Behavioural Security Group

UNIVERSITÄT BONN

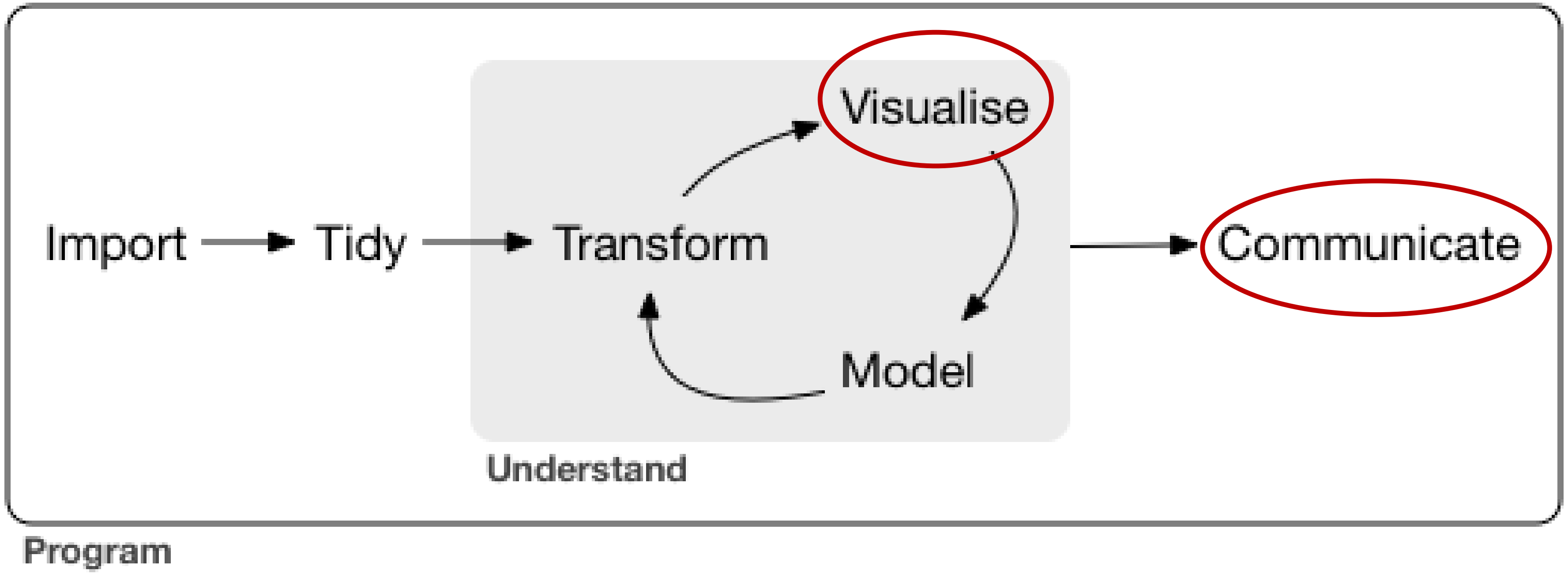
Usable Security and Privacy

Communication of Results

Goals Today

- Know criteria for what makes a good graph and apply them
- Choose appropriate types of graphs for different scenarios, depending on the variables visualized
- Use ggplot2 package to construct graphs for different scenarios
  - Scatterplot
  - Barplot
  - Boxplot
- Know the basic structure of how to communicate the results of inferential statistics
- Apply this structure for different tests
  - t-test (and derivates)
  - Chi-Square-Test

We are here



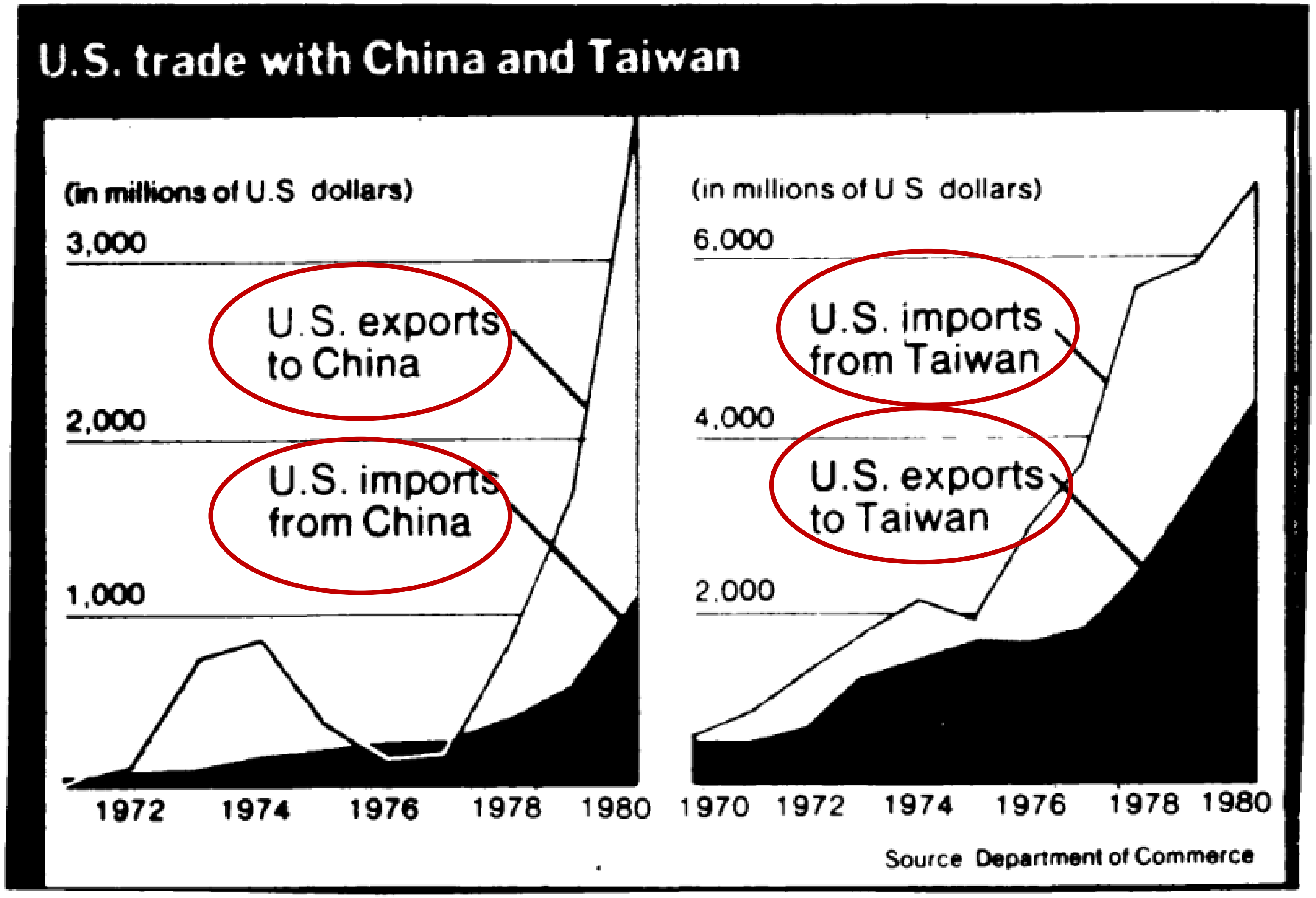
https://r4ds.had.co.nz/introduction.html

HOW (NOT) TO VISUALIZE DATA

Some criteria for good graphs (Tufte 2001)

- Show the data
- Focus on the data, rather than other visual aspects of the graph (no distractions)
- Avoid distorting the data / misleading
- Present many numbers with minimum ink
- Encourage the reader to compare different pieces of data

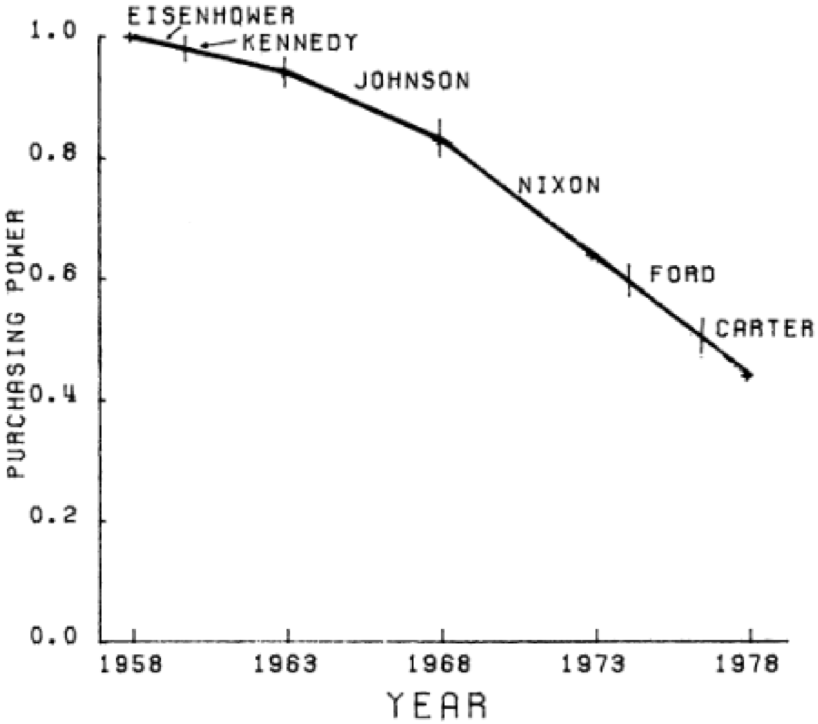
Changing visual metaphors mid-graph



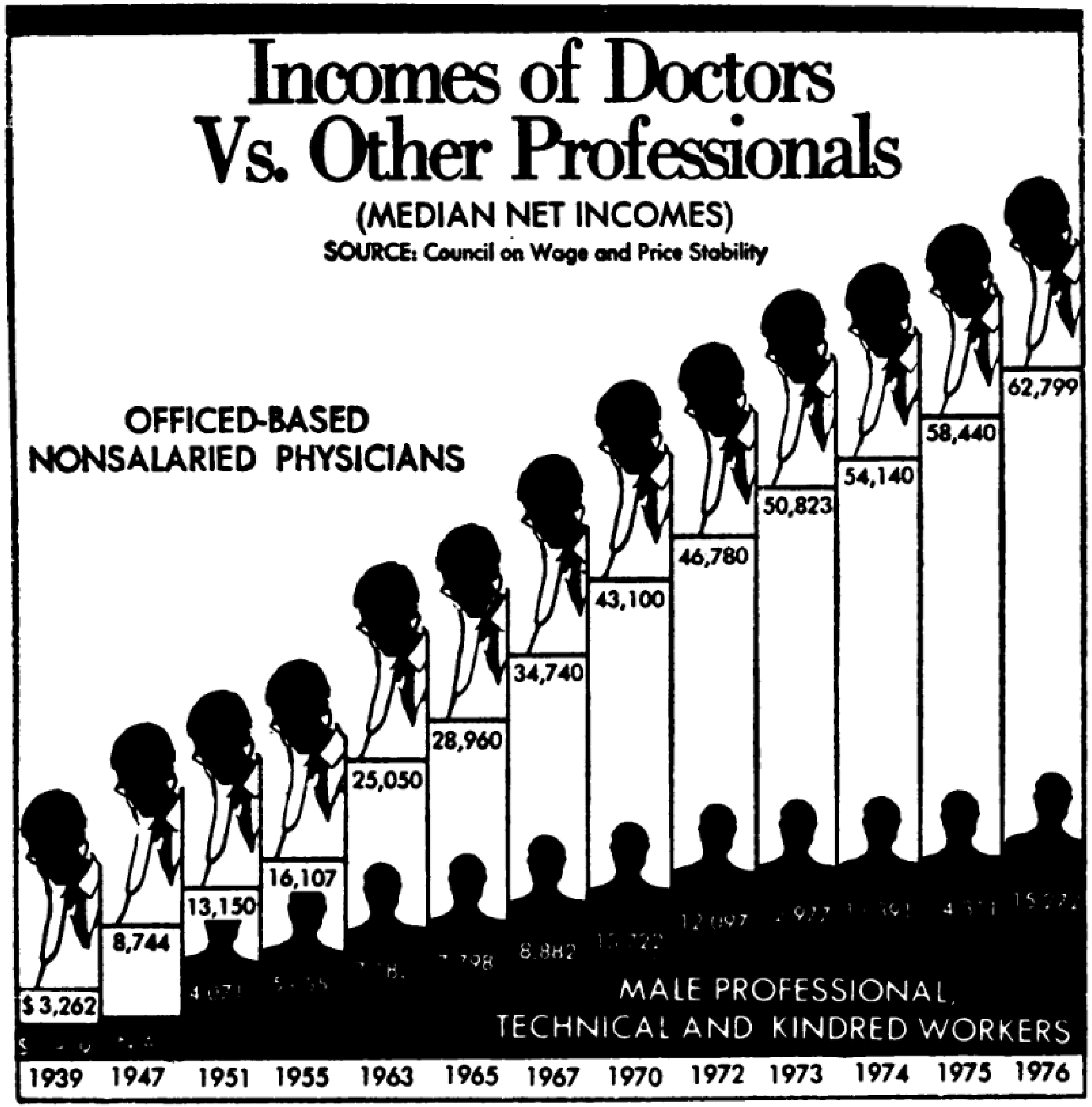
Examples from Wainer, H. (1984). How to display data badly. *The American Statistician*, *38*(2), 137-147.

Misleading axes

Length vs. Area (+ chart junk)

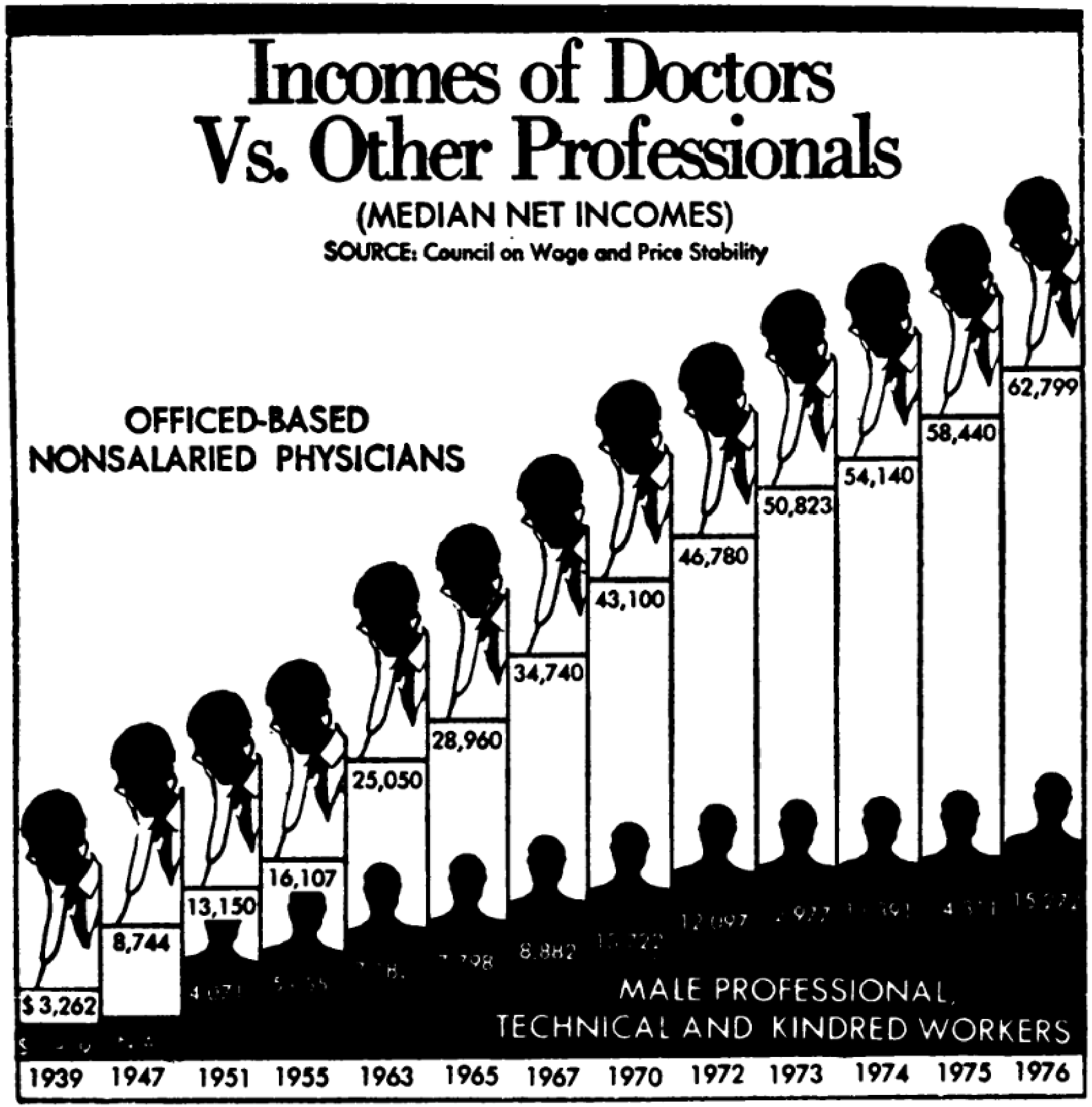


What are the problems with the following graph?



https://pingo.coactum.de/426954

What are the problems with the following graph?



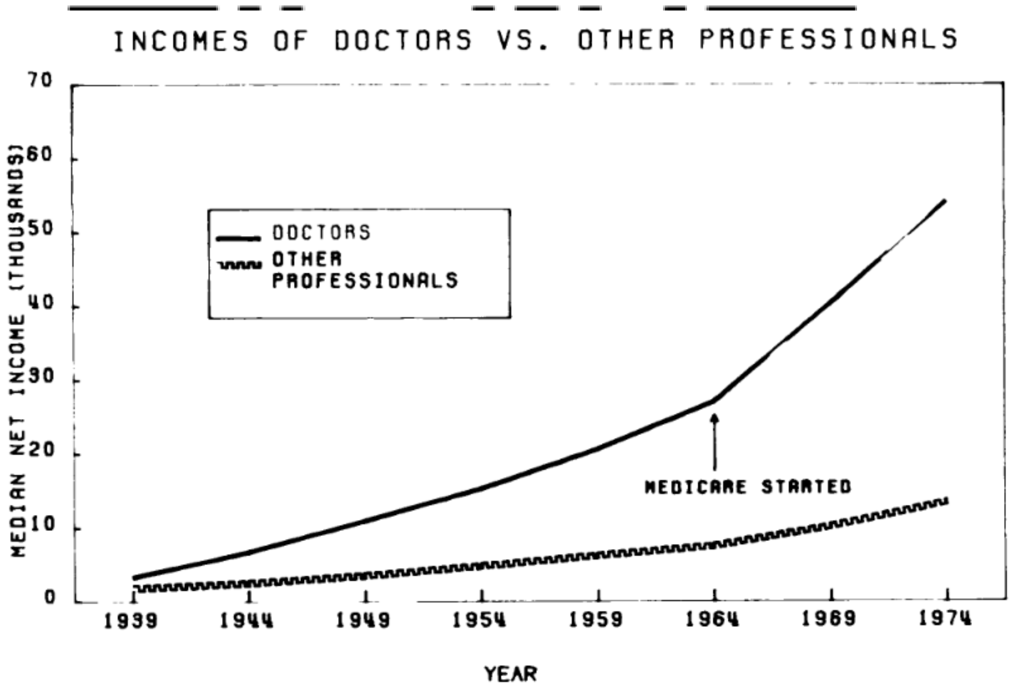
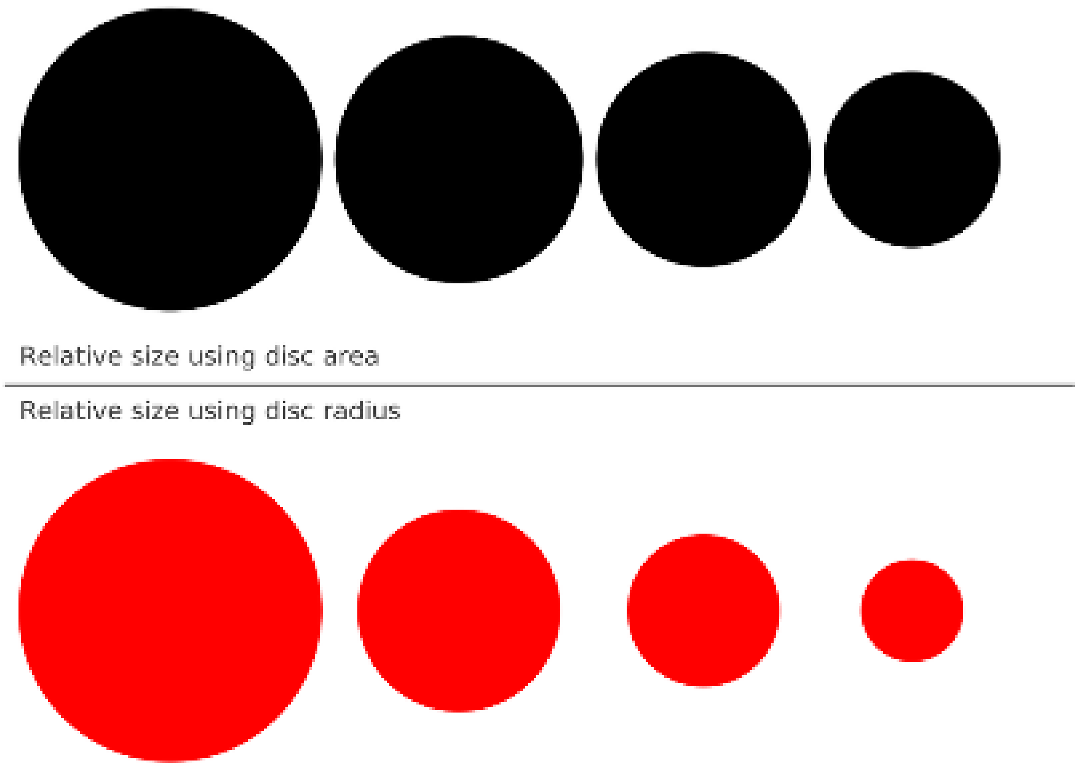


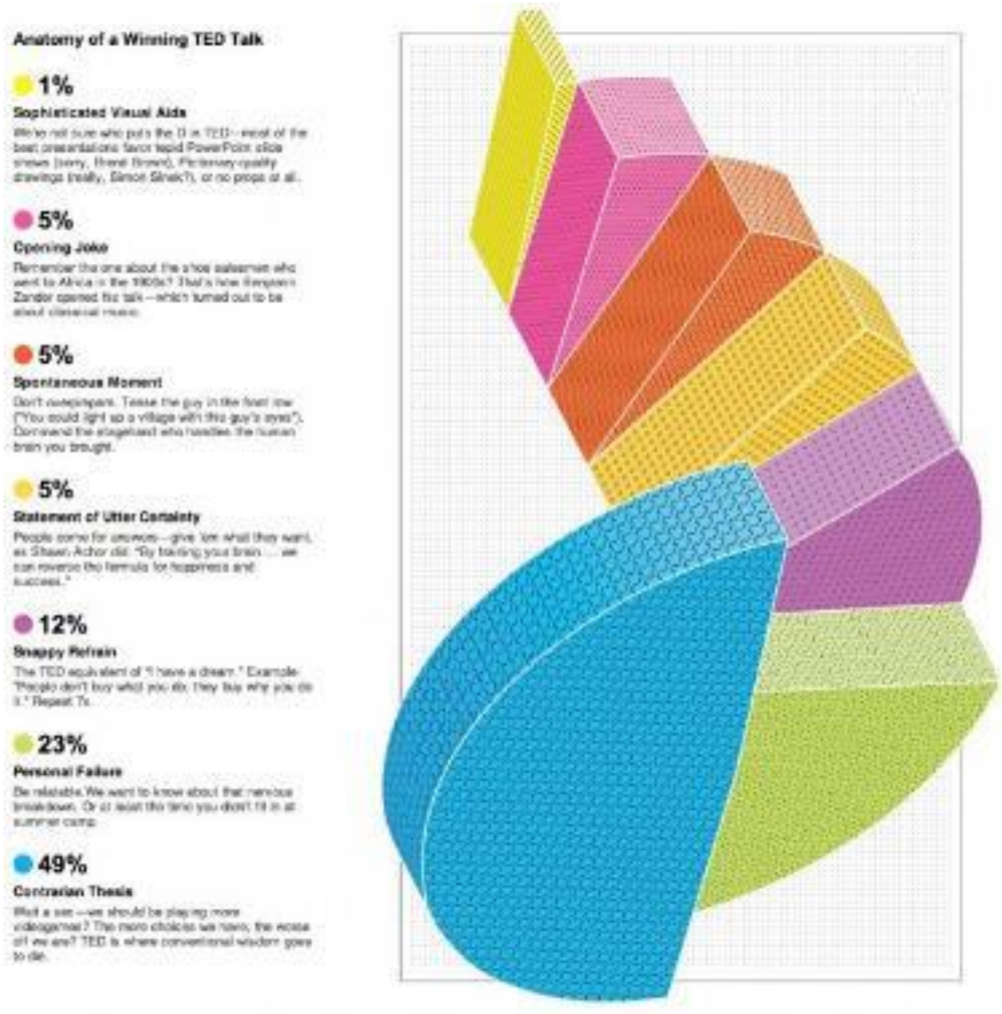
Figure 14. Data from Figure 13 redone with linear scale (from Wainer 1980).

https://pingo.coactum.de/426954

Ratio vs. Area



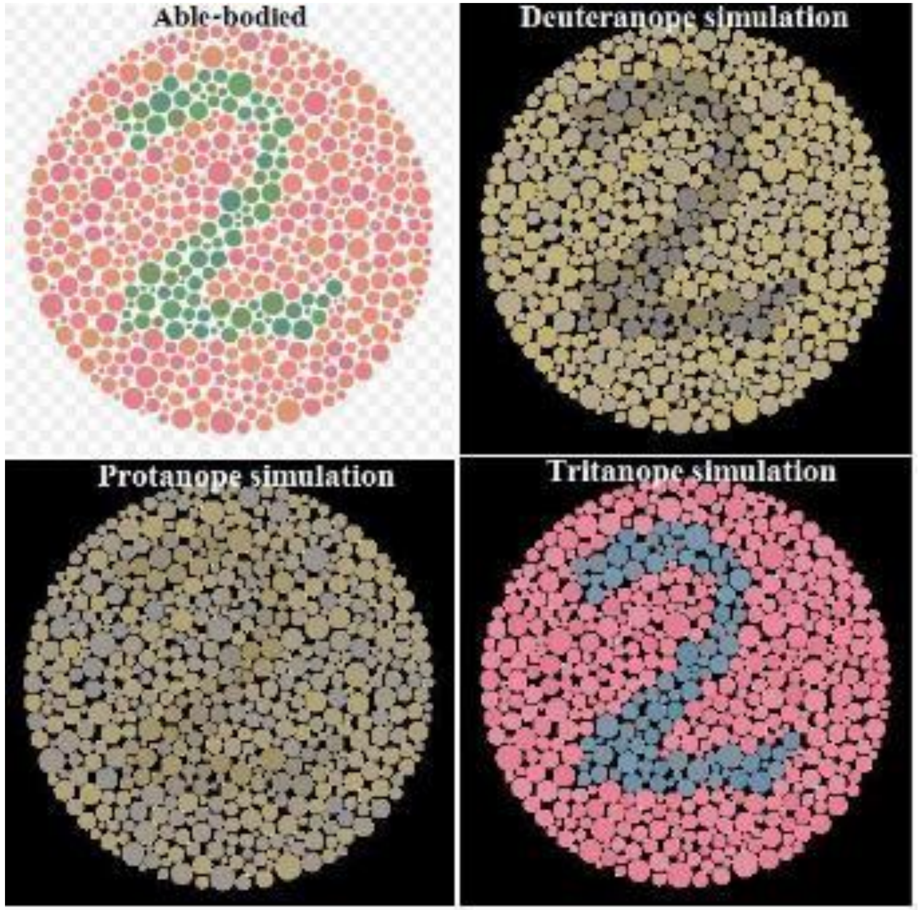
Avoid 3D



https://visual.ly/blog/learning-from-mistakes-in-visualization/

Accessibility

- ~ 8 % male Europeans, 1% female have Protanopia
- Other types less common
- Could be your supervisor / reviewer
- Use scales which are appropriate for different kind of color vision deficiencies



https://commons.wikimedia.org/wiki/File:Ishihara_compare_1.jpg

Accessible color-palette

- http://www.cookbook-r.com/Graphs/Colors_(ggplot2)/#a-colorblind-friendly-palette

	Original	*Simulation*					for Photoshop, Illustrator, Freehand, etc.		for Word, Power Point, Canvas, etc.
		Protan	Deutan	Tritan		Hue	C,M,Y,K (%)	R,G,B (0-255)	R,G,B (%)
1					Black	– °	(0,0,0,100)	(0,0,0)	(0,0,0)
2					Orange	41°	(0,50,100,0)	(230,159,0)	(90,60,0)
3					Sky Blue	202°	(80,0,0,0)	(86,180,233)	(35,70,90)
4					bluish Green	164°	(97,0,75,0)	(0,158,115)	(0,60,50)
5					Yellow	56°	(10,5,90,0)	(240,228,66)	(95,90,25)
6					Blue	202°	(100,50,0,0)	(0,114,178)	(0,45,70)
7					Vermilion	27°	(0,80,100,0)	(213,94,0)	(80,40,0)
8					reddish Purple	326°	(10,70,0,0)	(204,121,167)	(80,60,70)

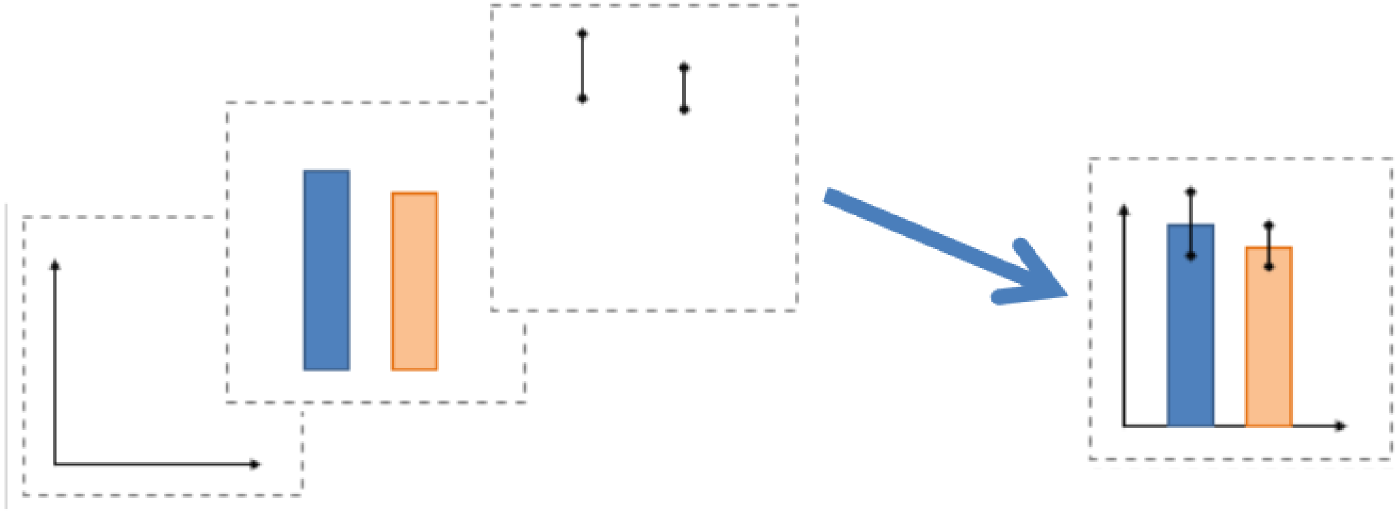
Other options for accessibility

- Use multiple channels to convey information (e.g. shape and color)
- Label colors directly in your visualization and not only in a legend
- Limit the use of color (too many colors or shapes) get confusing

GGPLOT

The principle of ggplot2

- R package to visualise data
- Build up graphics in layers
- Definition of aesthetic characteristics for single layers or complete graphs possible



Graphic adapted from Field (2012)

Star Wars Dataset for examples

- Comes with the tidyverse
- Removed list columns and changed character to factor for the examples

```
> glimpse(starwars)
Rows: 87
Columns: 14
$ name       <chr> "Luke Skywalker", "C-3PO", "R2-...
$ height     <int> 172, 167, 96, 202, 150, 178, 16...
$ mass       <dbl> 77, 75, 32, 136, 49, 120, 75, 3...
$ hair_color <chr> "blond", NA, NA, "none", "brown...
$ skin_color <chr> "fair", "gold", "white, blue", ...
$ eye_color  <chr> "blue", "yellow", "red", "yello...
$ birth_year <dbl> 19.0, 112.0, 33.0, 41.9, 19.0, ...
$ sex        <chr> "male", "none", "none", "male",...
$ gender     <chr> "masculine", "masculine", "masc...
$ homeworld  <chr> "Tatooine", "Tatooine", "Naboo"...
$ species    <chr> "Human", "Droid", "Droid", "Hum...
$ films      <list> [<"The Empire Strikes Back", "...
$ vehicles   <list> [<"Snowspeeder", "Imperial Spe...
$ starships  <list> [<"X-wing", "Imperial shuttle"...
```

Code for examples is on eCampus

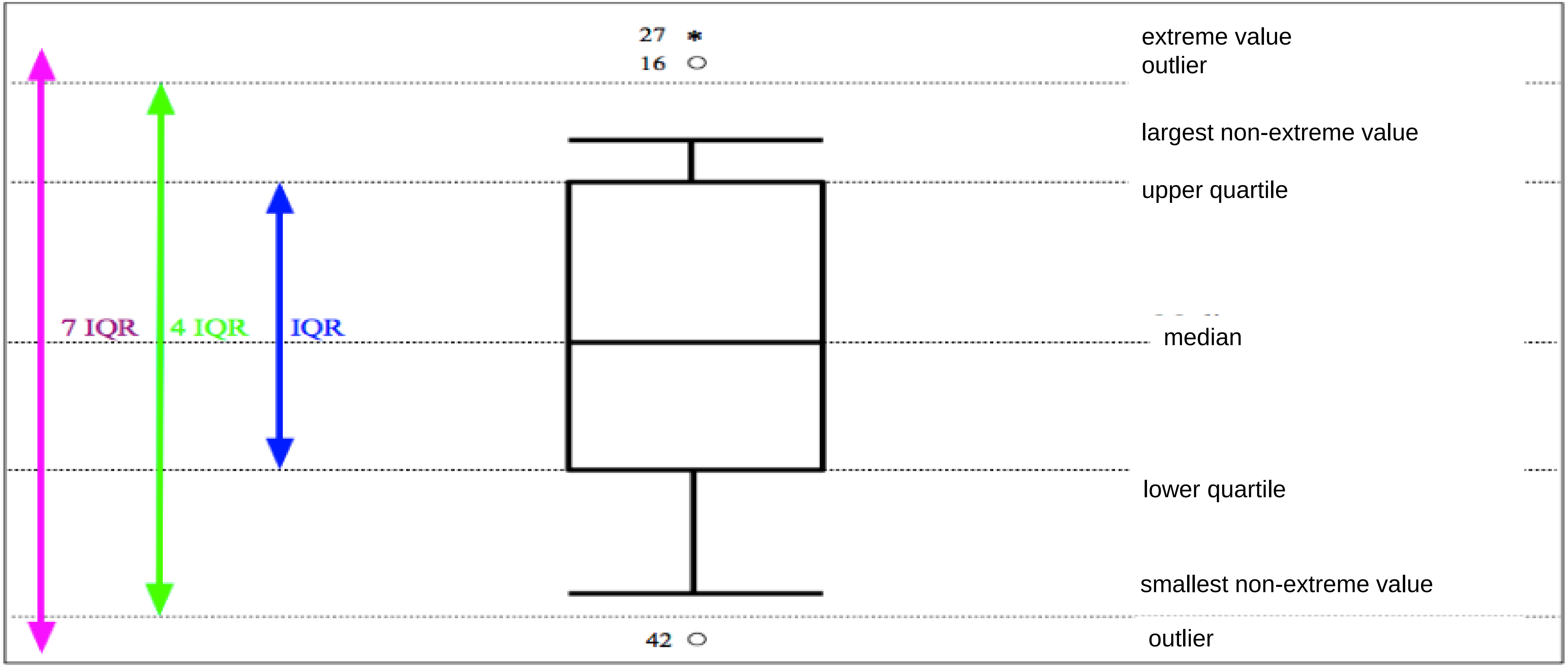
ggplot

```
ggplot(df, aes(variable_for_the_x_axis, variable_for_the_y_axis)) +
     geom_x()
```

- ggplot() call represents the base layer of the plot
- each call to a geom() represents an additional plot layer
- Examples for geom_x()
  - `geom_boxplot()`
  - `geom_histogram()`
  - `geom_bar()`
  - `geom_line()`
  - `geom_point()`

PLOTS

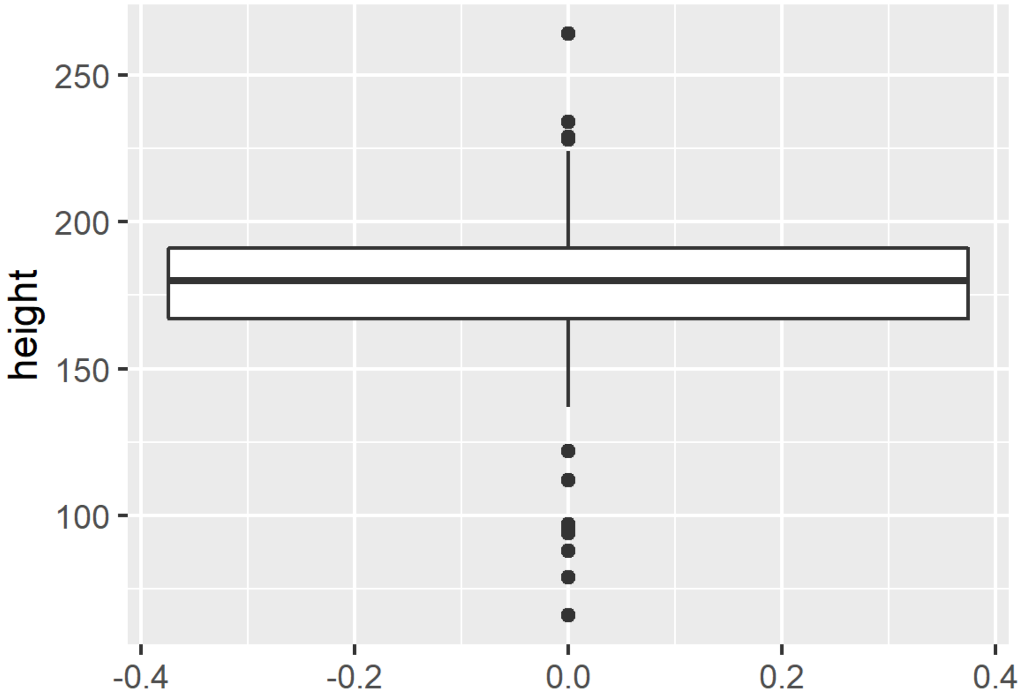
Describing A Distribution: Boxplots



Boxplots

- Use cases:
  - Distribution of a continuous variable

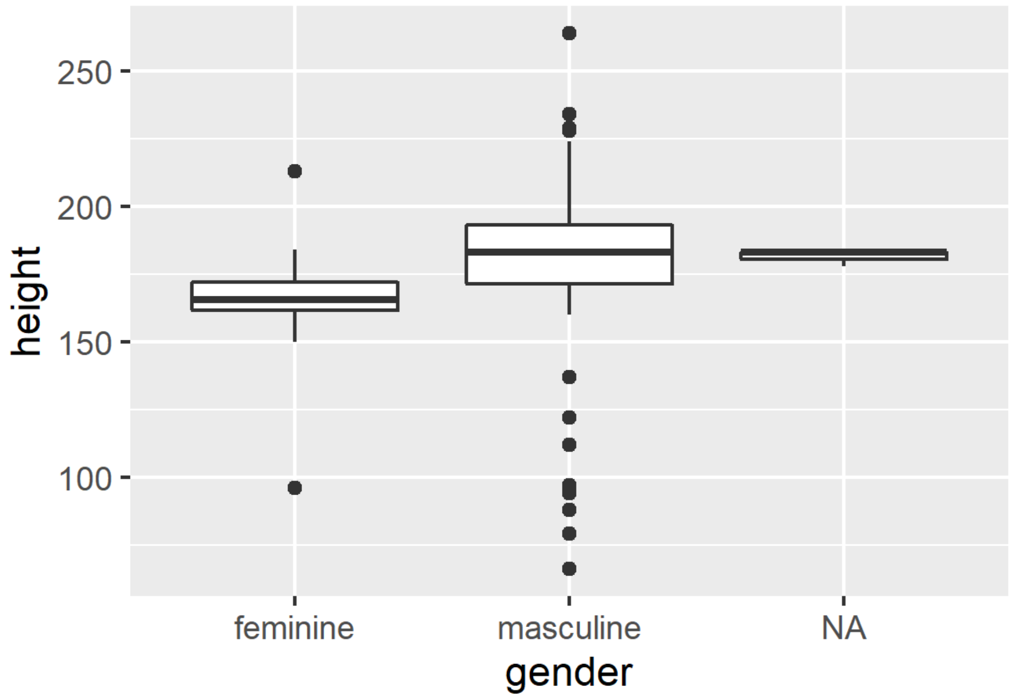
```
ggplot(starwars_df, aes(y=height)) +
  geom_boxplot()
```



Boxplots

- Use cases:
  - Distribution of a continuous variable
  - Can display multiple boxplots of different levels of an additional categorical variable

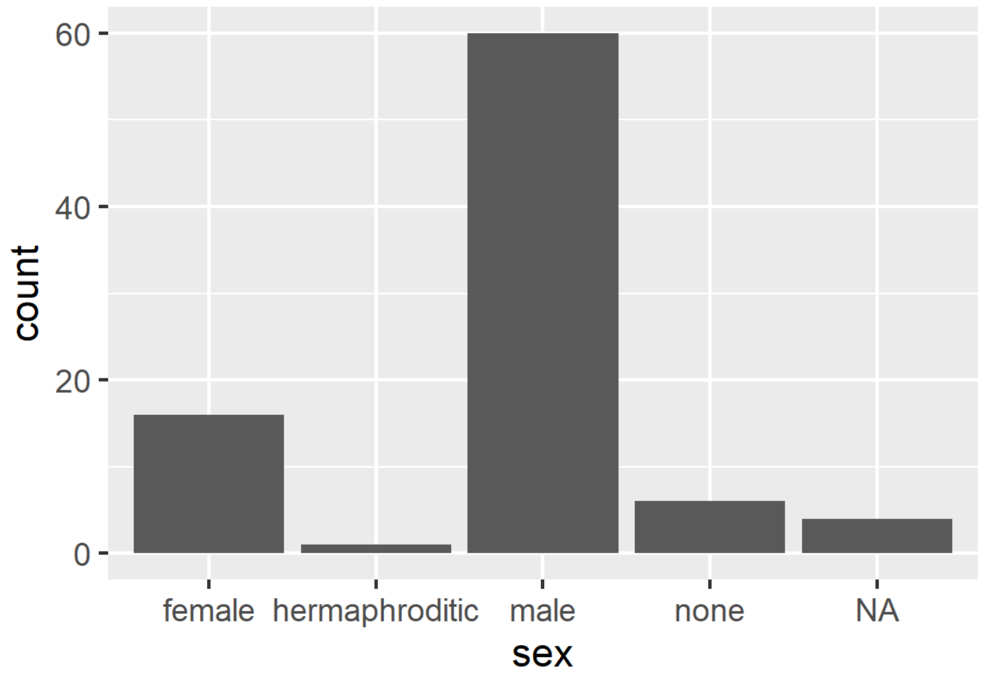
```
ggplot(starwars_df, aes(y=height, x=gender)) +
  geom_boxplot()
```



Barcharts

- Use cases:
  - Compare number of cases for levels of a categorical variable
  - `geom_bar` plots the number of cases

```
ggplot(starwars_df, aes(x=sex)) + geom_bar()
```



Barcharts

- Use cases:
  - Summary statistics (=mean) for a continuous variable for levels of categorical variable
    - Usually also includes visualization of spread in form of errorbars
      - **Standard deviation** for spread in sample
      - **Standard error (SE)** for how precise our measurement of the mean is
      - **Confidence intervals (CI)** for how likely it is, that if an experiment were repeated many times, the true value would be in the confidence interval
    - Some differences in calculation depending on experiment design (within/between groups)
    - http://www.cookbook-r.com/Graphs/Plotting_means_and_error_bars_(ggplot2)/

Barcharts

- Use cases:
  - Summary statistics (=mean) for a continuous variable for levels of categorical variable
  - `geom_col` plots values directly from the dataframe

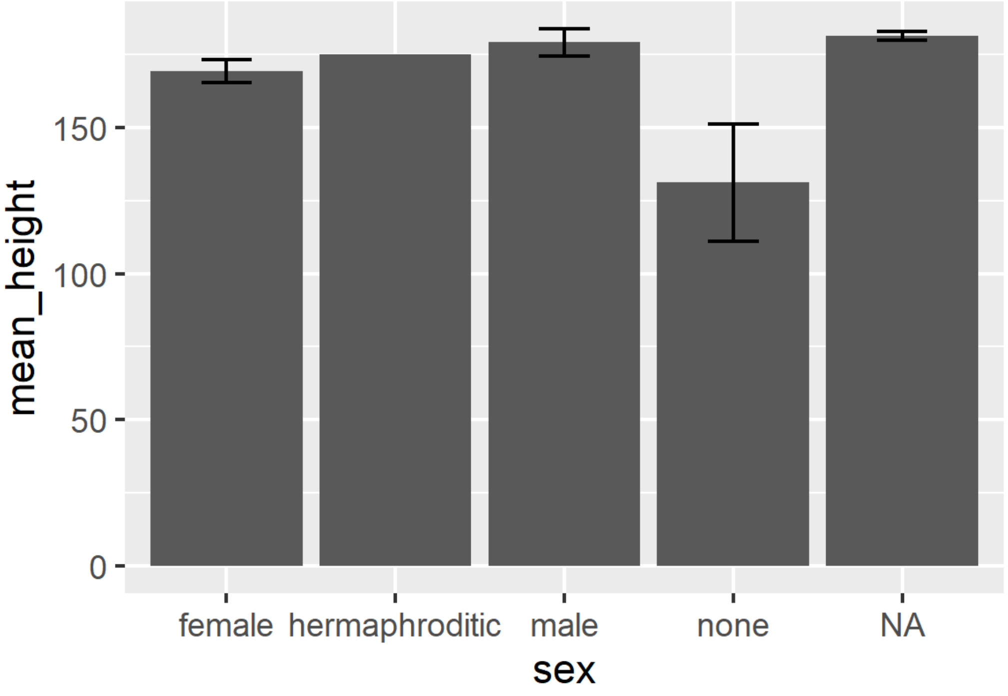
```
starwars_df %>%
  group_by(sex) %>%
  summarise(mean_height = mean(height, na.rm=TRUE),
            sd = sd(height, na.rm=TRUE),
            n= n(),
            se = sd/sqrt(n),
            upper_ci = CI(na.omit(height), ci= 0.95)["upper"],
            lower_ci = CI(na.omit(height), ci= 0.95)["lower"]) %>%
  ggplot(aes(y=mean_height, x=sex)) +
  geom_col()+
  geom_errorbar(aes(ymin=mean_height-se,
                    ymax=mean_height+se),
                width=0.3)
```

- Get values to display in plot
- Can pass manipulated dataframe to ggplot using piping (%>%)

Barcharts with Errorbars Using SE

- Use cases:
  - Summary statistics (=mean) for a continuous variable for levels of categorical variable
  - `geom_errorbar` needs minimum and maximum values

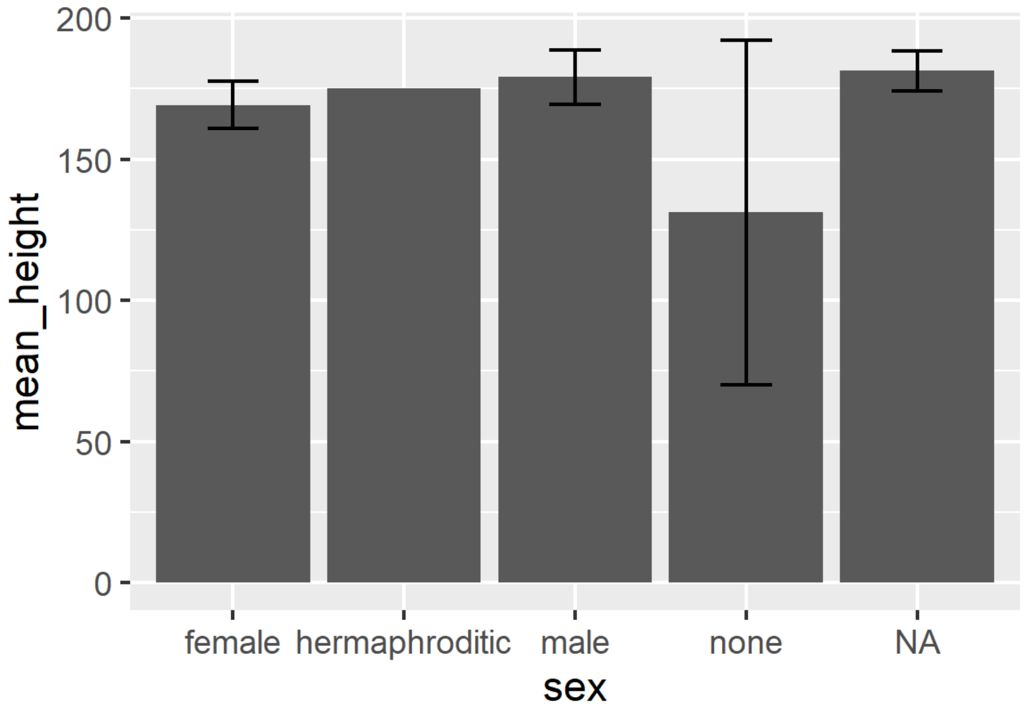
```
starwars_df %>%
  group_by(sex) %>%
  summarise(mean_height = mean(height, na.rm=TRUE),
            sd = sd(height, na.rm=TRUE),
            n= n(),
            se = sd/sqrt(n),
            upper_ci = CI(na.omit(height), ci= 0.95)["upper"],
            lower_ci = CI(na.omit(height), ci= 0.95)["lower"]) %>%
  ggplot(aes(y=mean_height, x=sex)) +
  geom_col()+
  geom_errorbar(aes(ymin=mean_height-se,
                    ymax=mean_height+se),
                width=0.3)
```



Barcharts with Errorbars Using CI

- Use cases:
  - Summary statistics (=mean) for a continuous variable for levels of categorical variable
  - `geom_errorbar` needs minimum and maximum values
  - When using CI, you pass the lower and upper CI in directly

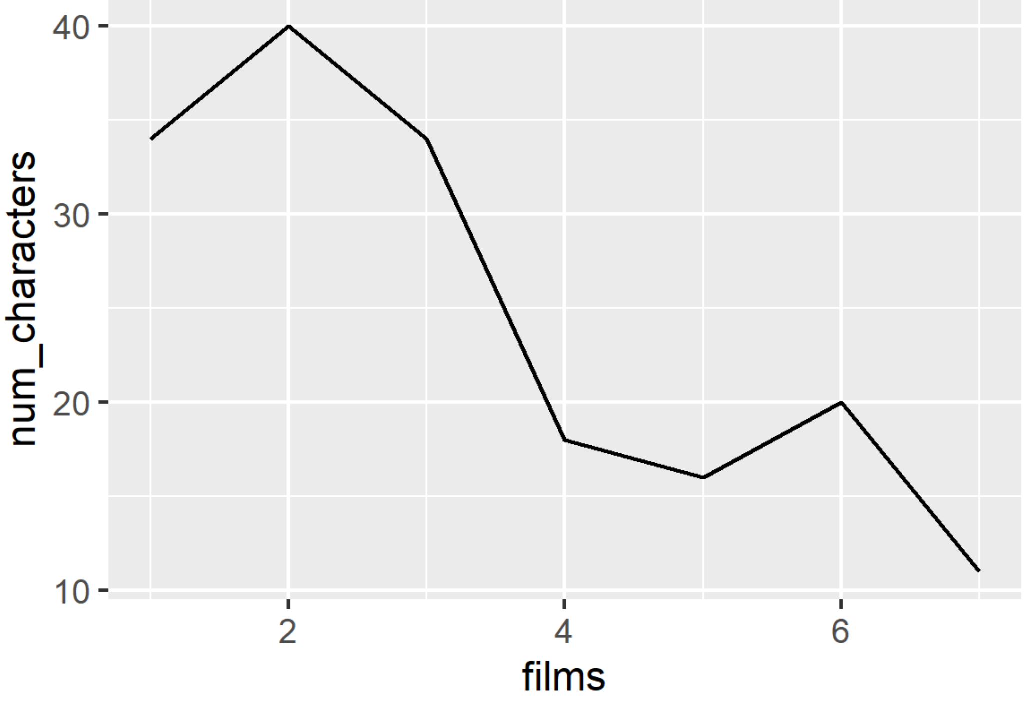
```
ggplot(summary_starwars, aes(y=mean_height, x=sex)) +
  geom_col()+
  geom_errorbar(aes(ymin=lower_ci,
                    ymax=upper_ci),
                width=0.3)
```



Linecharts

- Use cases:
  - Like barcharts, but when the categorical variable is ordinal (e.g. points in time, different amounts of intervention)
  - Can also add errorbars if plotting summary statistics

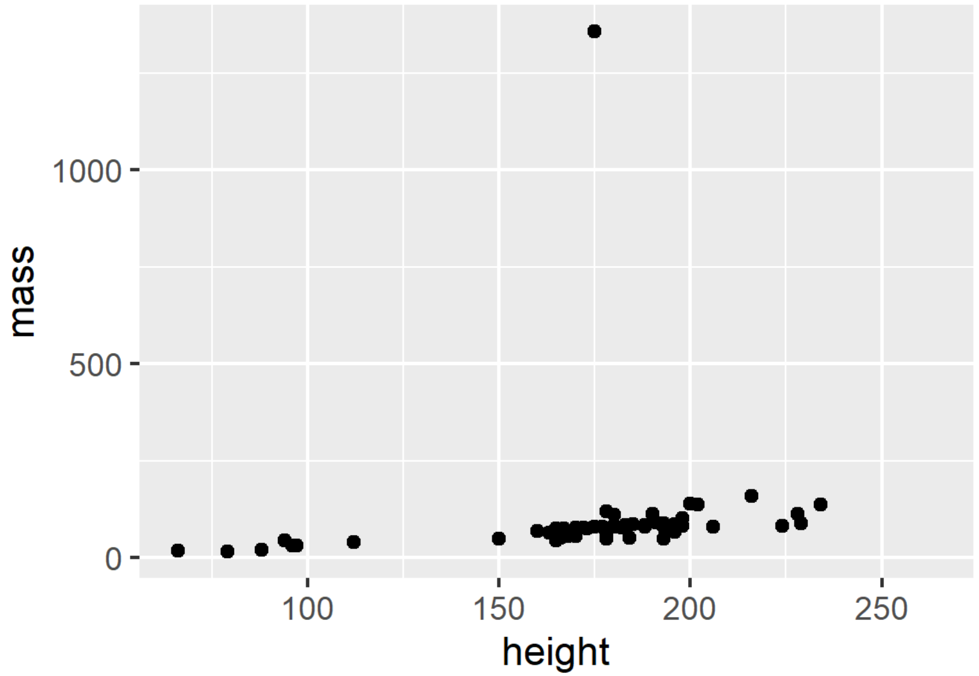
```
starwars_films %>%
  group_by(films) %>%
  summarize(num_characters=n()) %>%
ggplot(aes(y=num_characters, x=films)) +
  geom_line()
```



Scatterplots

- Use Case:
  - Two variables measured on continuous scale
  - Large number of possible values
  - Shows relationship between the two variables

```
ggplot(starwars_df, aes(x=height, y=mass)) +
  geom_point()
```

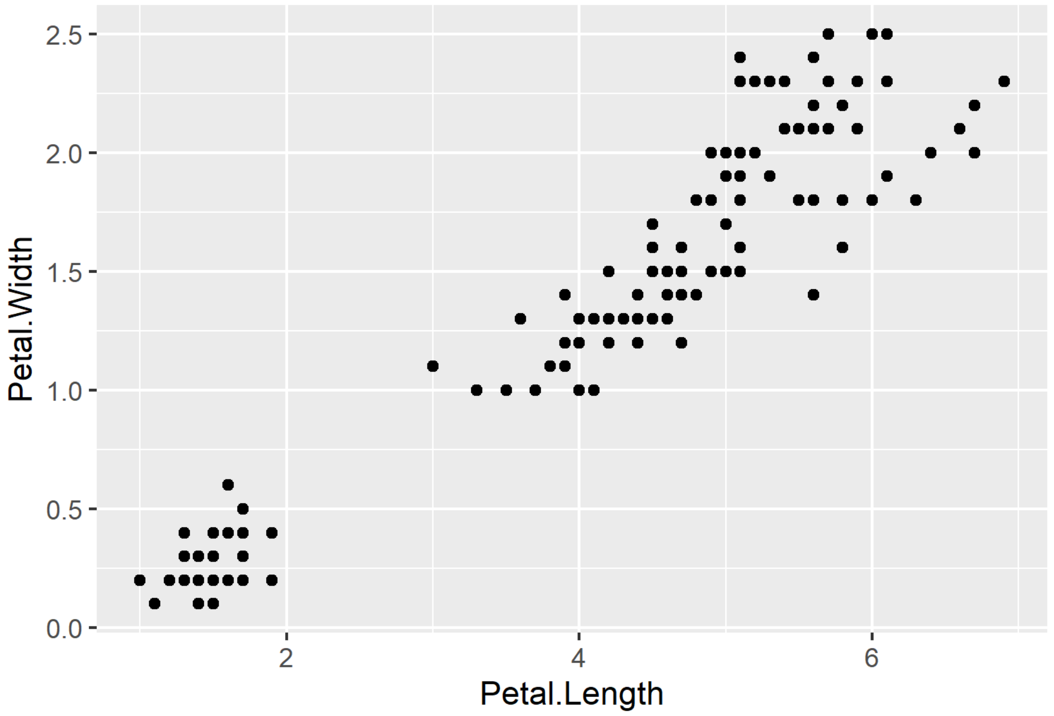


Saving Plots

- Possible through the RStudio-GUI
- Or in code:
  - `ggsave(filename, plot, units, width, height)`
  - Defaults use the last displayed plot and the size of the graphics device

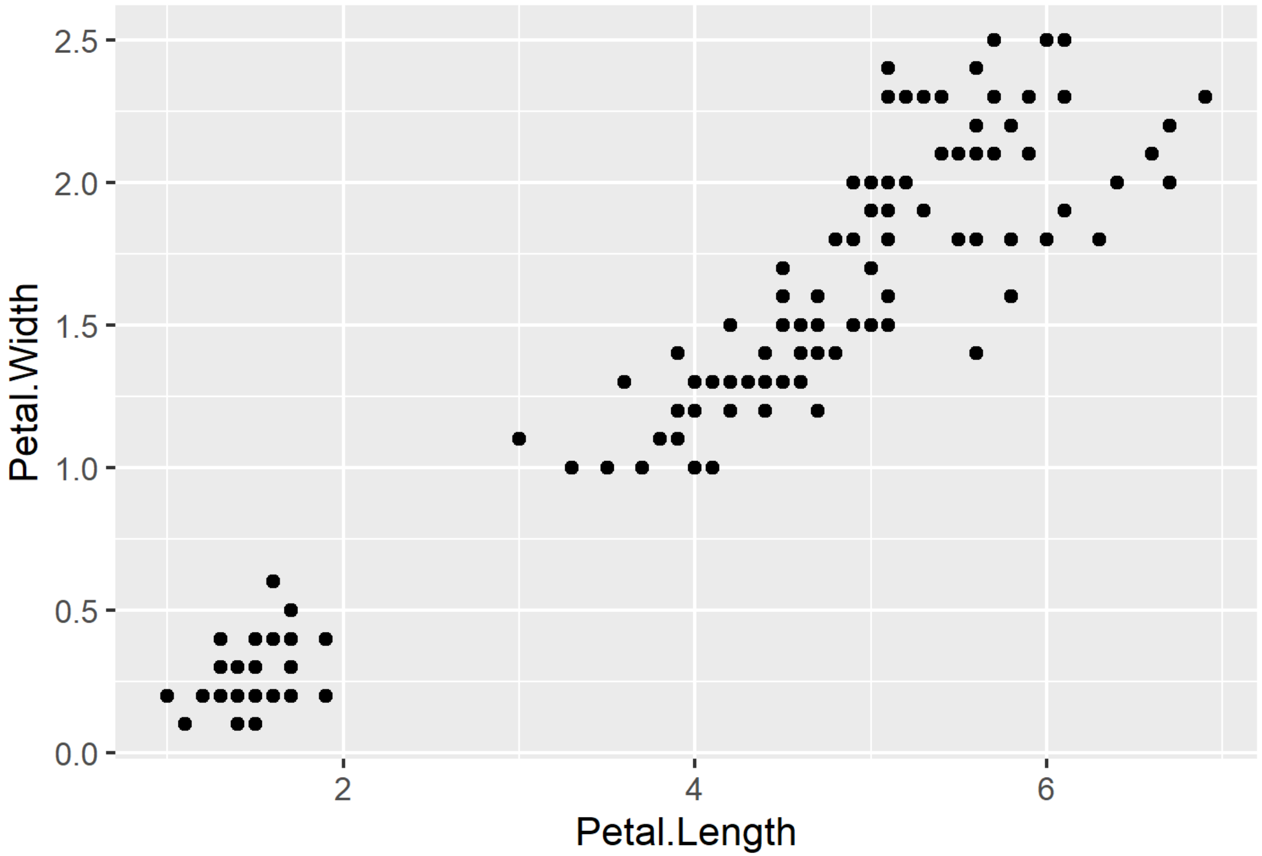
```
ggsave("img/scatterplot.png", units="cm", width=10, height=7)
```

Which code can be used to get the following plot?



- A) `ggplot(iris, aes(x=Petal.Length, y=Petal.Width)) + geom_point()`
- B) `ggplot(iris, aes(x=Petal.Width, y=Petal.Length)) + geom_point()`
- C) `ggplot(aes(x=Petal.Length, y=Petal.Width)) + geom_point()`
- D) `ggplot(iris, aes(x=Petal.Length, y=Petal.Width)) %>% geom_point()`
- E) `iris %>% ggplot(aes(x=Petal.Length, y=Petal.Width)) + geom_point()`

Which code can be used to get the following plot?



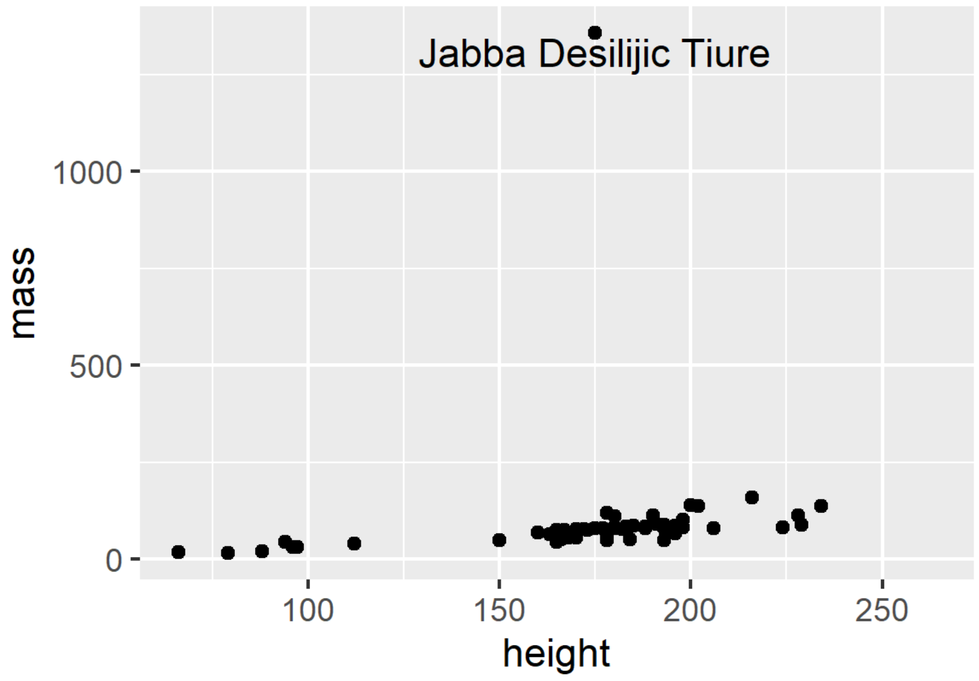
https://pingo.coactum.de/426954

EXTRAS FOR PLOTS

Adding text to plots

- Use cases:
  - Label outliers or other specific values in the data
  - Add explanatory comments
  - Add another channel of communicating categorical variables

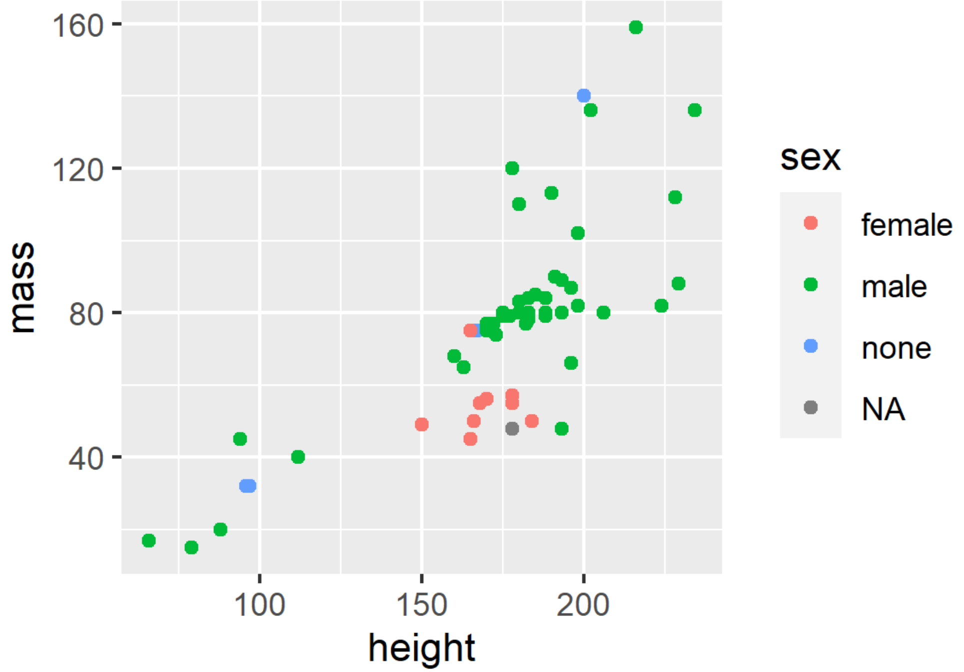
```
ggplot(starwars_df, aes(x=height, y=mass))+
  geom_point()+
  geom_text(data=filter(starwars_df, mass>1000),
            aes(label=name),
            nudge_y=-50)
```



More than two variables in a plot

- Using color / shape to depict a third/fourth categorical variable
  - Don‘t do this if there are too many levels in the variable → confusion
  - `fill` for bars, boxplots
  - `color` for points, lines, outlines of boxplots

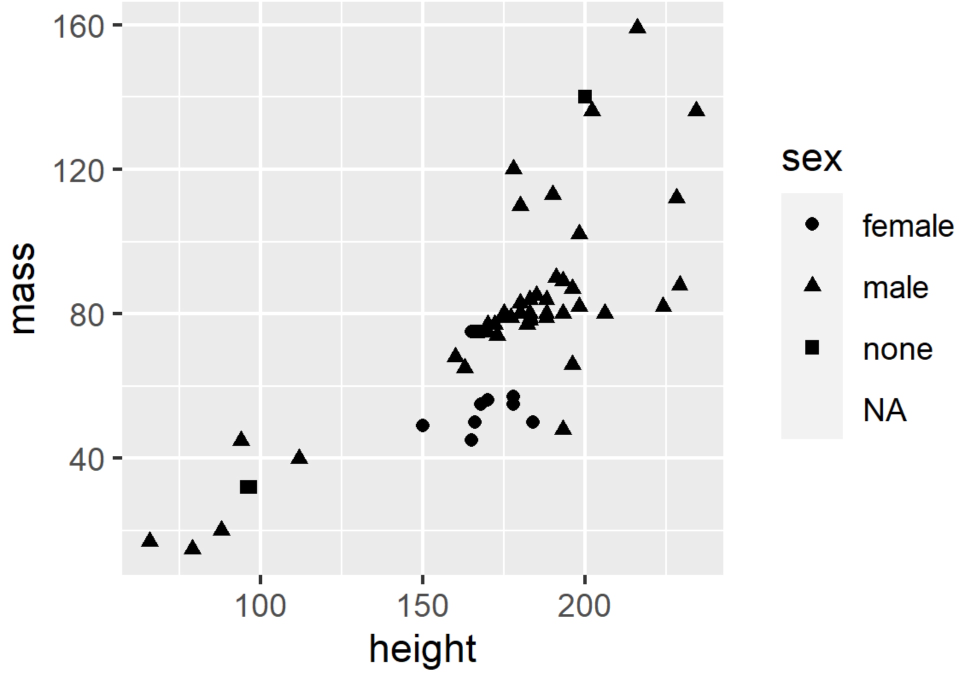
```
ggplot(starwars_df, aes(x=height, y=mass, color=sex)) +
  geom_point()
```



More than two variables in a plot

- Using color / shape to depict a third/fourth categorical variable
  - Don‘t do this if there are too many levels in the variable → confusion
  - `fill` for bars, boxplots
  - `color` for points, lines, outlines of boxplots

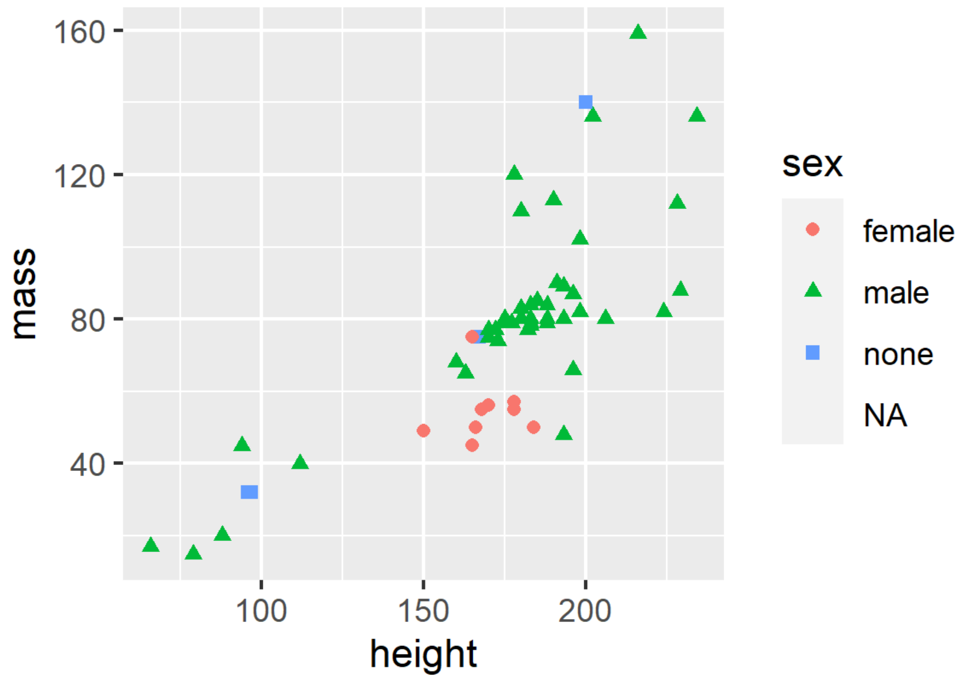
```
ggplot(starwars_df, aes(x=height, y=mass, color=sex)) +
  geom_point()

ggplot(starwars_df, aes(x=height, y=mass, shape=sex)) +
  geom_point()
```



More than two variables in a plot

- Using color / shape to depict a third/fourth categorical variable
  - Don‘t do this if there are too many levels in the variable → confusion
  - `fill` for bars, boxplots
  - `color` for points, lines, outlines of boxplots

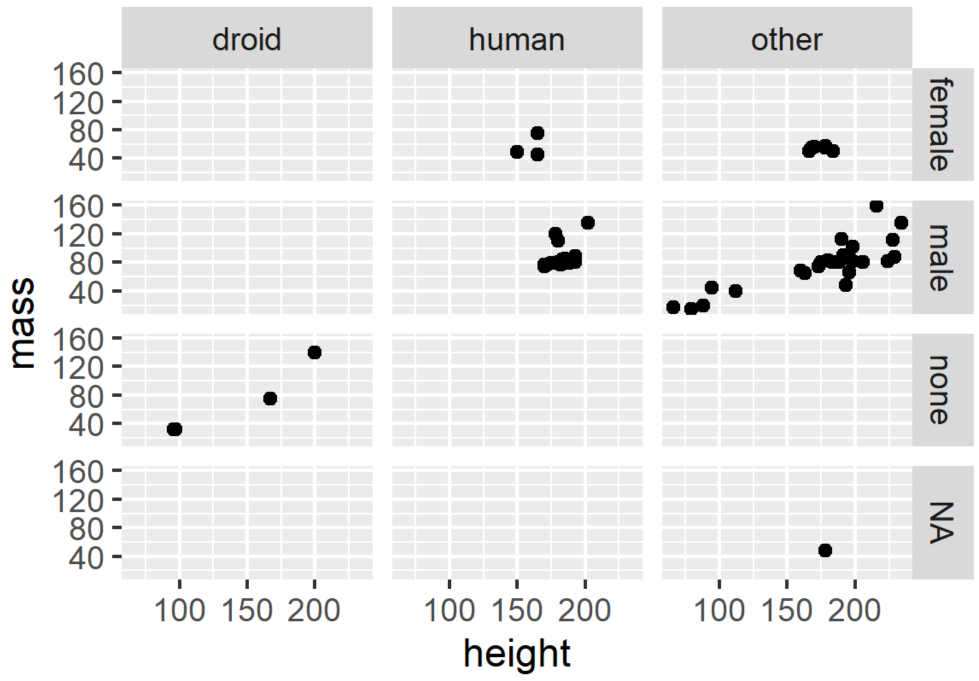
```
ggplot(starwars_df, aes(x=height, y=mass, color=sex)) +
  geom_point()

ggplot(starwars_df, aes(x=height, y=mass, shape=sex)) +
  geom_point()

ggplot(starwars_df, aes(x=height, y=mass, color=sex, shape=sex)) +
  geom_point()
```



More than two variables in a plot

- Using color / shape to depict a third/fourth categorical variable
- Using faceting
  - facet_grid to split up data by rows and columns (1 – 2 variables)
  - facet_wrap for one variable and facets „wrapping around“

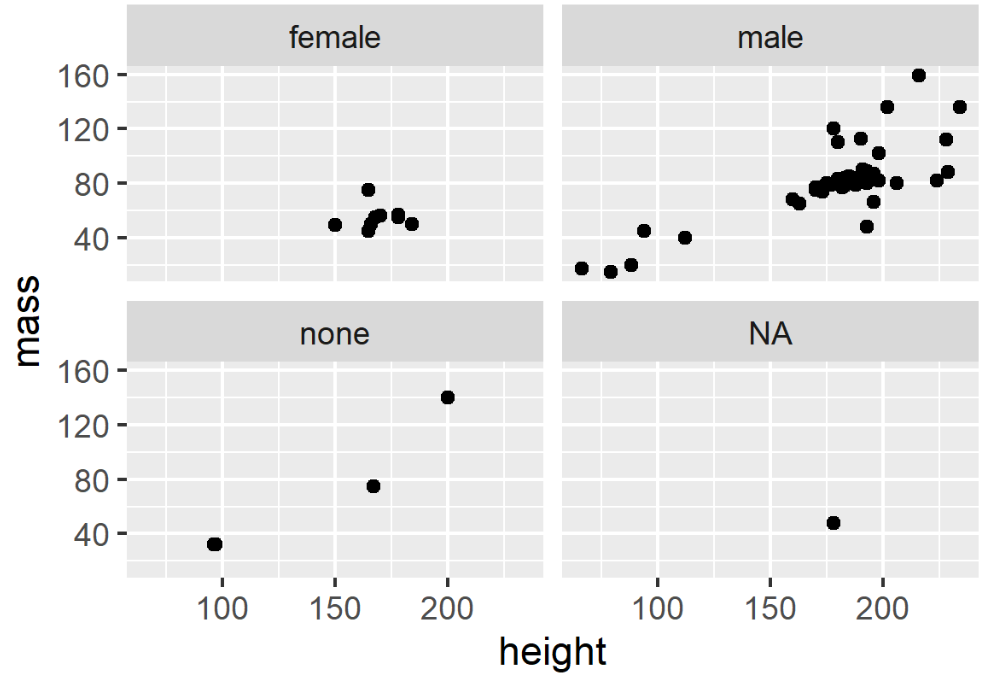
```
ggplot(starwars_df, aes(x=height, y=mass)) +
  facet_grid(sex~species)+
  geom_point()
```



More variables in a single plot

- Using color / shape to depict a third/fourth categorical variable
- Using faceting
  - facet_grid to split up data by rows and columns (1 – 2 variables)
  - facet_wrap for one variable and facets „wrapping around“

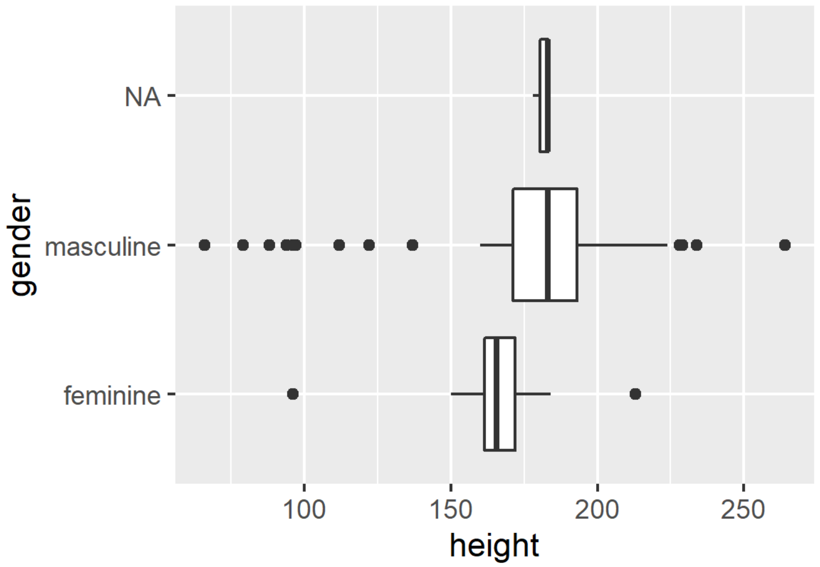
```
ggplot(starwars_df, aes(x=height, y=mass)) +
  facet_grid(sex~species)+
  geom_point()

ggplot(starwars_df, aes(x=height, y=mass)) +
  facet_wrap(sex~.)+
  geom_point()
```



Axes

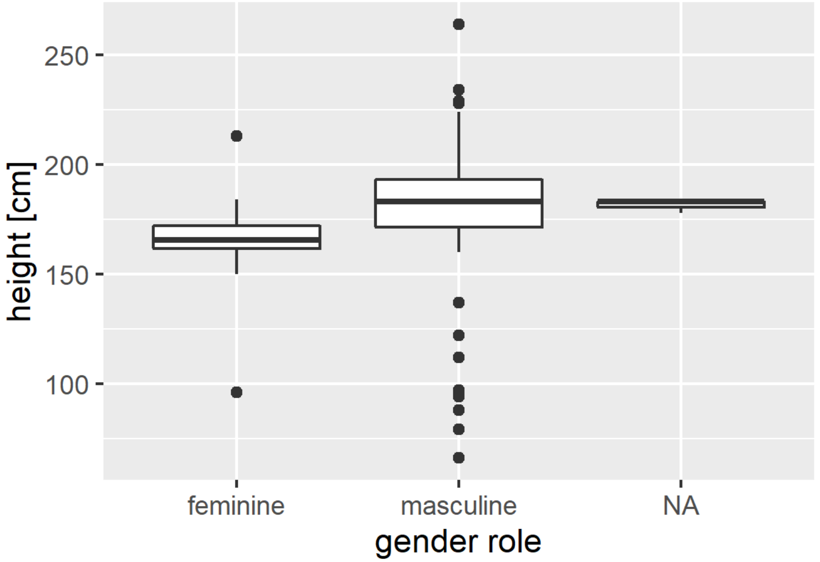
- Starting with our boxplot from before
- Swap the axes (great if you have overlapping tick labels)

```
boxplots +
  coord_flip()
```



- Or change axis labels

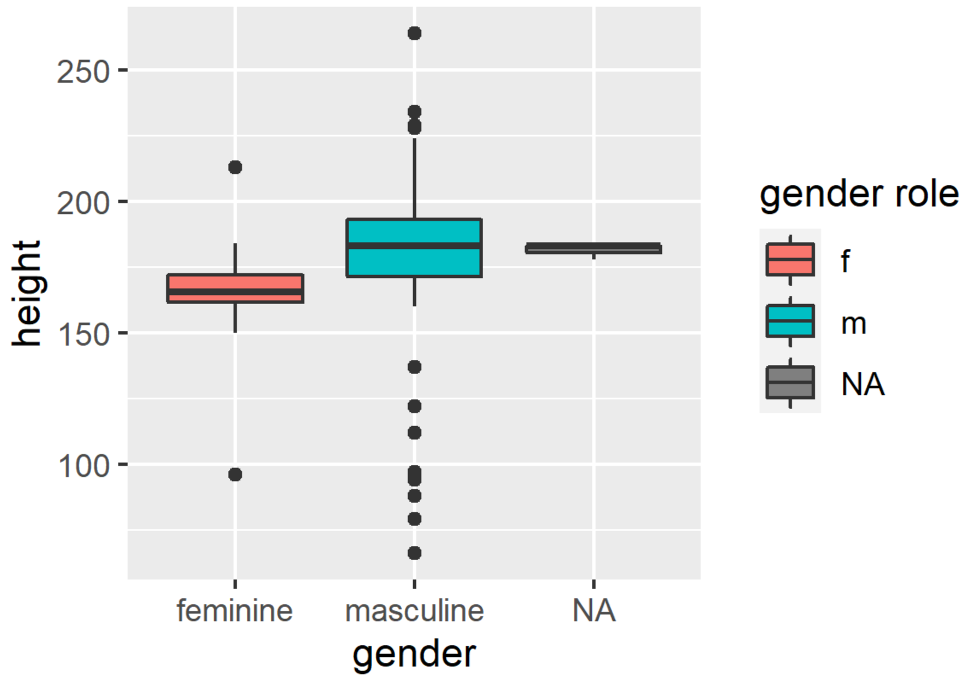
```
boxplots +
  ylab("height [cm]")+
  xlab("gender role")
```



Legends

- Manipulate text and title in legend

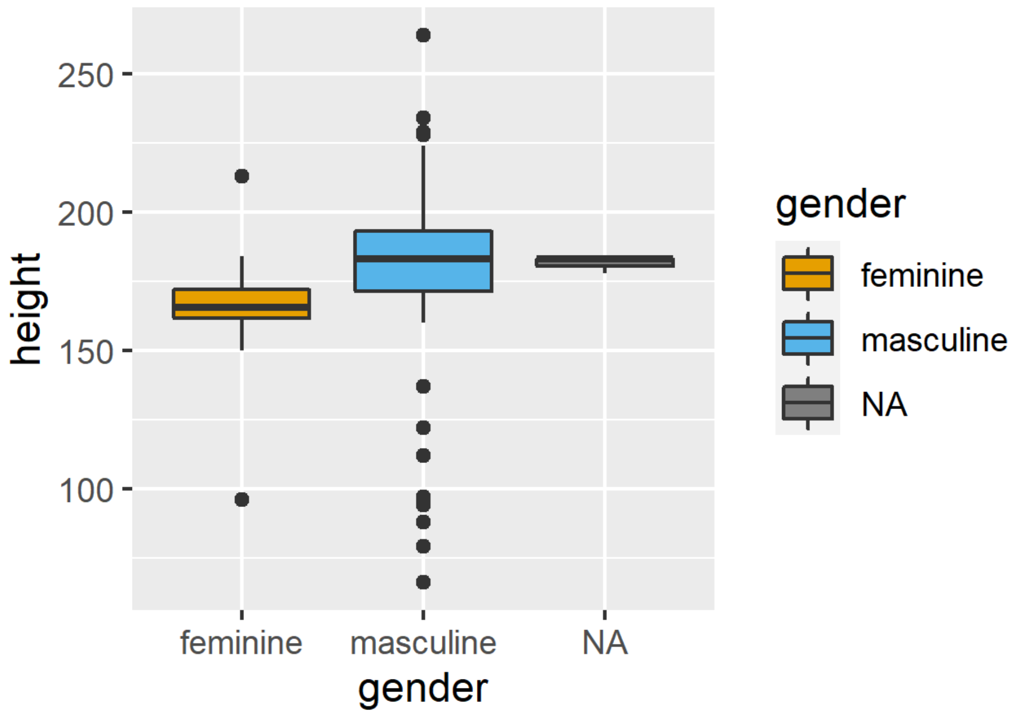
```
ggplot(starwars_df, aes(y=height, x=gender, fill=gender)) +
  geom_boxplot()+
  scale_fill_discrete(name="gender role",
                      breaks=c("feminine", "masculine", NA),
                      labels=c("f", "m", "NA"))
```



Scales

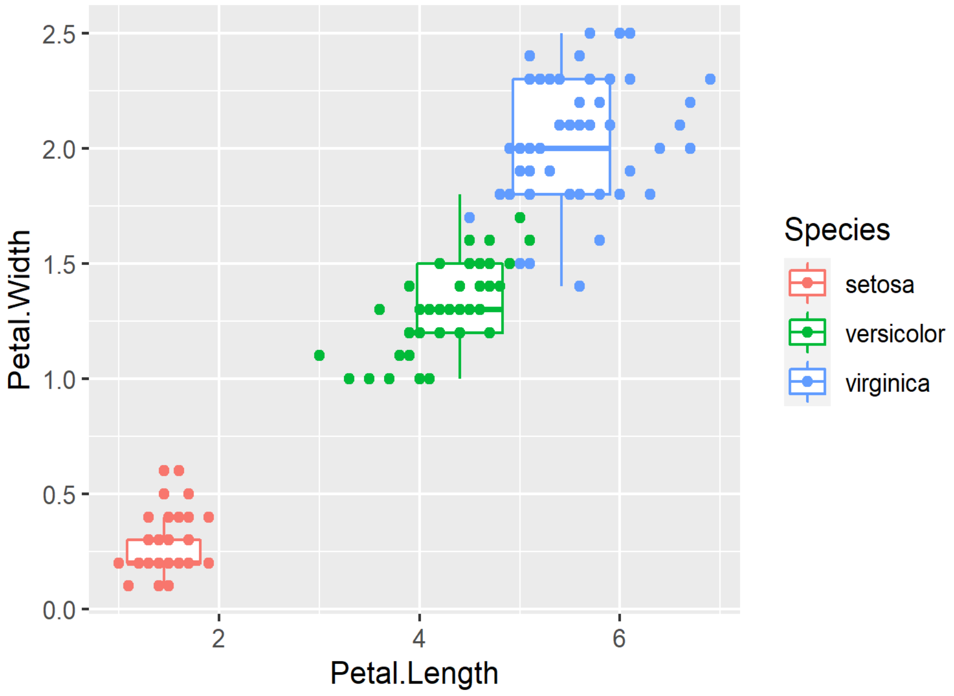
- Change the colors used (or shapes…)

```
cb_palette <- c("#E69F00", "#56B4E9", "#009E73", "#F0E442", "#0072B2", "#D55E00", "#CC79A7",
"#999999")
ggplot(starwars_df, aes(y=height, x=gender, fill=gender)) +
  geom_boxplot()+
  scale_fill_discrete(type=cb_palette)
```



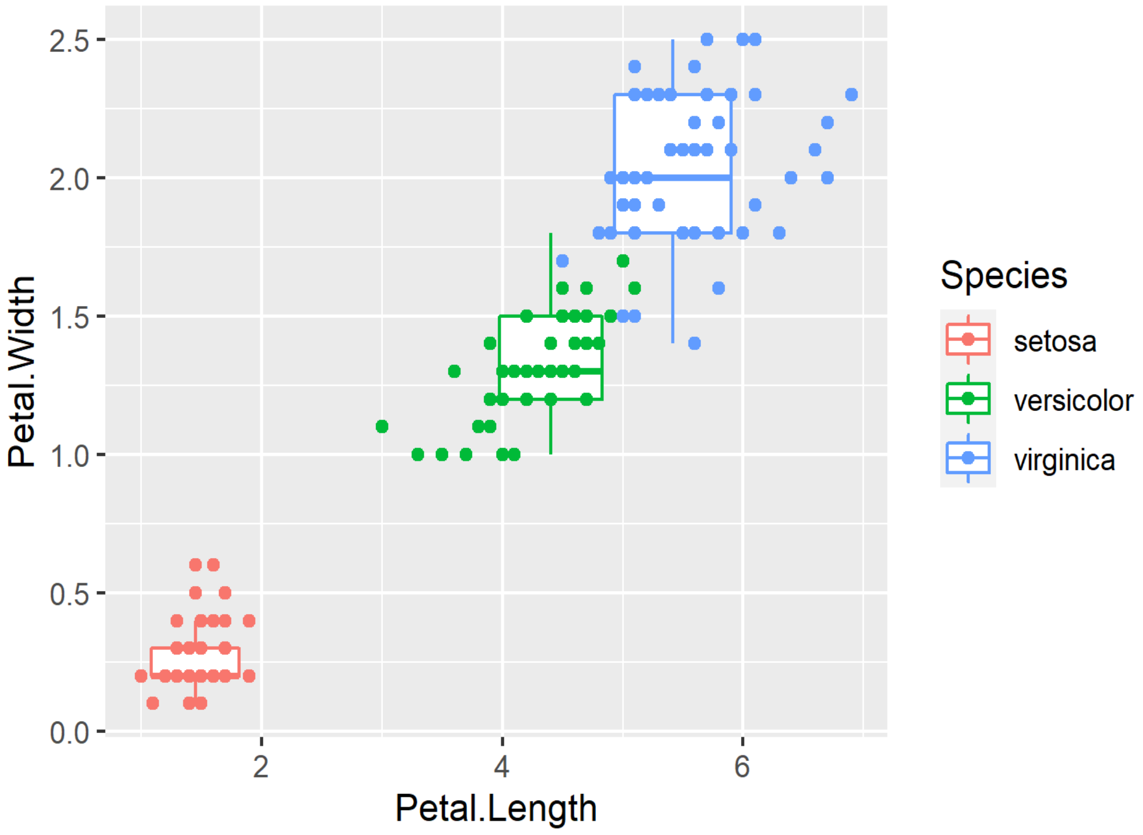
- `scale_[type]_[type of variable]`
  - Type, e.g. `fill, color, shape`
  - Variable type, e.g. `continuous, discrete, manual`
- Predefined color schemes, e.g. in the RColorBrewer-Package

Which code can be used to get the following plot?



- A) `ggplot(iris, aes(x=Petal.Length, y=Petal.Width, color=Species))`
- B) `ggplot(iris, aes(x=Petal.Length, y=Petal.Width, color=Species)) + geom_point() + geom_boxplot()`
- C) `ggplot(iris, aes(x=Petal.Length, y=Petal.Width, group=Species)) + geom_boxplot() + geom_point(aes(color=Species))`
- D) `ggplot(iris, aes(x=Petal.Length, y=Petal.Width)) + geom_boxplot() + geom_point(color=Species)`
- E) `ggplot(iris, aes(x=Petal.Length, y=Petal.Width, color=Species)) + geom_boxplot() + geom_point()`
- F) `ggplot(iris, aes(x=Petal.Length, y=Petal.Width)) + geom_boxplot() + geom_point(aes(color=Species))`

Which code can be used to get the following plot?



https://pingo.coactum.de/426954

REPORTING STATS RESULTS

From Numbers to Text

```
        Welch Two Sample t-test

data:  carFourAndSixCylinders$weight by carFourAndSixCylinders$numCylinde
rs
t = -3.8095, df = 15.998, p-value = 0.001542
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -1.2940827 -0.3687485
sample
```

```
                       | carsLonger$transmission
carsLonger$numCylinders |         1 |         2 | Row Total |
------------------------|-----------|-----------|-----------|
                      4 |         6 |        16 |        22 |
                        |     8.556 |    13.444 |           |
                        |     0.763 |     0.486 |           |
                        |   27.273% |   72.727% |   61.111% |
                        |   42.857% |   72.727% |           |
                        |   16.667% |   44.444% |           |
                        |    -0.874 |     0.697 |           |
------------------------|-----------|-----------|-----------|
                      6 |         8 |         6 |        14 |
                        |     5.444 |     8.556 |           |
                        |     1.200 |     0.763 |           |
                        |   57.143% |   42.857% |   38.889% |
                        |   57.143% |   27.273% |           |
                        |   22.222% |   16.667% |           |
                        |     1.095 |    -0.874 |           |
------------------------|-----------|-----------|-----------|
           Column Total |        14 |        22 |        36 |
                        |   38.889% |   61.111% |           |
------------------------|-----------|-----------|-----------|


Statistics for All Table Factors


Pearson's Chi-squared test
------------------------------------------------------------
Chi^2 =  3.212009     d.f. =  1     p =  0.07309969

Pearson's Chi-squared test with Yates' continuity correction
------------------------------------------------------------
Chi^2 =  2.078091     d.f. =  1     p =  0.149427


       Minimum expect
```

```
        Asymptotic Wilcoxon-Mann-Whitney Test

data:  birth_year by species (Human, Other)
Z = -0.41011, p-value = 0.6817
alternative hypothesis: true mu is not equal to 0
```

On average Star Wars characters born on Naboo (M=55.0, SD=18.4) did not differ significantly with respect to their birth year, t(12)=0.02, p=.98, from Star Wars characters born on Tatooine (M=54.6, SD=29.5). This effect was negligible (Cohen‘s d=-.01). This suggests that the homeplanet does not influence the birth year of characters from Naboo and characters from Tatooine.

This is interesting, considering that Naboo is mainly featured in the first two prequels , while Tatooine is prominently featured as the home planet of two main characters, and throughout six Star Wars films.

Rounding

- R-Output might contain numbers such as this

```
p-value = 9.509e-07
```

```
95 percent confidence interval:
 -2.658704 -1.289520
```

- It‘s ugly to have numbers like this in a paper or a report
- So we round!

How accurate should my reported numbers be?

Size of the number	Round to…
Larger than 100, e.g. 134.67	The whole number, e.g. 135
10 – 100, e.g. 23.345	1 decimal place, e.g. 23.3
0.10 – 10, e.g. 0.57904	2 decimal places, e.g. 0.58
0.001 – 0.10, e.g. 0.0342985	3 decimal places, e.g. 0.034
Smaller than 0.001, e.g. 3.845e-5	As many digits, as needed for the number to be non-zero, e.g. 0.00004, or in case of p-values, report as < .001

- Don‘t report fractions for values which can only be whole! E.g. 15 participants, not 15.0 participants.

Statistical Abbreviations

- Abbreviations with Latin letters should be in italics
  - *SD* = Standard Deviation
- Abbreviations in Greek letters should not be in italics, if you can‘t write Greek letters, just write them out in full
  - X^2 = Chi Squared
- Use abbreviations in parentheses and the full names in continuous text

Reporting descriptive statistics

- Choose between reporting descriptive statistics in the continuous text or in a table.
- Don‘t double report!

On average, the participants were 34.6 years old (SD = 8.34).

Occupation	**N**	**Age**	
		M	*SD*
Student	57	22,3	3,68
Researcher	11	31,7	8,32
Lecturer	20	38,4	5,98
NA	4	76,1	9,23

How to report inferential statistics

- Report inferential statistics like this:
  - testStatisticName(degrees of freedom) = testStatisticvalue, p = pValue, effectSizeStatisticName = effectSizeValue
  - For a t-test: $t(23) = 2.45$, $p = .031$, $d = 0.54$

- Look up the appropriate test statistic to report either in the link given in the lecture slides or online. You can also refer to other publications using the same method.

Finding things in R-output

```
        Two Sample t-test

data:  birth_year by homeworld
t = 0.024251, df = 12, p-value = 0.9811
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -31.58869  32.29980
sample estimates:
   mean in group Naboo mean in group Tatooine
              55.00000               54.64444
```

- testStatisticName(degrees of freedom) = value, p = value, effectSizeStatisticName = value
- t(12) = 0.02, p = .98
- Effect sizes will have to be calculated with a separate function.

Some specifics on p-values

- Report numbers (such as p-values) which cannot be larger than 1 without the leading zero
  - $p = .034$
- Report exact p-values, even if your result is not significant
  - $p = .58$
- Some statistical programs don‘t give you the exact p-value if it is very small. When the p-value is very small you can report it as
  - $p < .001$

Reporting inferential statistics in text

- Don‘t just write numbers, explain what you are trying to show and interpret your results
- Start with a sentence about which test you have conducted, what you are trying to show (and maybe why you have chosen this test → report checking your assumptions)

Reporting inferential statistics in text

```
> model <- aov(birth_year ~ homeworld, data=starwars_stats_df)
> shapiro.test(residuals(model))

        Shapiro-Wilk normality test

data:  residuals(model)
W = 0.94615, p-value = 0.5026
```

```
> leveneTest(birth_year ~ homeworld, starwars_stats_df)
Levene's Test for Homogeneity of Variance (center = median)
      Df F value Pr(>F)
group  1  0.6629 0.4314
      12
```

- According to a Shapiro-Wilk-test, the residuals of the model comparing birth years of characters born on Tatooine and Naboo are normally distributed. A Levene-Test, $F(1, 12)=0.66$, $p = .43$, suggested that variances in the groups are equal, so a t-test for independent samples was conducted to examine the differences in birth years between Star Wars characters whose home world is Naboo and Tatooine.

Reporting inferential statistics in text

- Report the results of your main analysis, and possibly some descriptive statistics to fit with it.
- In the case of a t-test, which compares means, this could be means and standard deviations.

```
> t.test(birth_year ~ homeworld, starwars_stats_df, var.equal=TRUE)

        Two Sample t-test

data:  birth_year by homeworld
t = 0.024251, df = 12, p-value = 0.9811
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -31.58869  32.29980
sample estimates:
   mean in group Naboo mean in group Tatooine
              55.00000               54.64444
```

- On average Star Wars characters born on Naboo (M=55.0, SD=18.4) did not differ significantly from Star Wars characters born on Tatooine (M=54.6, SD=29.5), with respect to their birth year, t(12)=0.02, p=.98.

Reporting inferential statistics in text

- Report effect sizes, when possible. They enable comparison across studies.
  - This effect was negligible (Cohen‘s d=-.01).

```
> cohen.d(birth_year ~ homeworld, starwars_stats_df)

Cohen's d

d estimate: 0.01352672 (negligible)
95 percent confidence interval:
     lower      upper
-1.201770  1.228823
```

Interpretation

- Don‘t forget to interpret your findings.
  - This suggests that the homeplanet does not influence the birth year of characters from Naboo and characters from Tatooine.
- You can specify your interpretation further by highlighting differences between the groups you compared.
  - This is interesting, considering that Naboo is mainly featured in the first two prequels , while Tatooine is prominently featured as the home planet of two main characters, and throughout six Star Wars films.

Reporting Non-parametric Tests

- This procedure works similarly for different kinds of tests
  - For non-parametric tests, often no degrees of freedom are given.
    - According to the Wilcoxon-Ranksum-test, there was no significant difference, Z=0.33, p=.74, between the birth year of characters from Naboo and Tatooine,

```
> wilcox_test(birth_year ~ homeworld, starwars_stats_df)

        Asymptotic Wilcoxon-Mann-Whitney Test

data:  birth_year by homeworld (Naboo, Tatooine)
Z = 0.33444, p-value = 0.738
alternative hypothesis: true mu is not equal to 0
```

Reporting Chi-Square Tests (Assumptions)

- Hypothesis: Gender among characters from Naboo is different from characters from Tatooine.
- Assumptions:

```
> contingency_table <- xtabs(~homeworld+gender, data=starwars_stats_df)
> contingency_table
          gender
homeworld  feminine masculine
  Naboo           3         6
  Tatooine        2         8
```

```
> chisq_result$expected
          gender
homeworld  feminine masculine
  Naboo    2.368421  6.631579
  Tatooine 2.631579  7.368421
```

  - Since the cell values in the contingency table were smaller than 5 both for the expected and the observed values, so we used a Fisher's Exact-Test instead of th Chi-Square-Test.

Reporting Chi-Square Tests (descriptive stats)

- Hypothesis: Gender among characters from Naboo is different from characters from Tatooine.

- Report descriptive statistics in a table (e.g. the contingency table) or in textual form
  - Among the Star Wars characters whose home planet is Naboo, 6 identified as masculine, and 3 as feminine, while for Tatooine, there were 2 feminine and 8 masculine characters.

Reporting Chi-Square Tests (inferential stats)

- Hypothesis: Gender among characters from Naboo is different from characters from Tatooine.

```
> chisq_result

	Pearson's Chi-squared test with Yates' continuity correction

data:  contingency_table
X-squared = 0.018849, df = 1, p-value = 0.8908
```

- There was no significant difference in gender among characters from Naboo and Tatooine, $X^2(1)=0.02$, $p=.89$.

Reporting Fisher's Exact Tests (inferential stats)

- Hypothesis: Gender among characters from Naboo is different from characters from Tatooine.

```
> fisher.test(contingency_table)

        Fisher's Exact Test for Count Data

data:  contingency_table
p-value = 0.6285
alternative hypothesis: true odds ratio is not equal to 1
95 percent confidence interval:
  0.163118 30.218011
sample estimates:
odds ratio
  1.927386
```

- According to the Fisher's exact test, there was no significant difference in gender among characters from Naboo and Tatooine, p=.63.

How should you report the results?

```
        Two Sample t-test

data:  Petal.Length by Species
t = -12.604, df = 98, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -1.495426 -1.088574
sample estimates:
mean in group versicolor  mean in group virginica
                   4.260                    5.552
```

https://pingo.coactum.de/426954

1) The mean petal length of versicolor iris is significantly smaller than the petal length of virginica iris, $p<0.001$.
2) A t-test showed that petal length of versicolor iris (M=4.26) differs significantly from petal length of virginica iris (M=5.55), $t(98)=-12.6$, $p < 0.001$
3) A t-test showed that petal length of versicolor iris (M=4.3) differs significantly from petal length of virginica iris (M=5.6), $t(-12.6)=98$, $p < 0.001$
4) The petal length of versicolor iris differs significantly from the petal length of virginica iris $t=-12.6$, $df=98$, $p = 2.2e-16$.

More Hints on Reporting Inferential Stats

- Depending on how many analyses you report, you may cut back on the detail and elaboration for something which is not the focus of your work
- When reporting in German, remember to use commas as the decimal separator, everything else stays the same

In a nutshell

- A good plot can say more than a thousand numbers, but graphs can also mislead the viewer or hide information
- The ggplot2-package offers a wide variety of plots for different situations and can be customized to get publication-ready-plots
- Round the numbers you report (to which decimal place depends on the size of the number)
- Report sensible descriptive statistics as a table or as text
- Report relevant numbers for inductive statistics (see guidelines)
- Interpret your results in textual form