

Lec 10 - ggplot2 ecosystem & designing visualizations

Statistical Programming

Fall 2021

Dr. Colin Rundel

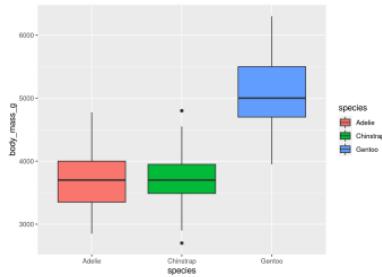
The ggplot2 ecosystem

ggthemes

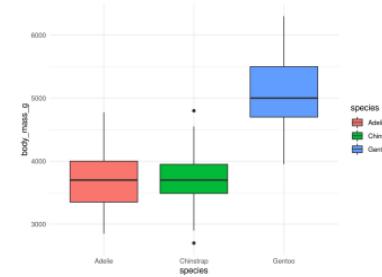
ggplot2 themes

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

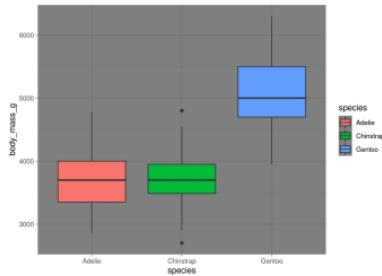
g



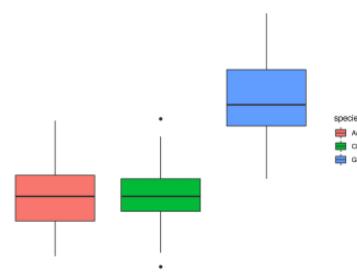
```
g + theme_minimal()
```



```
g + theme_dark()
```

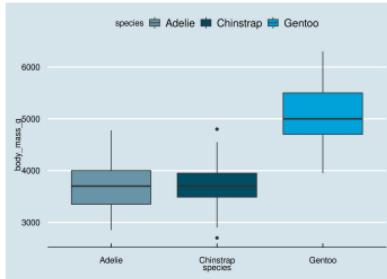


```
g + theme_void()
```

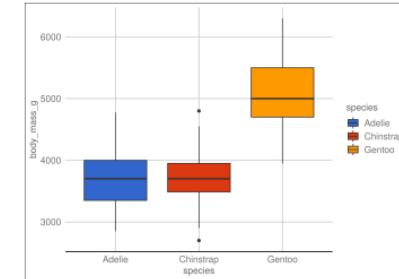


ggthemes

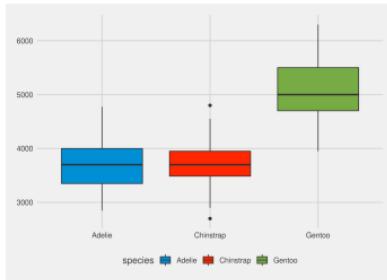
```
g + ggthemes::theme_economist() +  
ggthemes::scale_fill_economist()
```



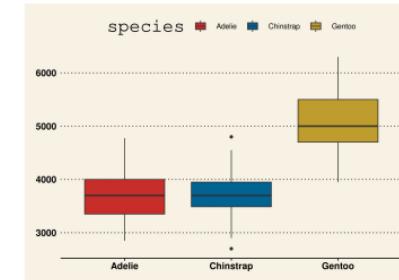
```
g + ggthemes::theme_gdocs() +  
ggthemes::scale_fill_gdocs()
```



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

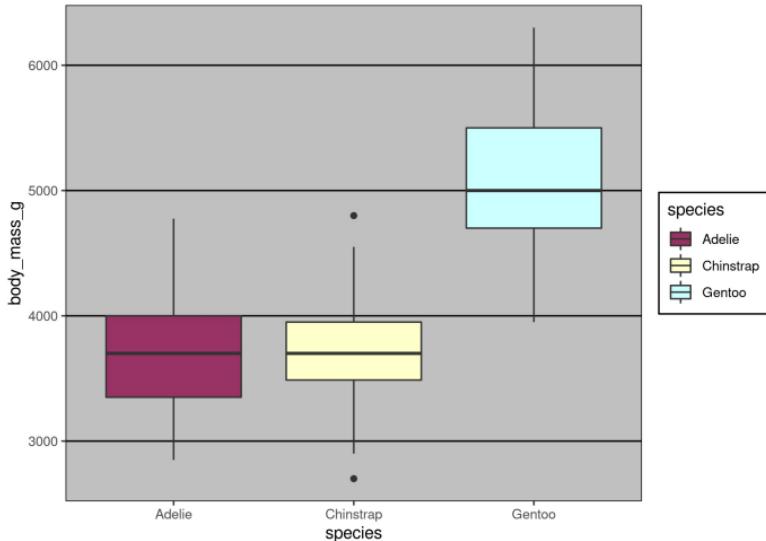


```
g + ggthemes::theme_wsj() +  
ggthemes::scale_fill_wsj()
```

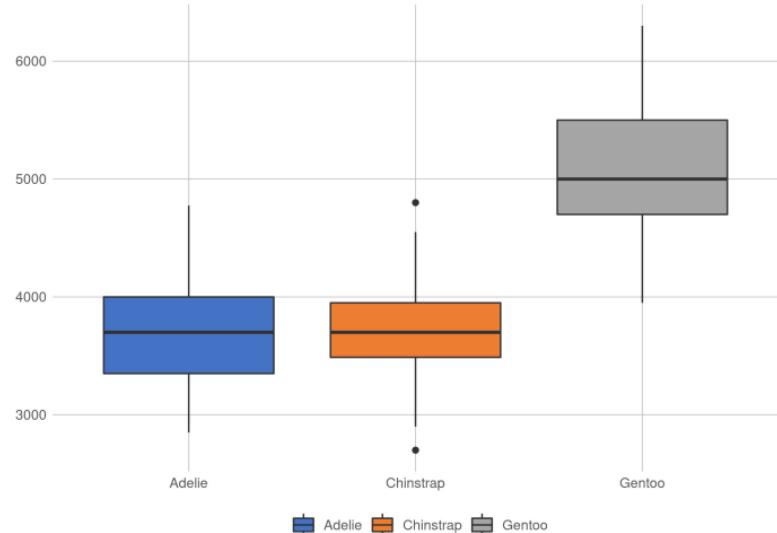


And for those who miss Excel

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

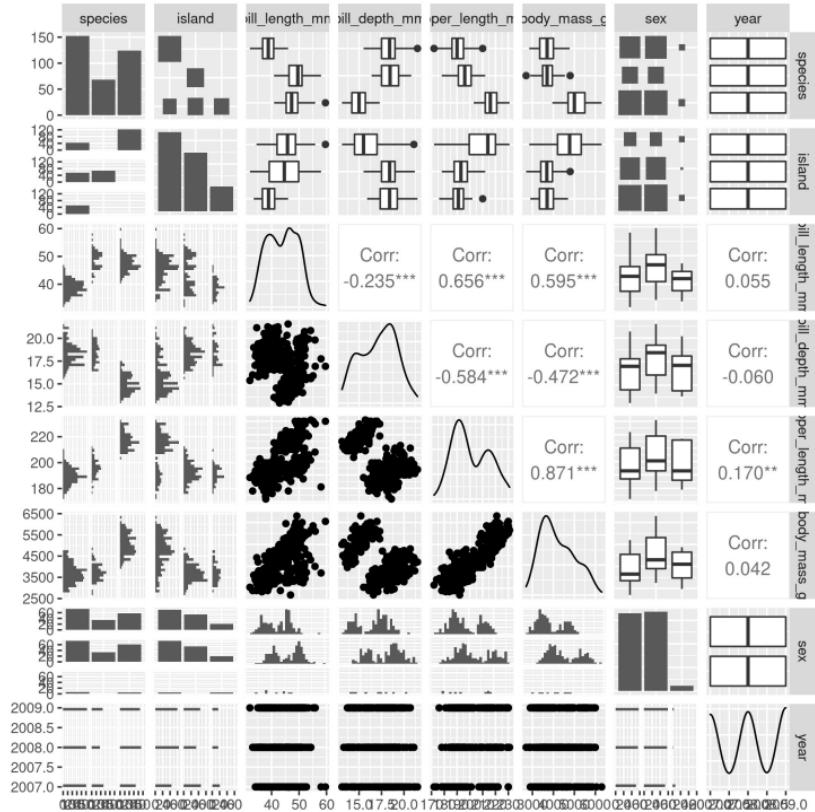


```
g + ggthemes::theme_excel_new() +  
ggthemes::scale_fill_excel_new()
```



GGally

```
GGally::ggpairs(palmerpenguins::penguins)
```



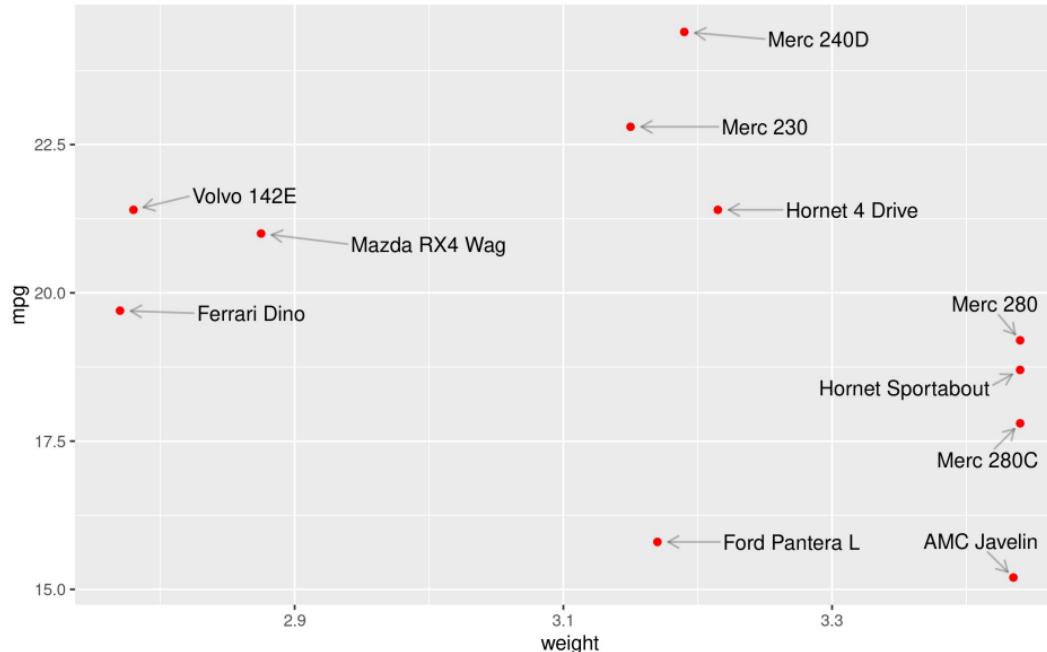


```
d = tibble(  
  car = rownames(mtcars),  
  weight = mtcars$wt,  
  mpg = mtcars$mpg  
) %>%  
  filter(weight > 2.75, weight < 3.45)
```

```
ggplot(d, aes(x=weight, y=mpg)) +  
  geom_point(color="red") +  
  geom_text(  
    aes(label = car)  
)
```

```
ggplot(d, aes(x=weight, y=mpg)) +  
  geom_point(color="red") +  
  ggrepel::geom_text_repel(  
    aes(label = car)  
)
```

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





Plot objects

```
library(patchwork)

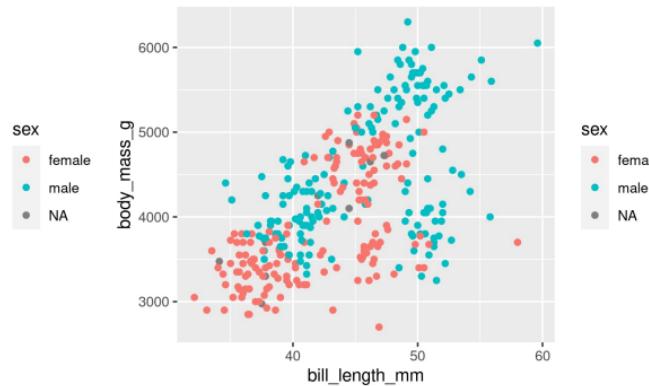
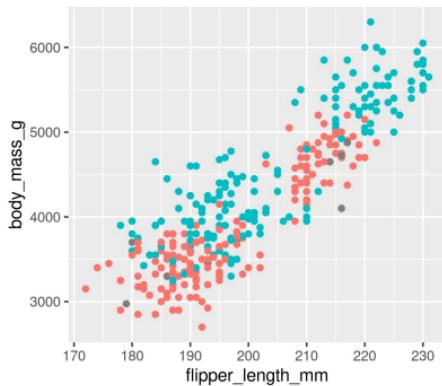
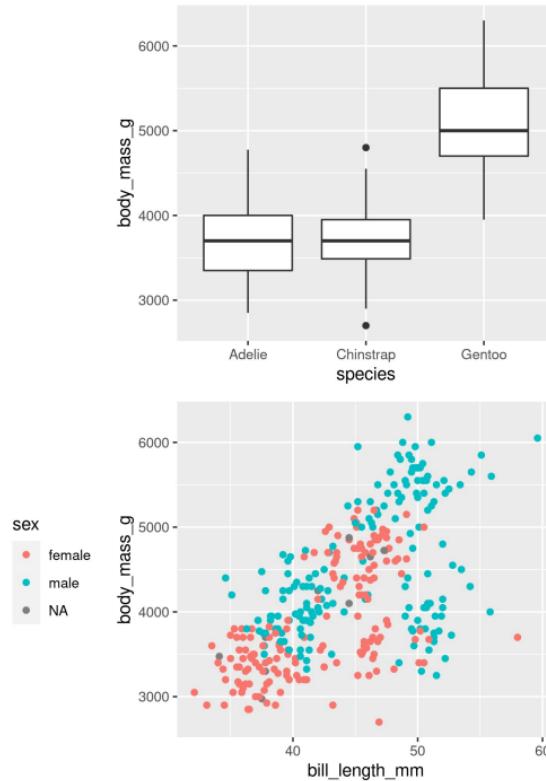
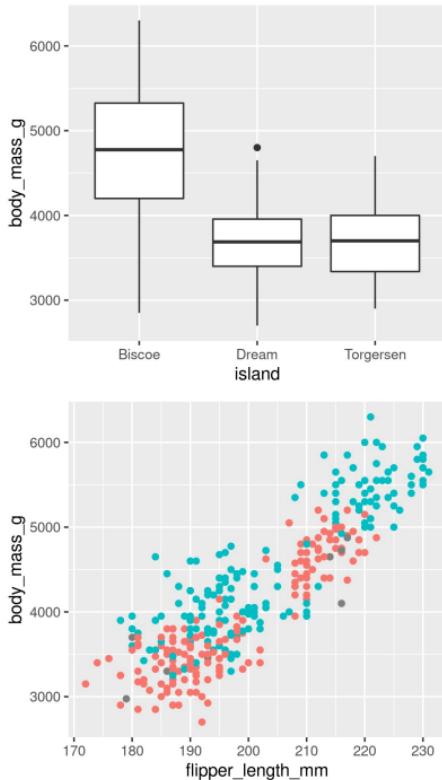
p1 = ggplot(palmerpenguins::penguins) +
  geom_boxplot(aes(x = island, y = body_mass_g))

p2 = ggplot(palmerpenguins::penguins) +
  geom_boxplot(aes(x = species, y = body_mass_g))

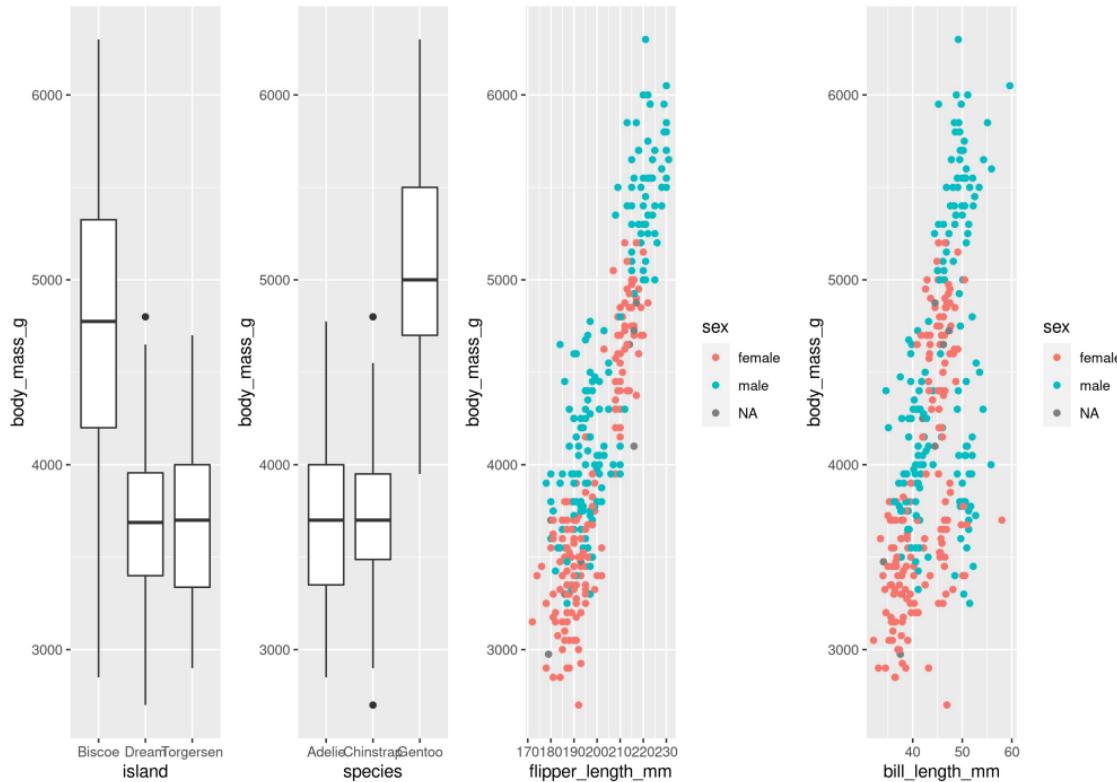
p3 = ggplot(palmerpenguins::penguins) +
  geom_point(aes(x = flipper_length_mm, y = body_mass_g, color = sex))

p4 = ggplot(palmerpenguins::penguins) +
  geom_point(aes(x = bill_length_mm, y = body_mass_g, color = sex))
```

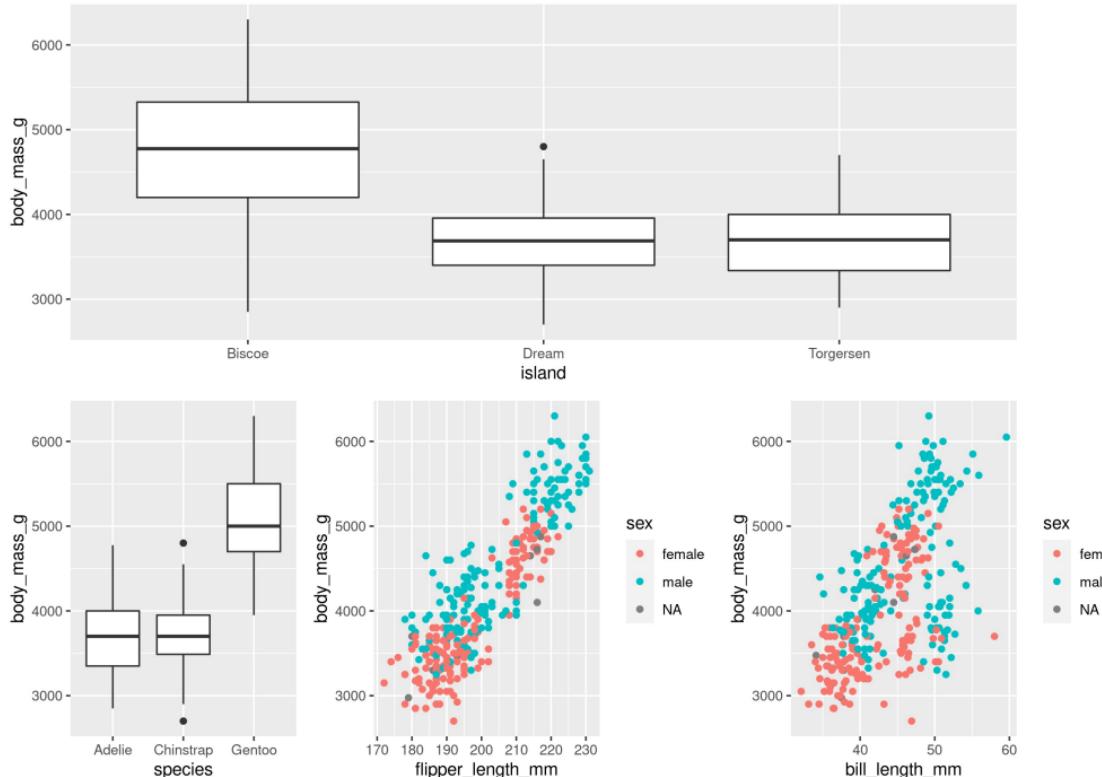
p1 + p2 + p3 + p4



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



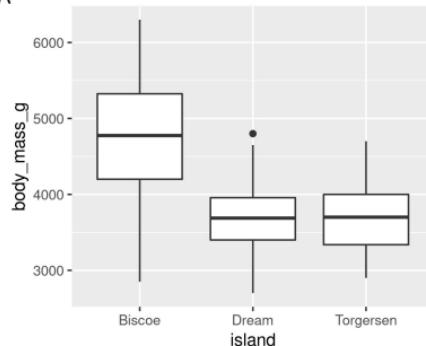
$$p1 / (p2 + p3 + p4)$$



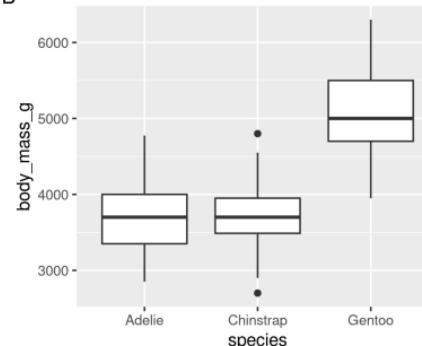
```
p1 + p2 + p3 + p4 +  
plot_annotation(title = "Palmer Penguins", tag_levels = c("A"))
```

Palmer Penguins

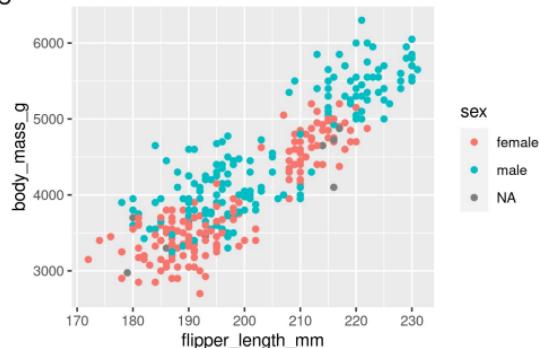
A



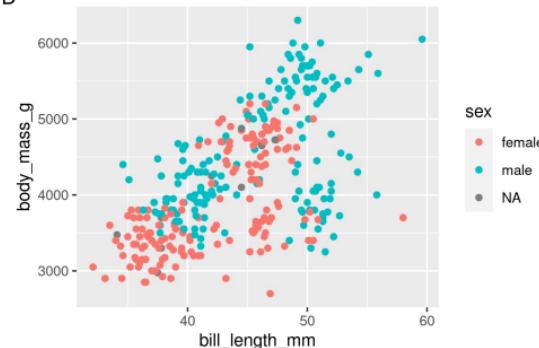
B



C



D



```
p1 + {  
  p2 + {  
    p3 + p4 + plot_layout(ncol = 1) + plot_layout(tag_level = 'new')  
  }  
} +  
plot_layout(ncol = 1) +  
plot_annotation(tag_levels = c("1", "a"), tag_prefix = "Fig ")
```



```

airq = airquality
airq$Month = month.name[airq$Month]

ggplot(
  airq,
  aes(Day, Temp, group = Month)
) +
  geom_line() +
  geom_segment(
    aes(xend = 31, yend = Temp),
    linetype = 2,
    colour = 'grey'
  ) +
  geom_point(size = 2) +
  geom_text(
    aes(x = 31.1, label = Month),
    hjust = 0
  ) +
  gganimate::transition_reveal(Day) +
  coord_cartesian(clip = 'off') +
  labs(
    title = 'Temperature in New York',
    y = 'Temperature (°F)'
  ) +
  theme_minimal() +
  theme(plot.margin = margin(5.5, 40, 5.5, 5.5))
https://github.com/thomasp85/gganimate

```



More ggplot2 extensions

<https://exts.ggplot2.tidyverse.org/gallery/>

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

101 registered extensions available to explore

Sort Text Filter Author Filter Tag Filter CRAN Only

Github stars ▼ search name, autho ▼

Showing 86 of 101

patchwork 1932

Easy composition of ggplot plots using arithmetic operators

- author: thomasp85
- tags: visualization, composition
- js libraries:

ggridge 1709

A Grammar of Animated Graphics.

- author: thomasp85
- tags: visualization, general
- js libraries:

ggstatsplot 1283

'ggstatsplot' provides a collection of functions to enhance 'ggplot2' plots with results from statistical tests.

- author: IndrajeetPatil
- tags: visualization, statistics
- js libraries:

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Why do we visualize?

Anscombe's Quartet

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

```
## # A tibble: 11 × 8
##       x1     x2     x3     x4     y1     y2     y3     y4
##   <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <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     8  4.82  7.26  6.42  7.91
## 11     5      5      5     8  5.68  4.74  5.73  6.89
```

Tidy anscombe

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

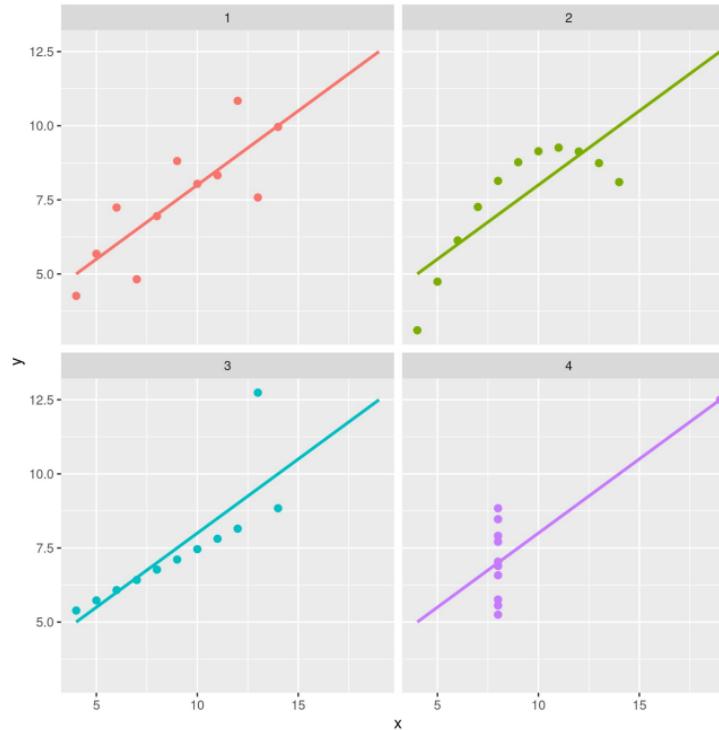


```
## # A tibble: 44 × 3
##       group     x     y
##   <chr> <dbl> <dbl>
## 1 1         10  8.04
## 2 1          8  6.95
## 3 1         13  7.58
## 4 1          9  8.81
## 5 1         11  8.33
## 6 1         14  9.96
## 7 1          6  7.24
## 8 1          4  4.26
## 9 1         12 10.8
## 10 1         7  4.82
## # ... with 34 more rows
```

```
tidy_anscombe %>%
  group_by(group) %>%
  summarize(
    mean_x = mean(x), mean_y = mean(y),
    sd_x = sd(x), sd_y = sd(y),
    cor = cor(x,y), .groups = "drop"
  )

## # 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
```

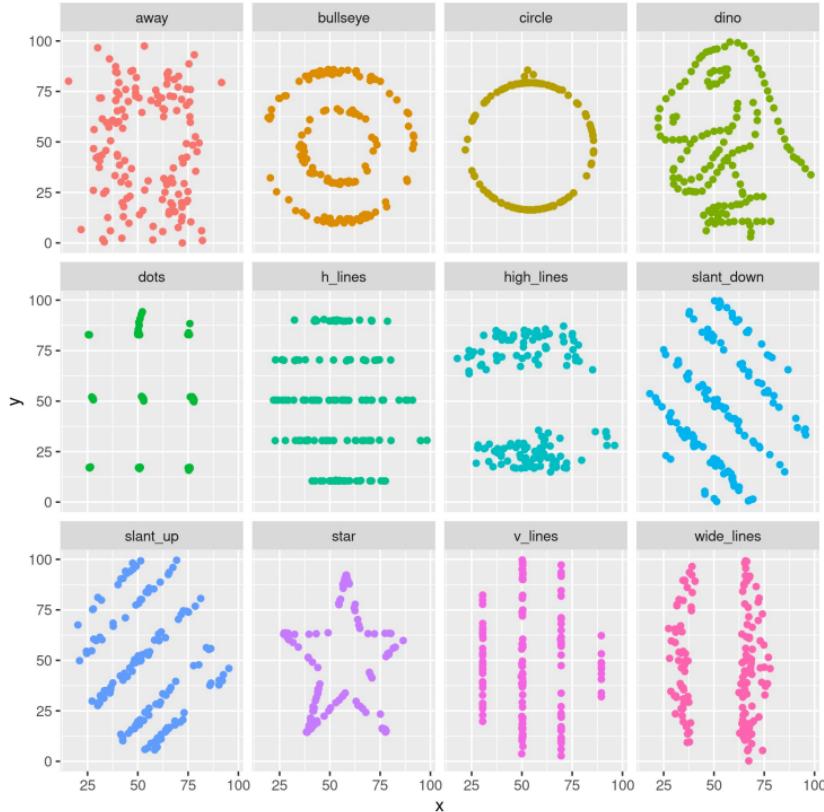
```
ggplot(tidy_anscombe, aes(x = x, y = y, color = as.factor(group))) +  
  geom_point(size=2) +  
  facet_wrap(~group) +  
  geom_smooth(method="lm", se=FALSE, fullrange=TRUE, formula = y~x) +  
  guides(color="none")
```

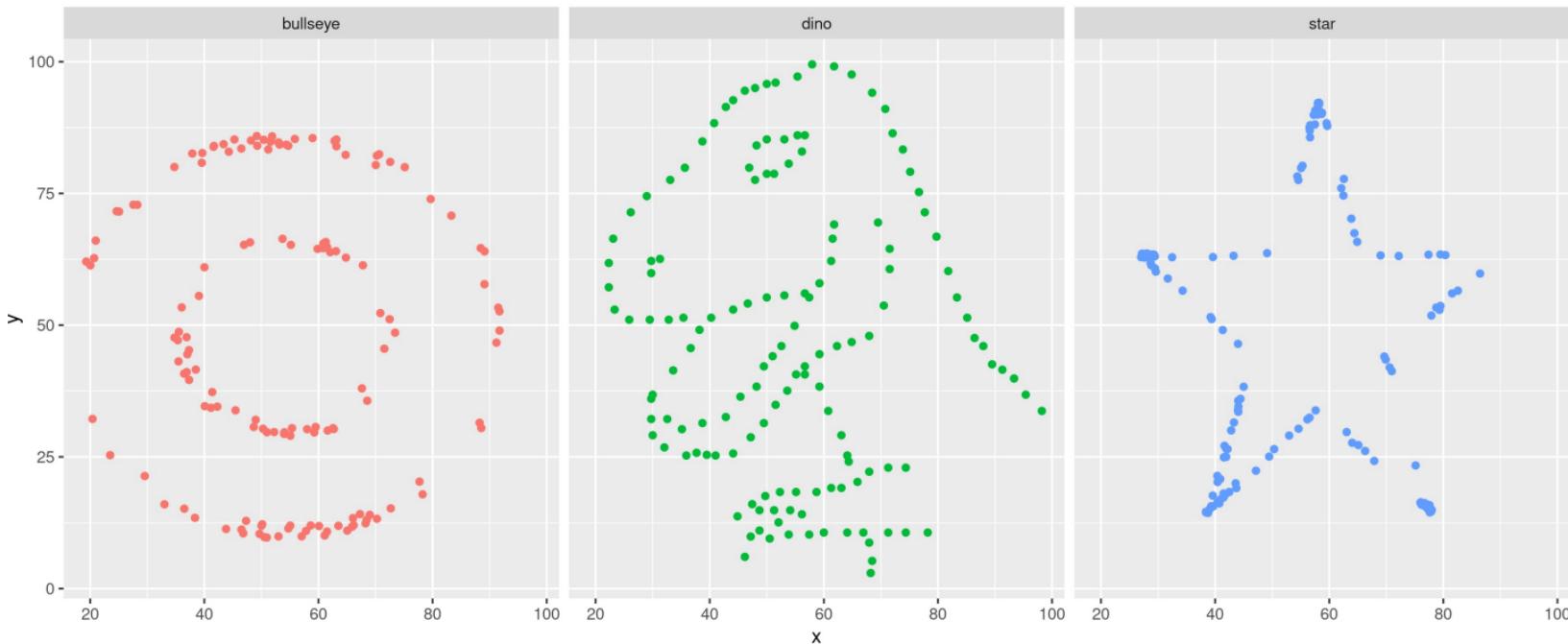


DatasauRus

```
library(datasauRus)

ggplot(
  datasaurus_dozen,
  aes(
    x = x, y = y,
    color = dataset
  )
) +
  geom_point() +
  facet_wrap(~dataset) +
  guides(color="none")
```





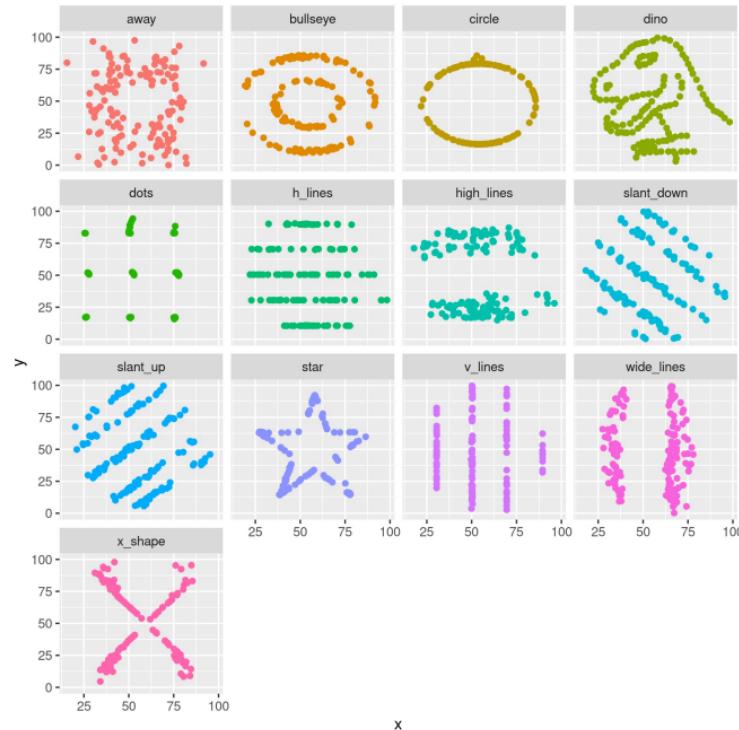
```
datasauRus::datasaurus_dozen
```

```
## # 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
## # ... with 1,836 more rows
```

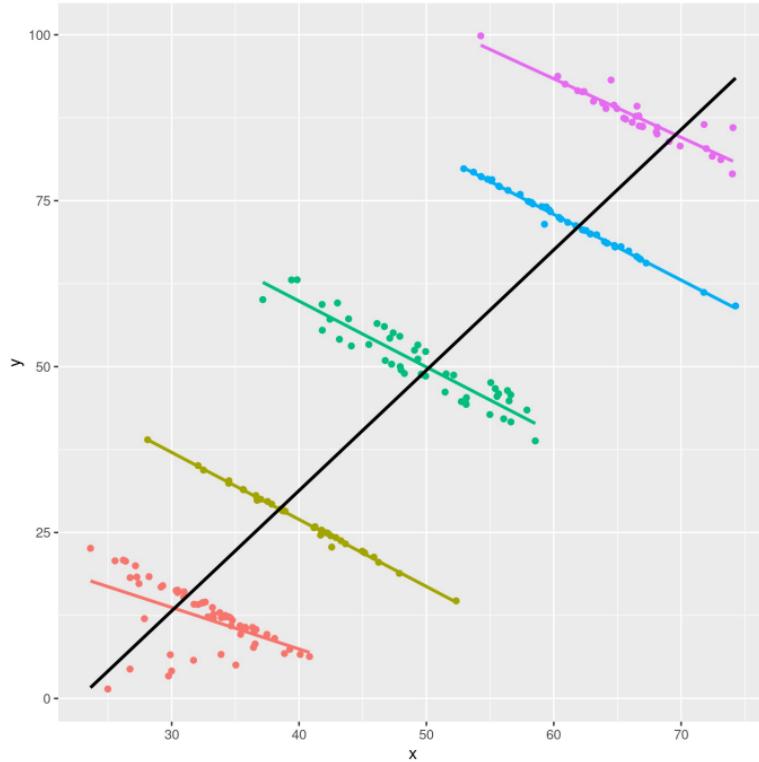
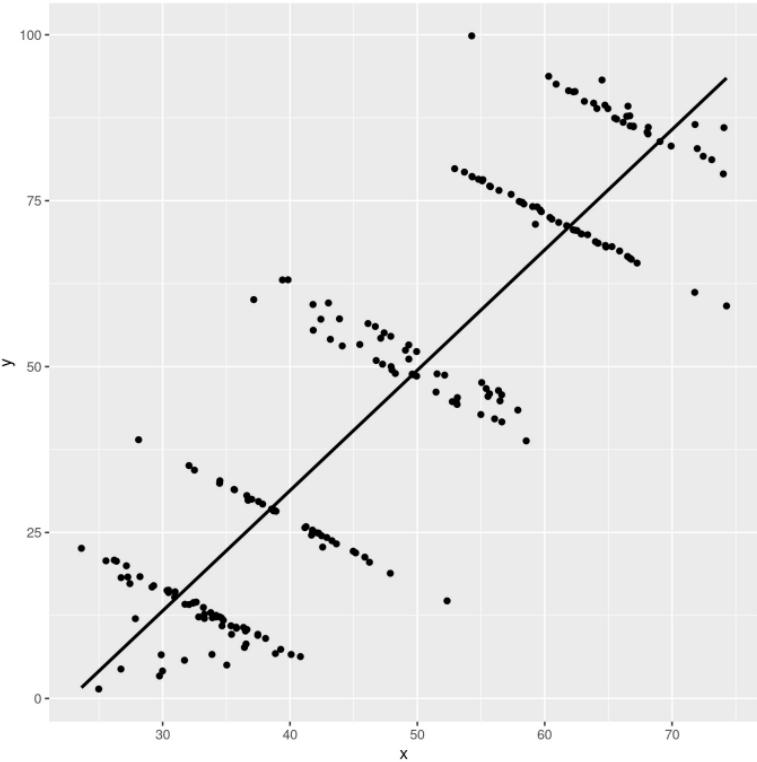
```
datasaurus_dozen %>%
  group_by(dataset) %>%
  summarize(mean_x = mean(x), mean_y = mean(y),
            sd_x = sd(x), sd_y = sd(y),
            cor = cor(x,y), .groups = "drop")
```

```
## # A tibble: 12 × 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
```

```
ggplot(datasauRus::datasaurus_dozen, aes(x = x, y = y, color = dataset)) +  
  geom_point() +  
  facet_wrap(~dataset) +  
  guides(color="none")
```



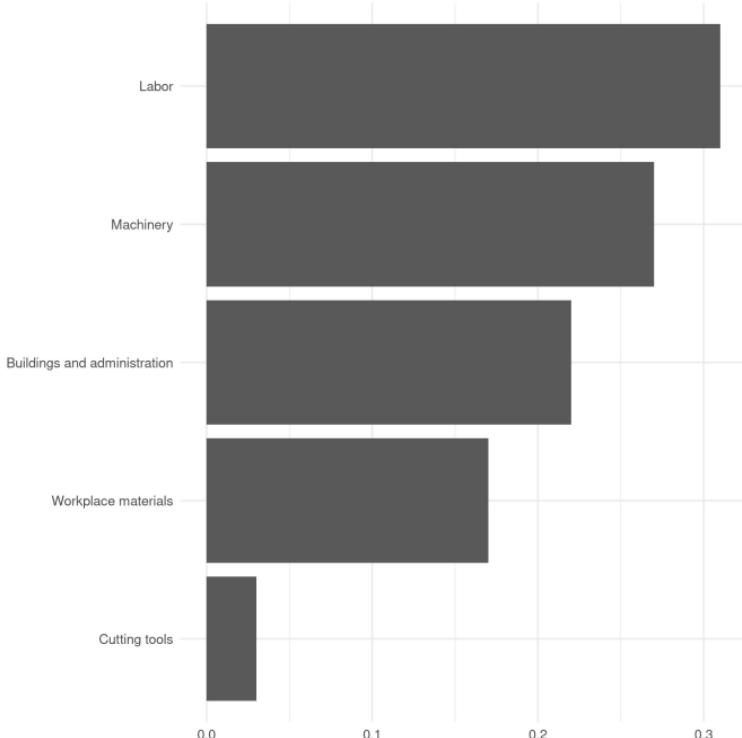
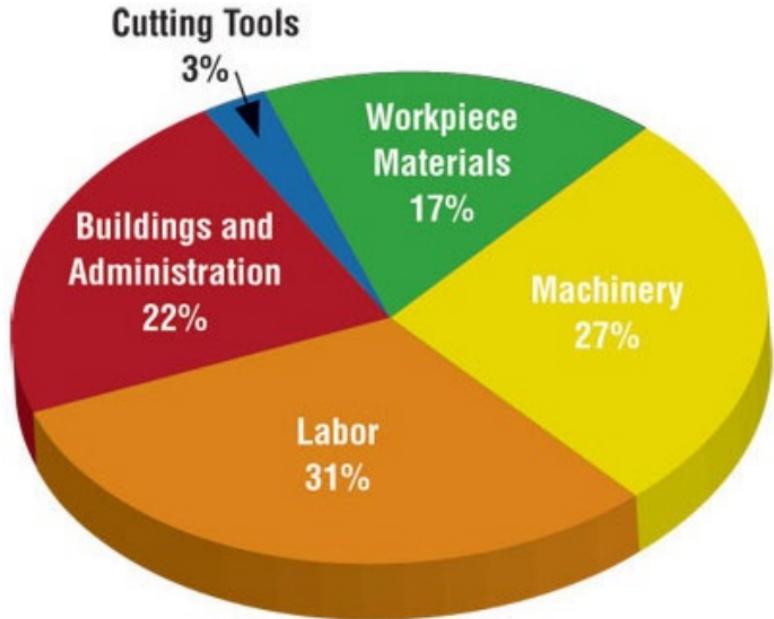
Simpson's Paradox



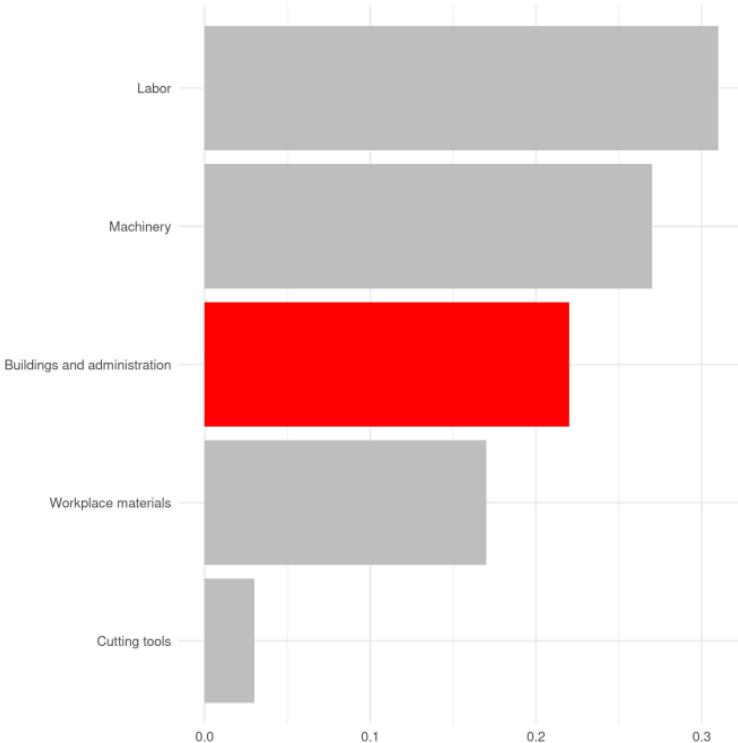
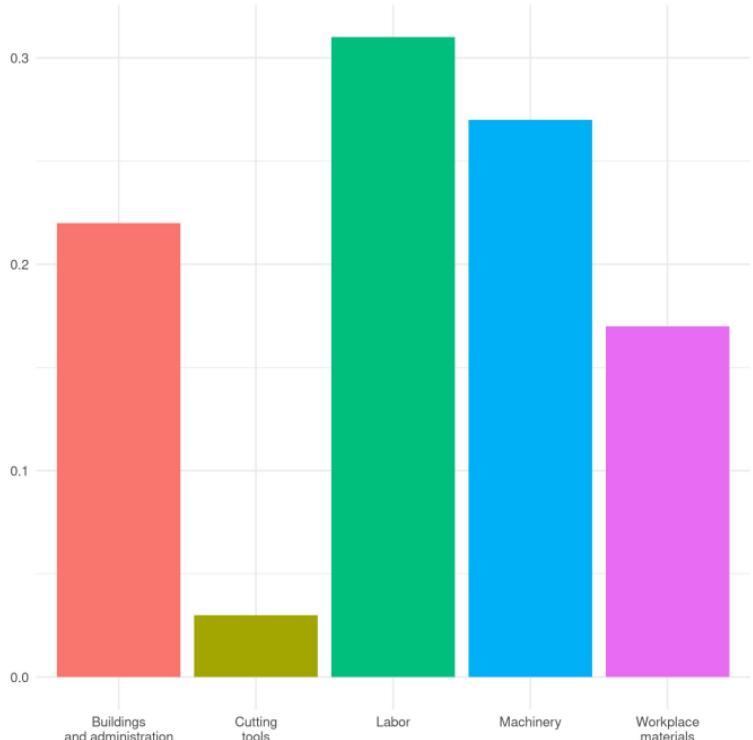
Designing effective visualizations

Gapminder

Keep it simple



Use color to draw attention



Tell a story



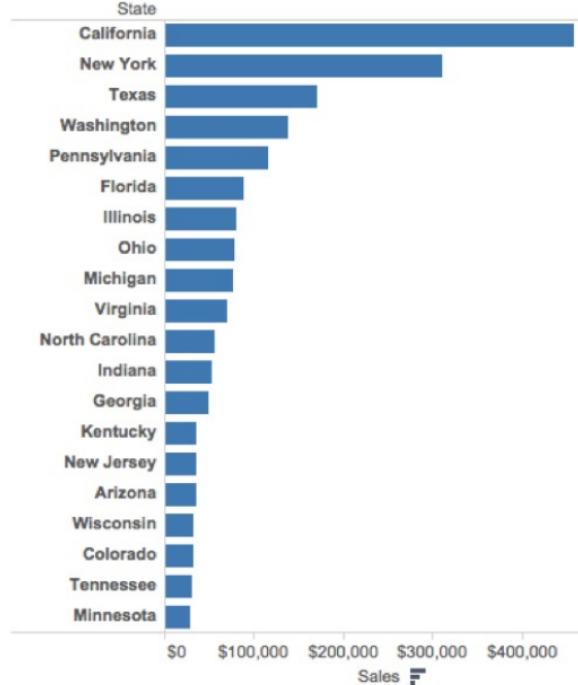
Credit: Angela Zoss and Eric Monson, Duke DVS

Leave out non-story details



Credit: Angela Zoss and Eric Monson, Duke DVS

Ordering matter



Credit: Angela Zoss and Eric Monson, Duke DVS

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



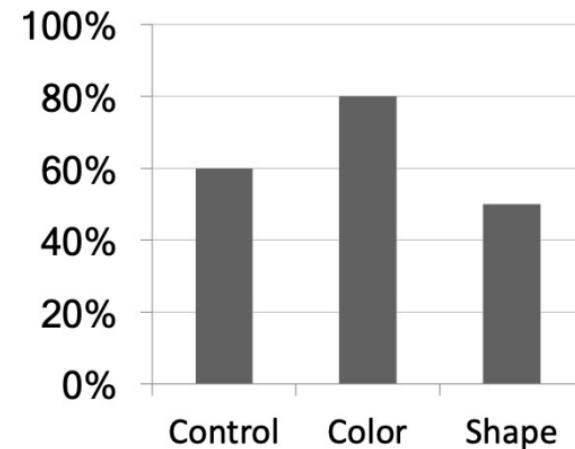
<http://www.storytellingwithdata.com/2012/09/some-finer-points-of-data-visualization.html>

Use descriptive titles

**Accuracy versus
Color and Shape**



**Accuracy Improved by
Color, not Shape**



Credit: Angela Zoss and Eric Monson, Duke DVS

Annotate figures directly

AAPL stock example



All of the data doesn't tell a story

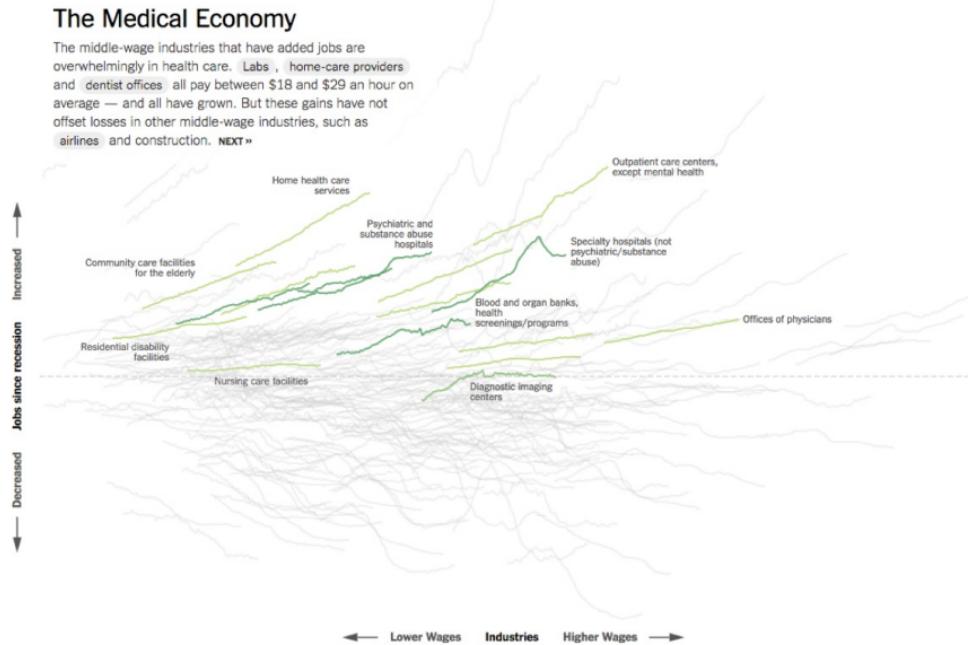


<http://www.nytimes.com/interactive/2014/06/05/upshot/how-the-recession-reshaped-the-economy-in-255-charts.html>

All of the data doesn't tell a story

The Medical Economy

The middle-wage industries that have added jobs are overwhelmingly in health care. Labs, home-care providers and dentist offices all pay between \$18 and \$29 an hour on average — and all have grown. But these gains have not offset losses in other middle-wage industries, such as airlines and construction. [NEXT »](#)



<http://www.nytimes.com/interactive/2014/06/05/upshot/how-the-recession-reshaped-the-economy-in-255-charts.html>

All of the data doesn't tell a story

A Long Housing Bust

Home prices have rebounded from their crisis lows, but home building remains at historically low levels. Overall, industries connected with construction and real estate have lost 19 percent of their jobs since the recession began — hundreds of thousands more than health care has added. [NEXT »](#)



<http://www.nytimes.com/interactive/2014/06/05/upshot/how-the-recession-reshaped-the-economy-in-255-charts.html>

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

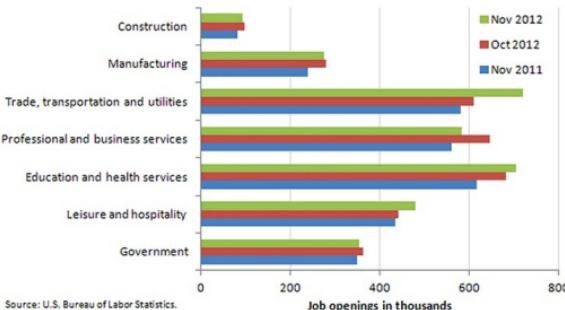
JANUARY 11, 2013

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.* (in progress) 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