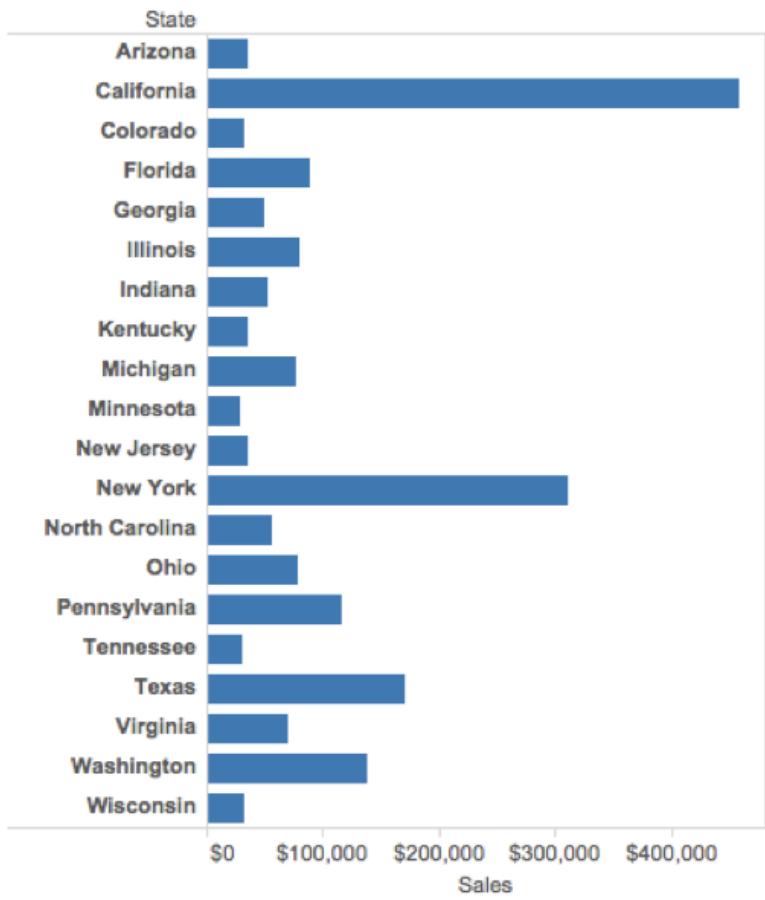
Tell a story



Leave out non-story details



Ordering matter



Clearly indicate missing data

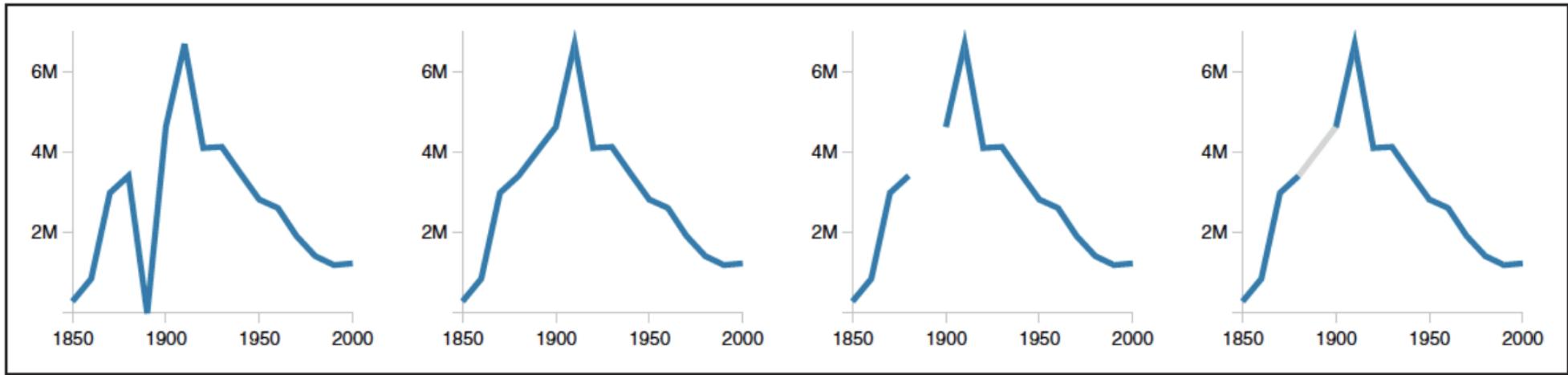
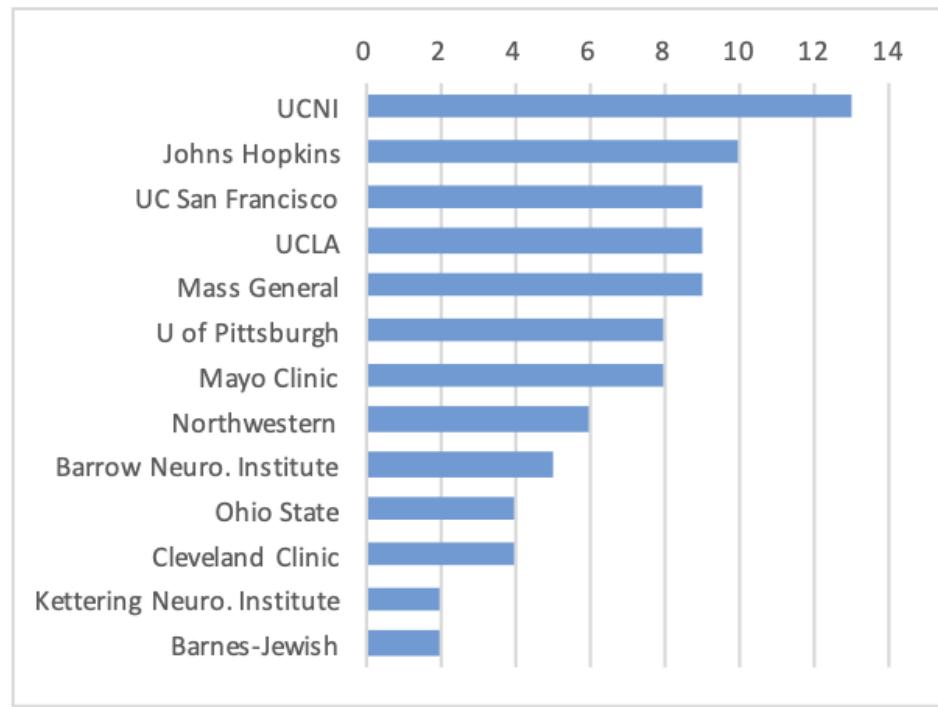
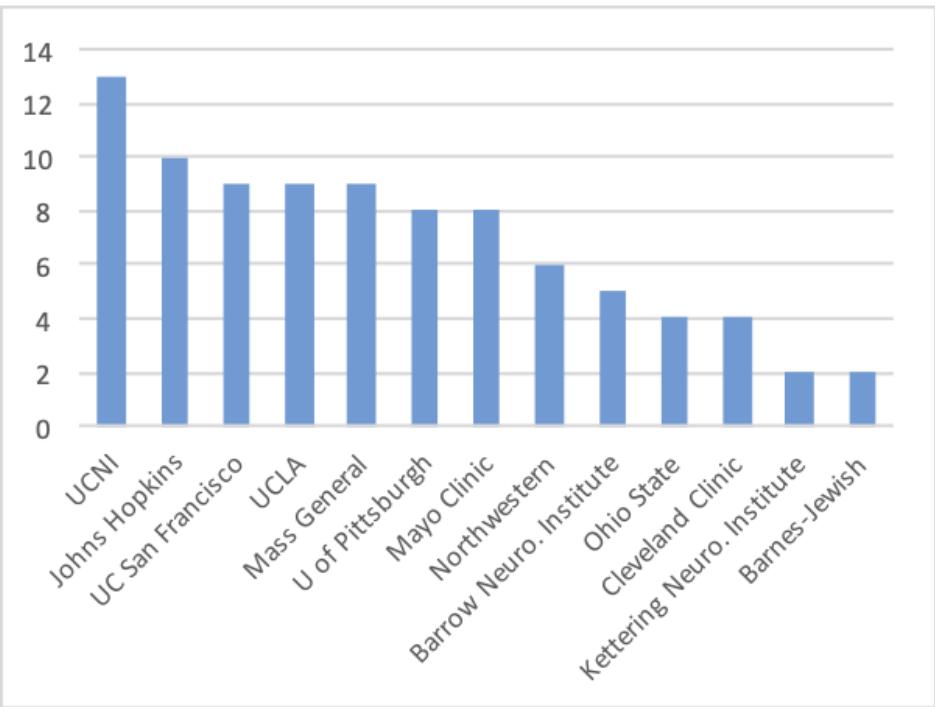


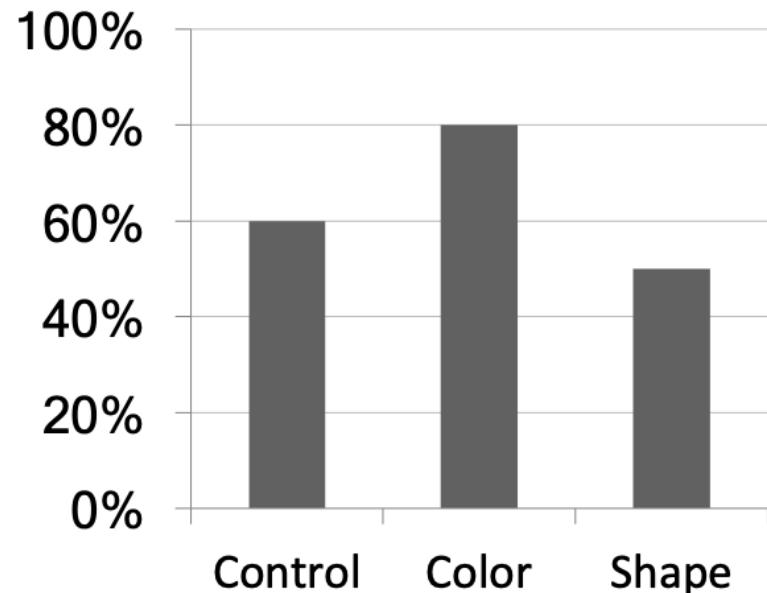
Figure 4. Alternative representations of missing data in a line chart. The data are U.S. census counts of people working as 'Farm Laborers'; values from 1890 are missing due to records being burned in a fire. (a) Missing data is treated as a zero value. (b) Missing data is ignored, resulting in a line segment that interpolates the missing value. (c) Missing data is omitted from the chart. (d) Missing data is explicitly interpolated and rendered in gray.

Reduce cognitive load

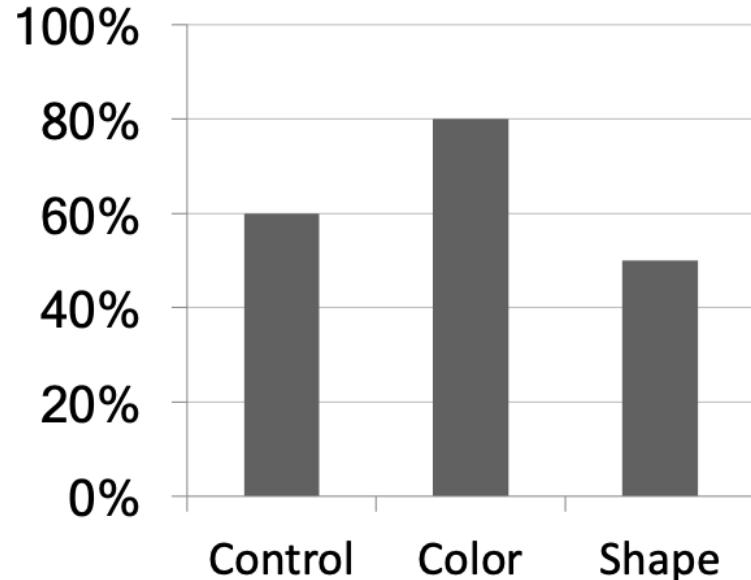


Use descriptive titles

**Accuracy versus
Color and Shape**



**Accuracy Improved by
Color, not Shape**

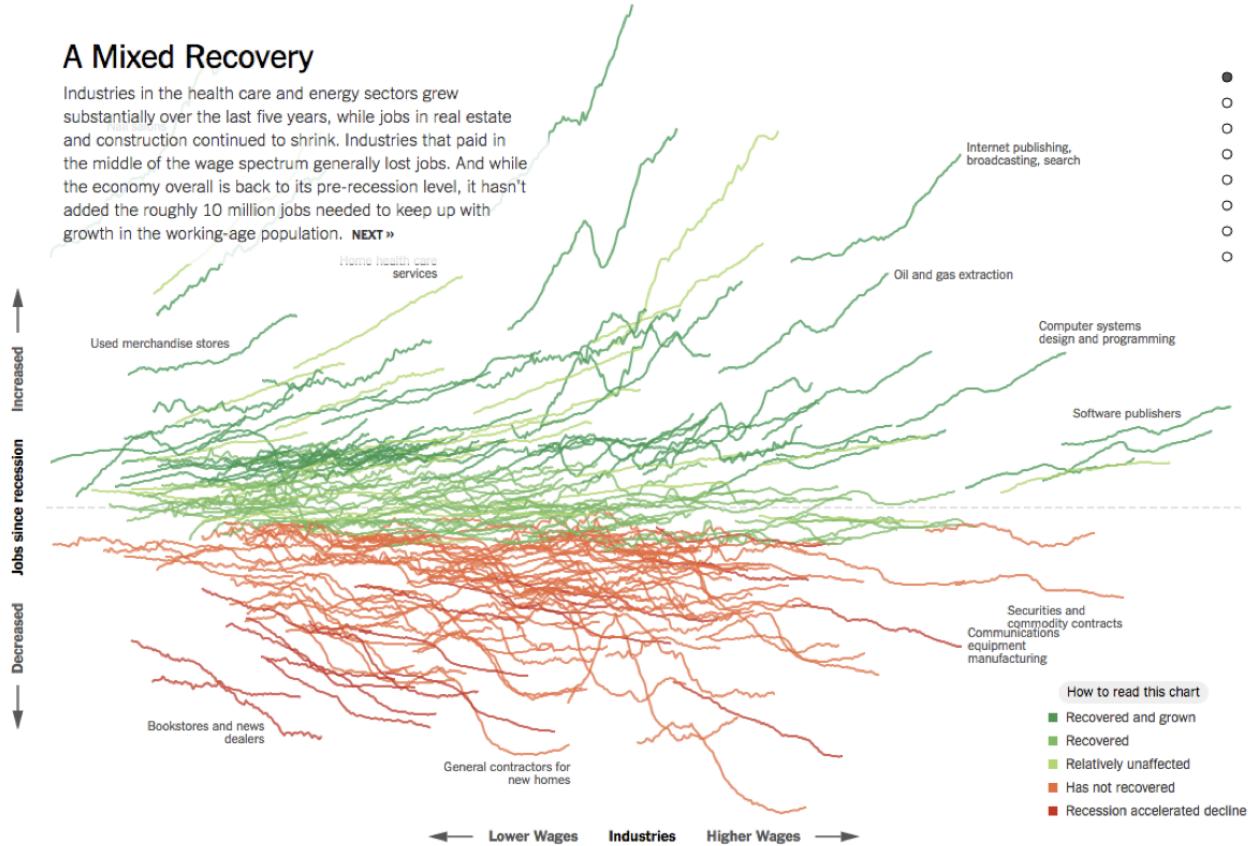


Annotate figures

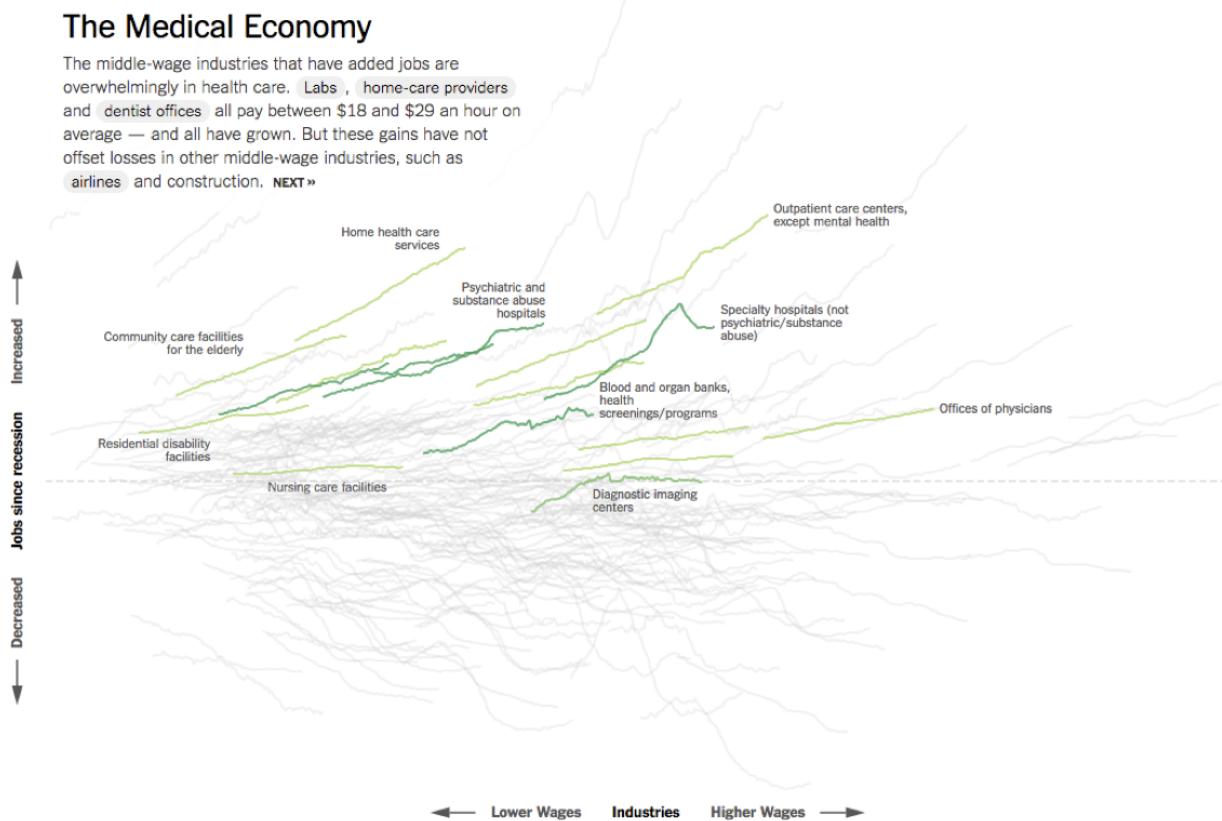
AAPL stock example



All of the data doesn't tell a story



All of the data doesn't tell a story



All of the data doesn't tell a story

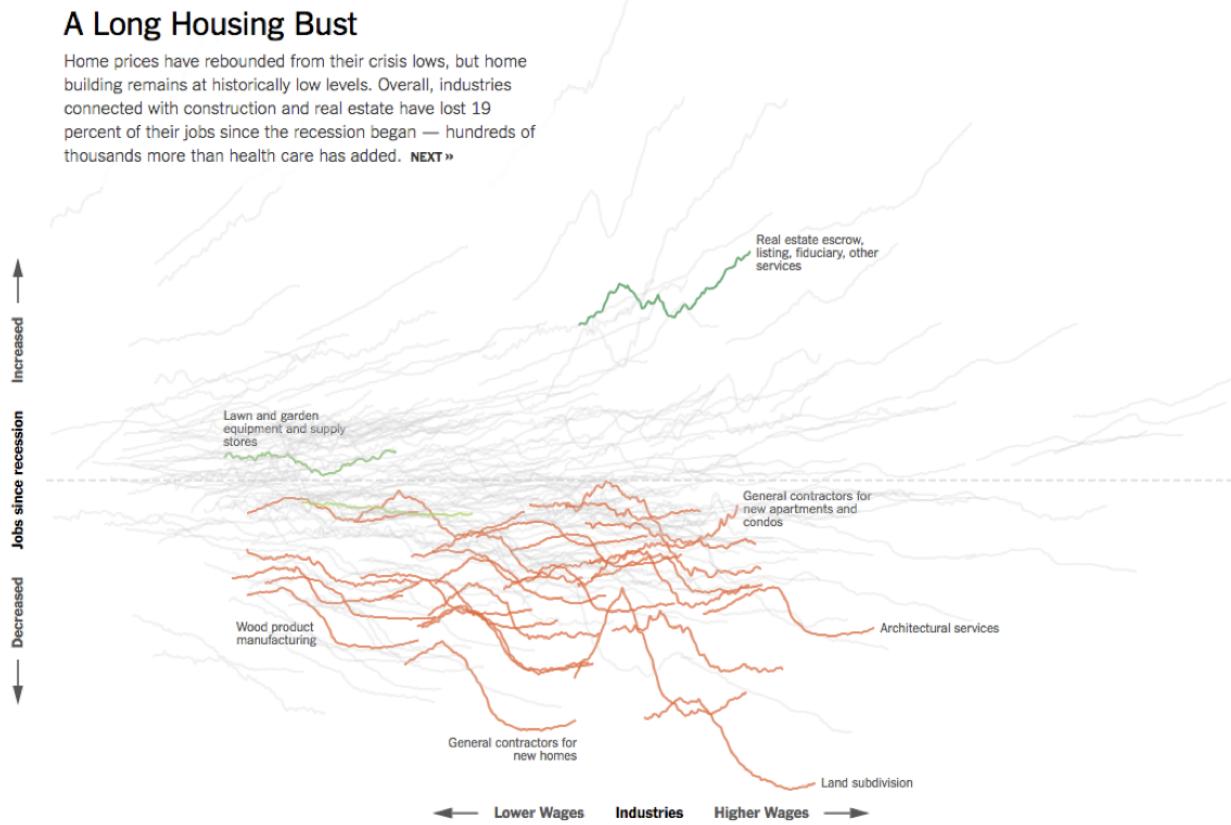
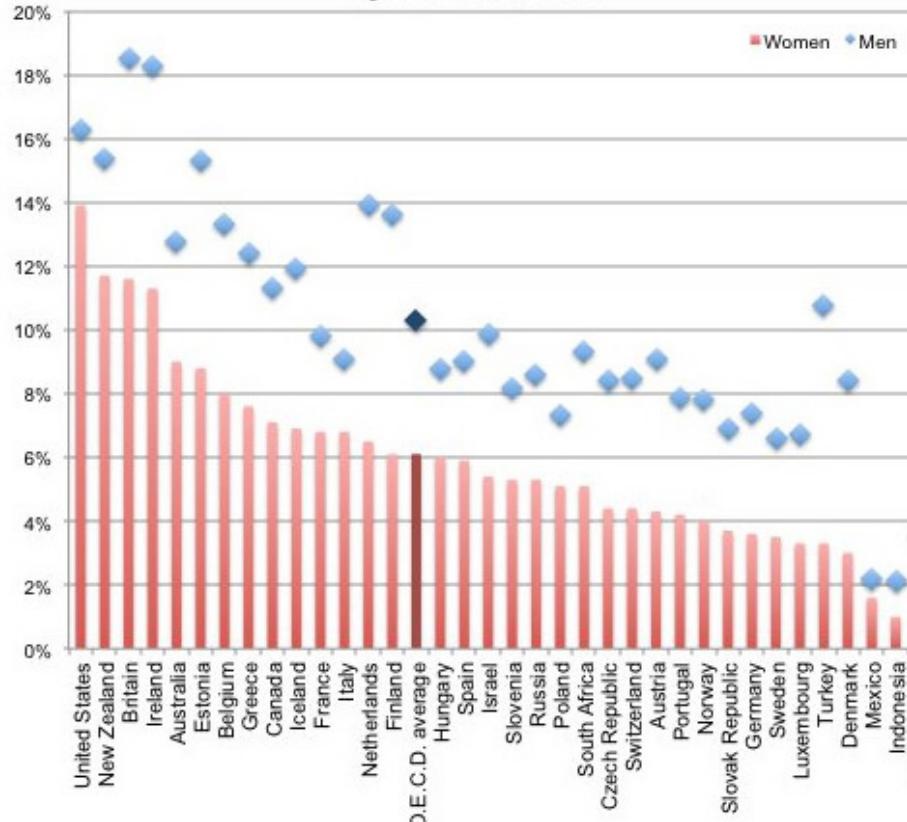


Chart Remakes / Makeovers

The Why Axis - Gender Gap

Percentage of Employed Who Are Senior Managers,
by Gender, 2008



The Why Axis - BLS

Job openings in November 2012

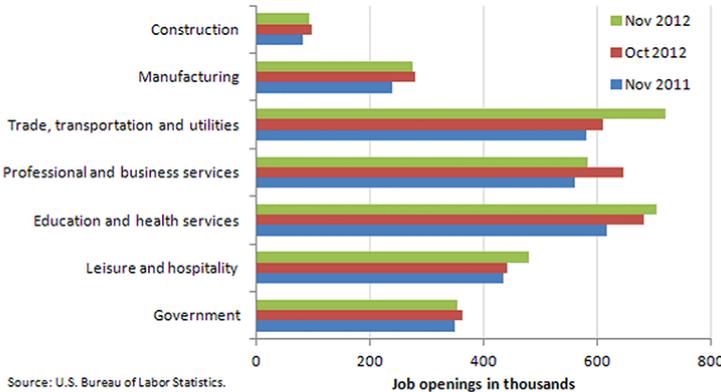
JANUARY 11, 2013

There were 3.7 million job openings on the last business day of November 2012, unchanged from October 2012. In November 2011 there were 3.3 million job openings.

CHART IMAGE

CHART DATA

Job openings by industry, November 2011, October 2012 and November 2012, seasonally adjusted



Source: U.S. Bureau of Labor Statistics.

Job openings in thousands

From November 2011 to November 2012, job openings increased most in retail trade (144,000, within the trade, transportation and utilities industry) and health care and social assistance (91,000, within the education and health services industry).

Government job openings increased the least, by 6,000.

These data are from the [Job Openings and Labor Turnover Survey](#). Data for the most recent month are preliminary and subject to revision. For additional information, see Job Openings and Labor Turnover — November 2012" ([HTML](#)) ([PDF](#)), news release USDL-13-0015. More charts featuring data on job openings, hires, and employment separations can be found in [Job Openings and Labor Turnover Survey Highlights: November 2012](#) ([PDF](#)).

Other Resources

- Duke Library - Center for Data and Visualization Sciences -
<https://library.duke.edu/data/>
- Tidy tuesday - <https://github.com/rfordatascience/tidytuesday>
- Flowing data - <https://flowingdata.com/>
- Twitter - #dataviz, #tidytuesday
- Books:
 - Wickham, Navarro, Pedersen. *ggplot2: Elegant Graphics for Data Analysis.* 3rd edition. Springer, 2021.
 - Wilke. *Fundamentals of Data Visualization.* O'Reilly Media, 2019.
 - Healy. *Data Visualization: A Practical Introduction.* Princeton University Press, 2018.
 - Tufte. *The visual display of quantitative information.* 2nd edition. Connecticut Graphics Press, 2015.

Acknowledgments

Above materials are derived in part from the following sources:

- Visualization training materials developed by Angela Zoss and Eric Monson, Duke DVS

