Intro to R for Biologists
Session 4
Data Visualisation

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INTRO TO R FOR BIOLOGISTS

- **Data Visualisation**
    - Intro to ggplot2
    - Base R plotting vs ggplot2
    - ggplot2 syntax (demo)
    - Intro to factors
    - Problem set from Session 3
    - Merging and reshaping data.frames (demo)
    - Dot/box/bar plots (demo with Covid vaccine data)
    - Practical (breakout room)
        - OWID Covid data

How to choose the graph type

- Human perception is not uniformly good at distinguishing different physical aspects – e.g. length is better than volume
- Factors to help decide on viz:
  - Information – detail or summary?
  - Number of dimensions
  - Comparisons
  - Continuous vs categorical data
  - Scale – e.g. linear or log?
  - Shape and size
  - Colours – distinct? Colour-blind friendly?
  - Legends and labels
  - Subplots
- From Data to Viz – A handy tool to help you decide

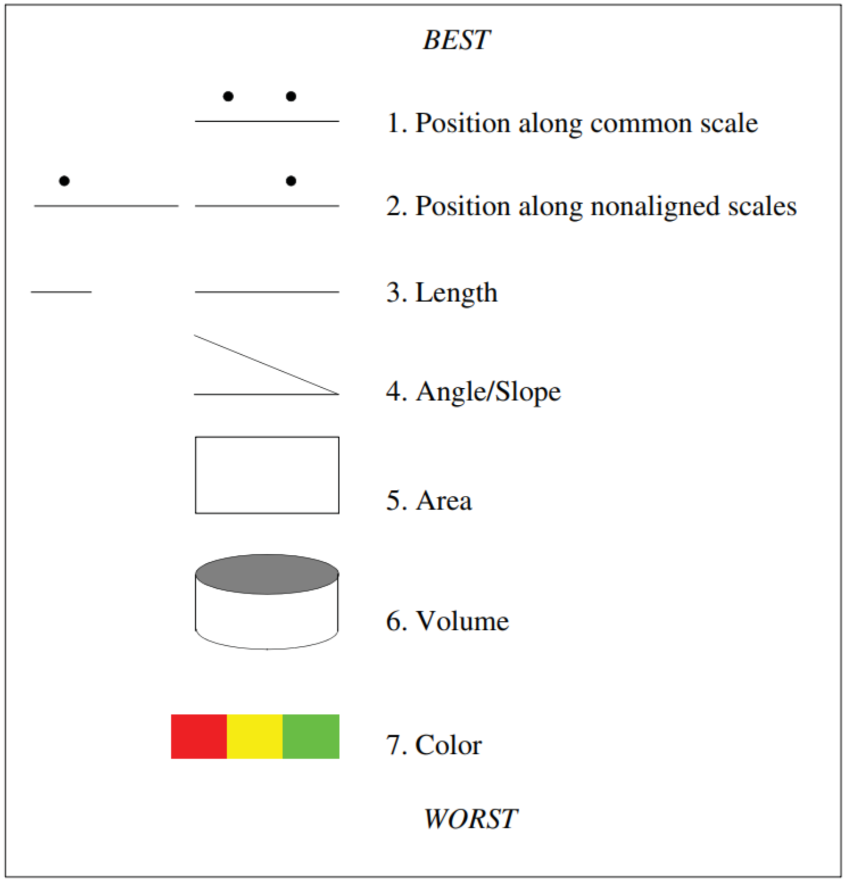
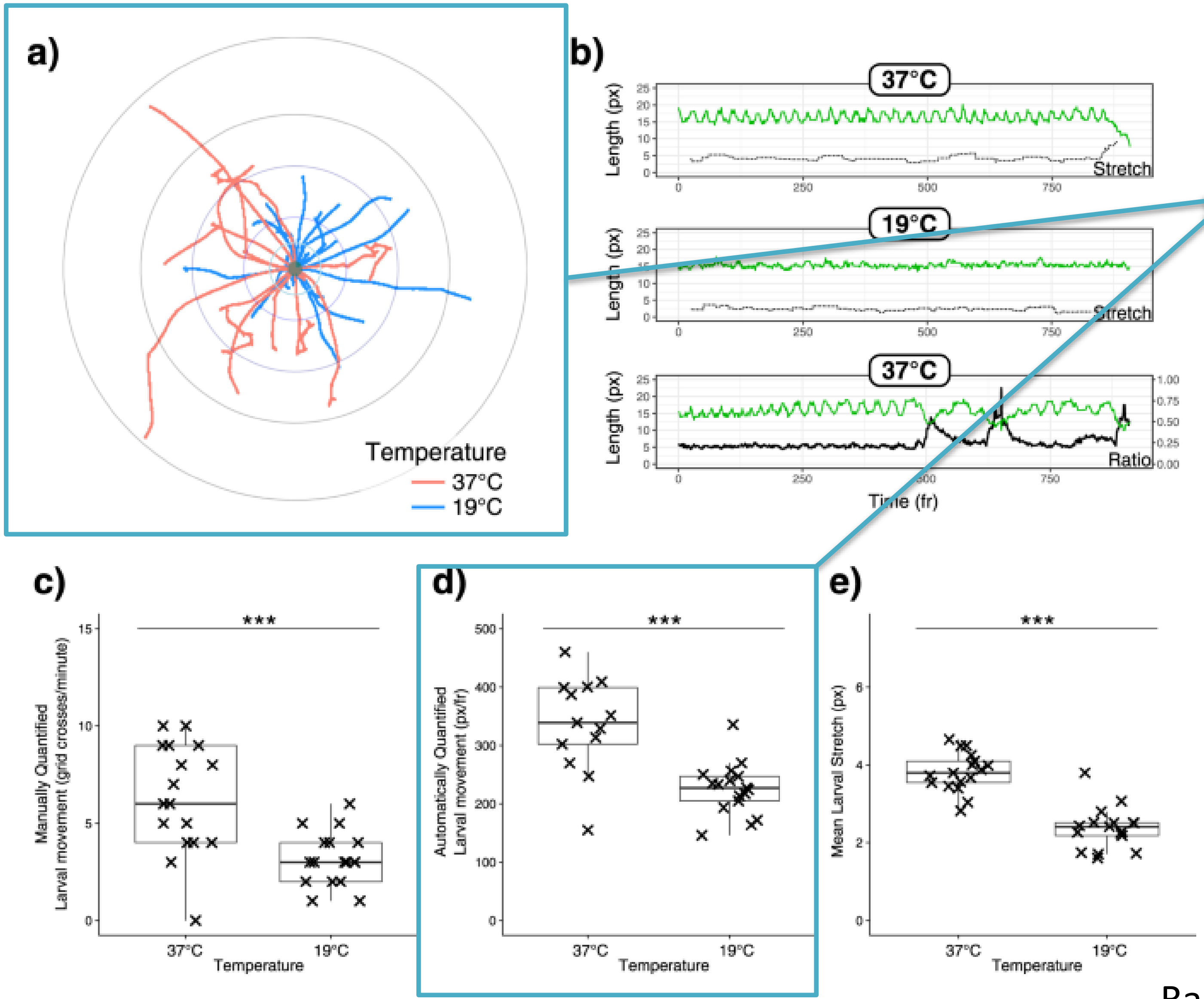

BEST
1. Position along common scale
2. Position along nonaligned scales
3. Length
4. Angle/Slope
5. Area
6. Volume
7. Color
WORST

Figure 10.3 *Cleveland graphic elements hierarchy*

The Grammar of Graphics, 2005

How to choose the graph type



Using the same data but making different points

Rao et al., *Sci Rep*, 2019

Visualising data in R

- Base R plotting (e.g. plot() function)

```
plot(x = iris$Sepal.Length, y =
iris$Petal.Length, col =
iris$Species)
```

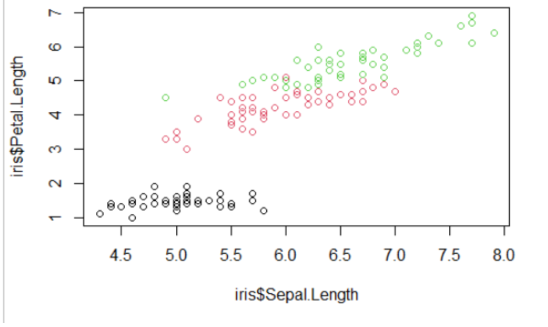
- ggplot2 package

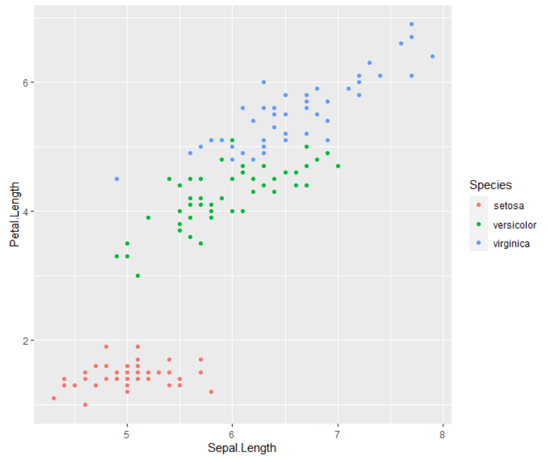
```
ggplot(iris, aes(x = Sepal.Length,
y = Petal.Length, colour =
Species)) + geom_point()
```

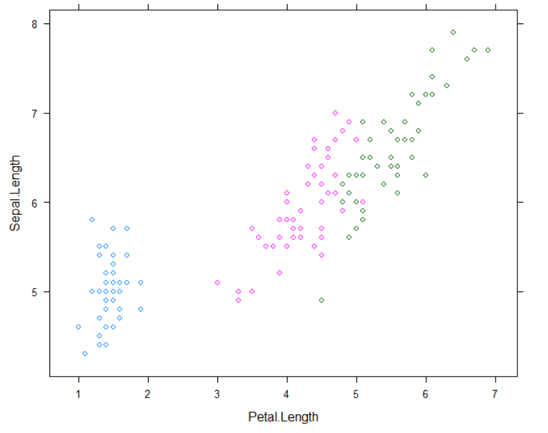
- Lattice package

```
xyplot(Sepal.Length ~ Petal.Length,
data = iris, groups = Species)
```

- Grid package
  - Low level plotting (both ggplot2 and lattice built on grid graphics)





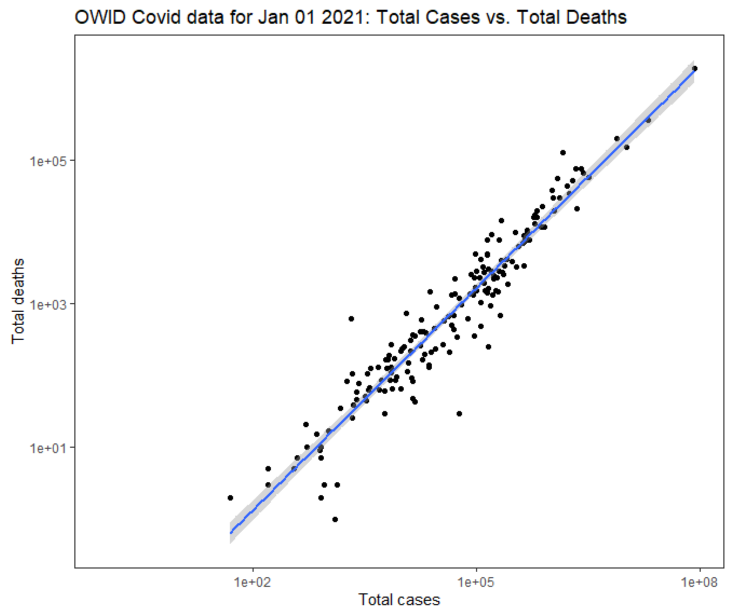


Graphics devices in R

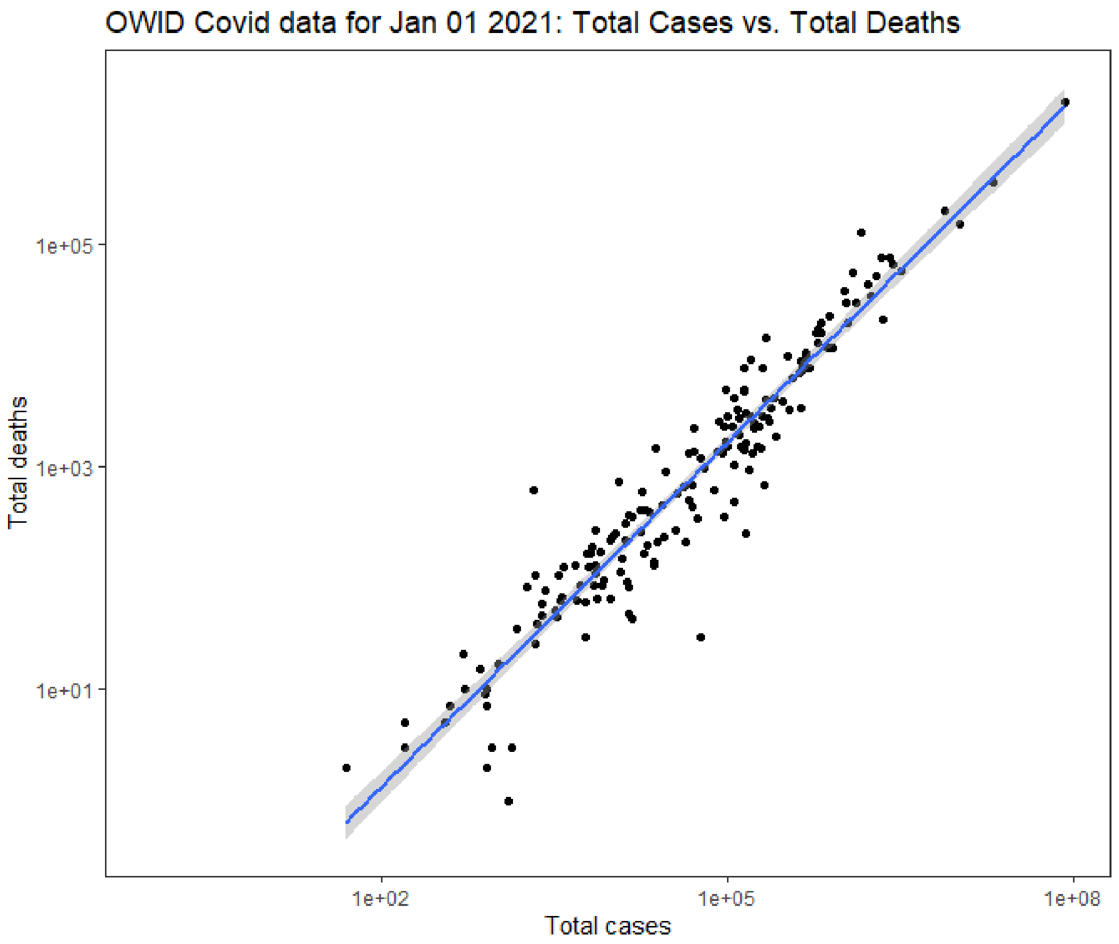
- The plotting window in Rstudio
  - Needs to be saved manually
  - Size of the figure can be adjusted manually
  - Can be copied to clipboard from RStudio
  - For quick exploratory visualisation

- A file (svg, png, pdf, tiff, jpeg, bmp)
  - Saved to file from code
  - Size of the figure can be specified in the code
  - For creating reproducible figures
  - `png(), pdf(), svg(), ggsave()` are functions to save plots
- Start or close graphical devices with `dev.new()` or `dev.off()` respectively
  - Tip: If your plot is not showing up on the window or file that you are expecting it to, you are probably drawing on the wrong device. `dev.off()` may solve this issue.

Building a graph step-by-step with ggplot2



```
ggplot(owid_covid_newyear, aes(x = tot
    geom_point() +
    scale_x_log10() +
    scale_y_log10() +
    geom_smooth(method = "lm") +
    ggtitle("OWID Covid data for Jan (
    xlab("Total cases") +
    ylab("Total deaths") +
    theme_bw() +
    theme(panel.grid = element_blank()
```



ggplot2 syntax

```
ggplot(data, mapping) +
    geom_point(mapping, stat, position, colour, fill, shape,
size, alpha) +
    coord_cartesian() +
    scale_colour_discrete() +
    facet_wrap() +
    theme_bw() +
    ggtitle() +
    labs()
```

Global mapping – applies to the entire plot

Geom-specific

Where,

```
mapping = aes(x, y, colour, fill, shape, size, alpha)
```

Note: Colour, shape, alpha, etc. can be passed

1) to the mapping argument - changes attributes based on some variable in the dataset itself (e.g. colour = location, or shape = hdi_class)
2) directly as specific arguments in the geom function - changes the attributes to fixed values that are provided separately from the data (e.g. colour = “red” or size = 10)

Let's explore practically

How to plot your data?

The most common plots in publications:

box plots/violin plots, bar plots, dot plots, histograms/density plots, line graphs, networks, heatmaps, PCA, etc.

Hint: choose the appropriate representation based on the type of data you have.

Typical data types: numeric, categoric, maps, network, time series

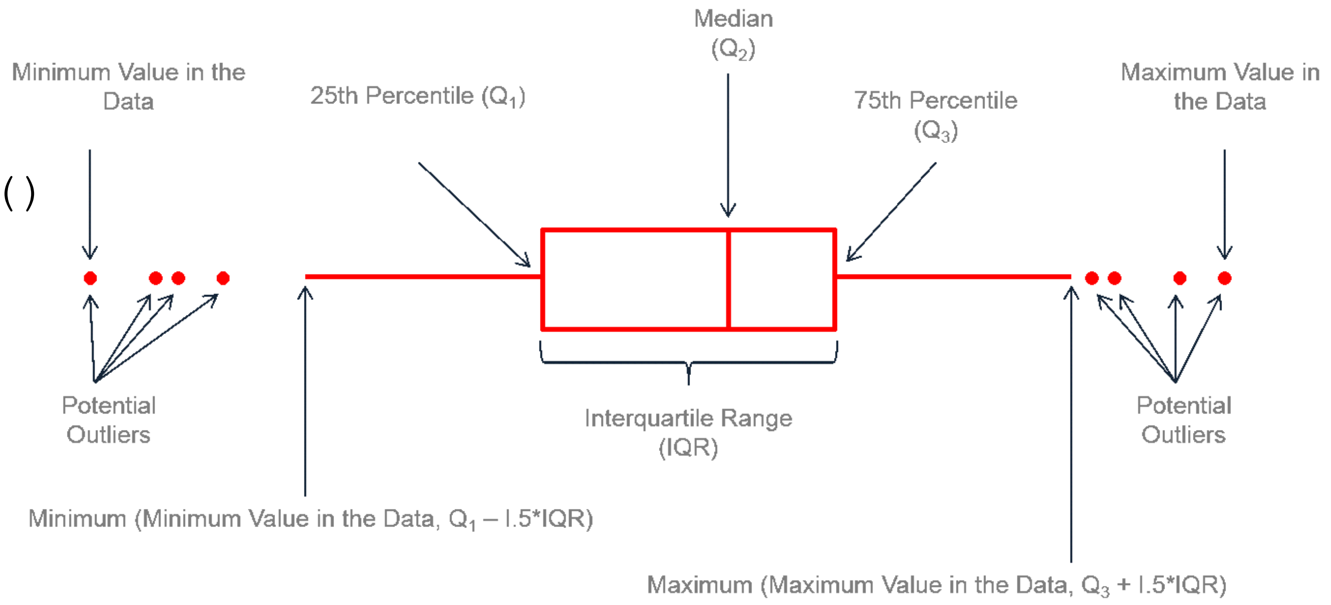
+combinations of those

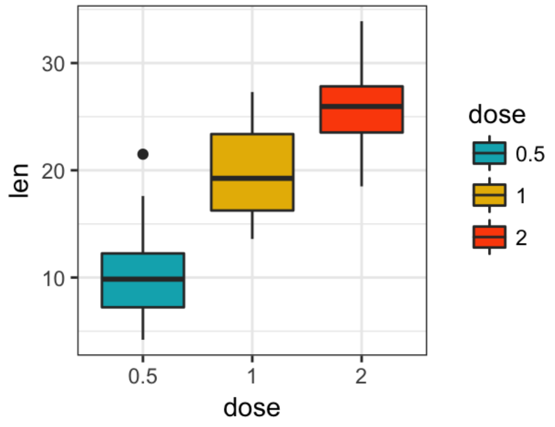
From Data to Viz – Decision tree to choose an appropriate chart type for your data

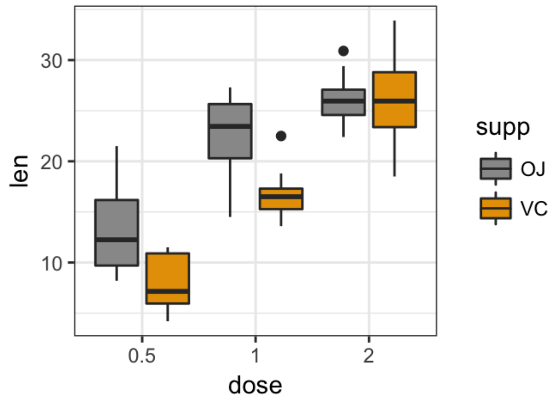
Plotting grouped data

Box-plots

`geom_boxplot()`


Median (Q_2)
Minimum Value in the Data
25th Percentile (Q_1)
75th Percentile (Q_3)
Maximum Value in the Data
Potential Outliers
Interquartile Range (IQR)
Potential Outliers
Minimum (Minimum Value in the Data, Q_1 – 1.5*IQR)
Maximum (Maximum Value in the Data, Q_3 + 1.5*IQR)

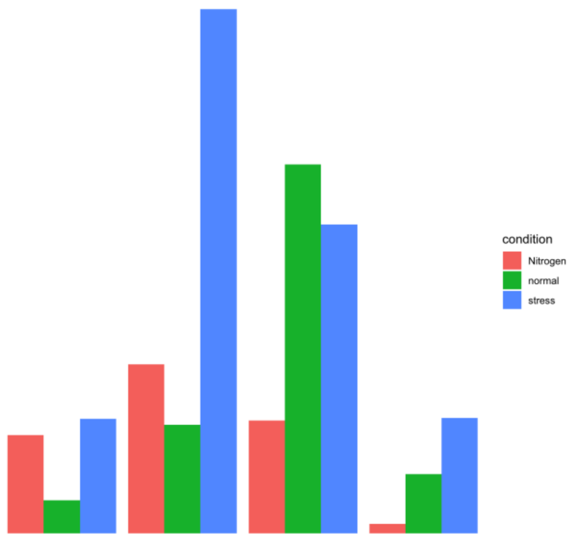




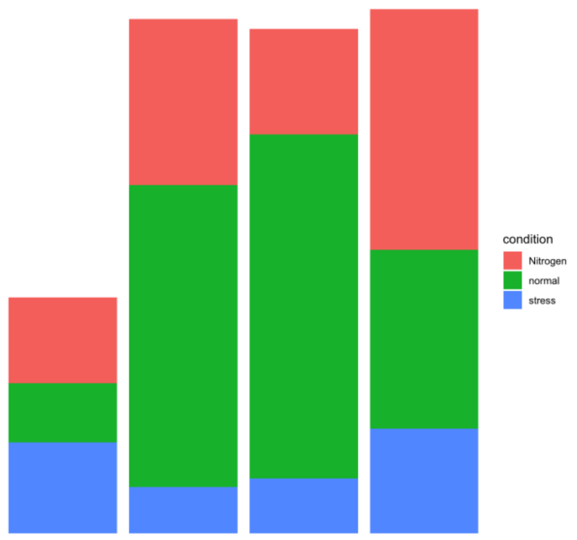
Plotting grouped data

Bar plots

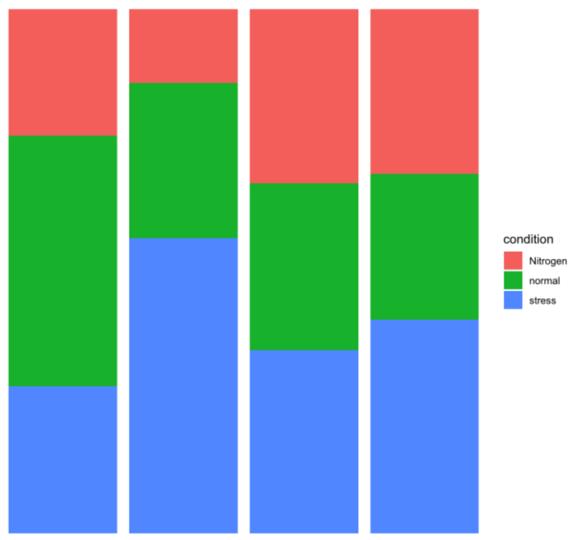
`geom_bar(position=...)`



`position="dodge"`



`position="stack"`

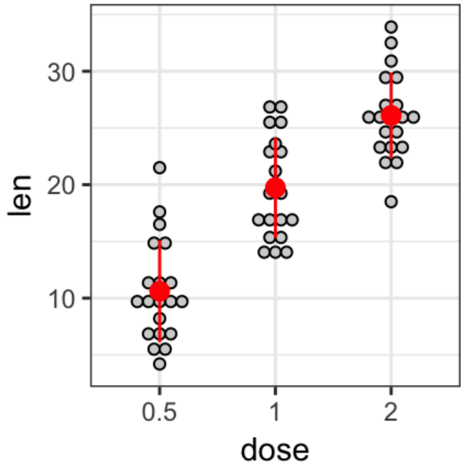


`position="fill"`

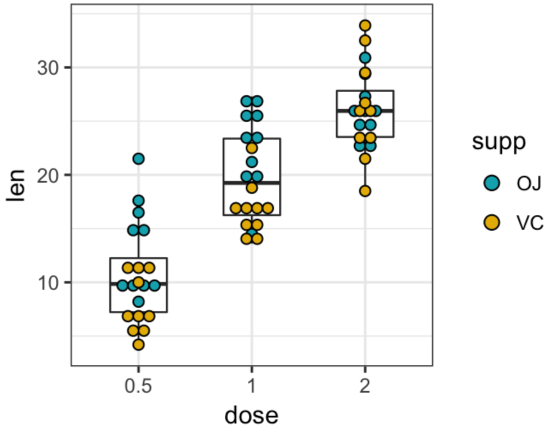
Plotting grouped data

Dot plots

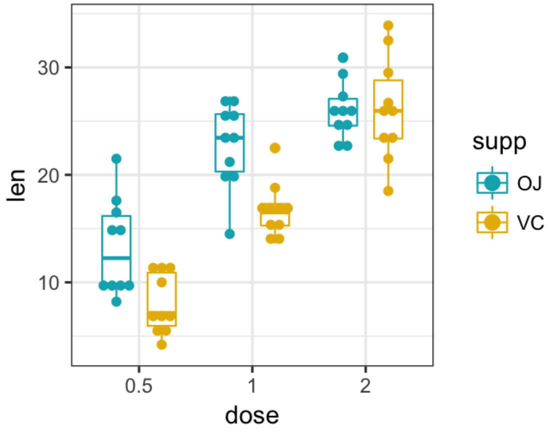
`geom_dotplot()`



```
ggplot(…)+
geom_dotplot(…)
```



```
ggplot(…)+
geom_boxplot(…)+
geom_dotplot(…)
```



```
ggplot(…)+
geom_boxplot(position = "dodge")+
geom_dotplot(…)
```

Understanding factors

- Factors are used to represent categorical data.
- Factors don't have to be binary! You can have many categories.
- When you import a table to R, your categorical columns are treated as characters ("Germany", "Belgium", "Germany", etc.) or numbers (1, 2): using safest option - `stringsAsFactors = FALSE` argument in `read...` functions.
- You know where your categories are presented. Convert the relevant column into factor:

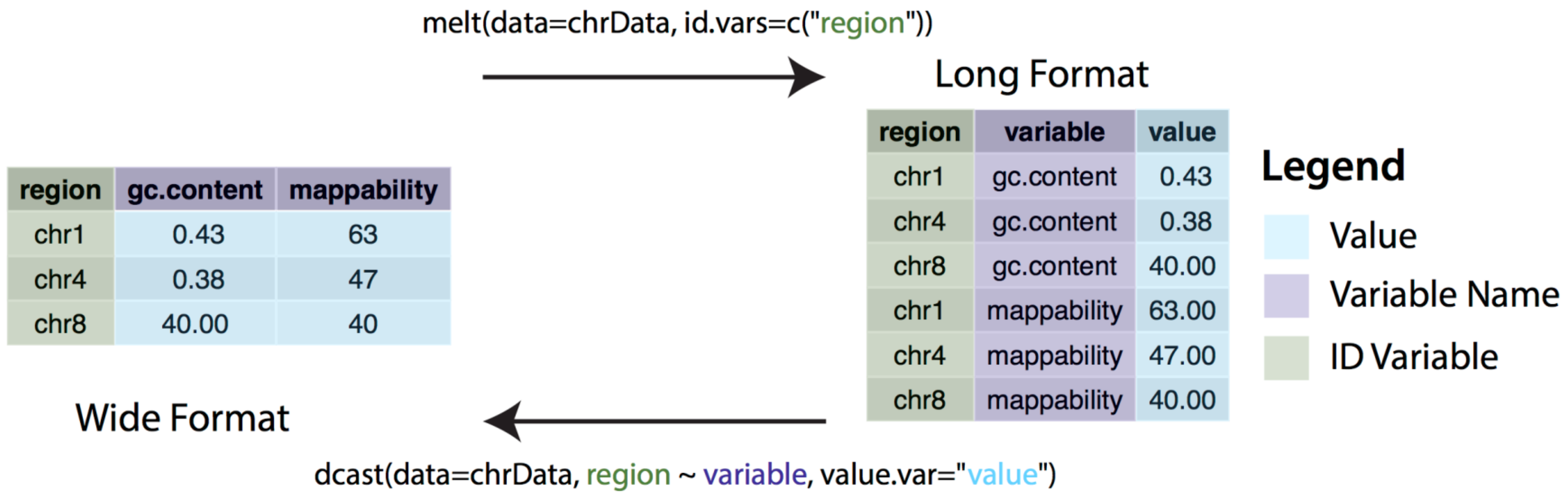
  ```
  df1$col1 <- as.factor(df1$col1)
  ```
- Factors have levels, you can check all the categories within the factor:

  ```
  levels(df1$col1)
  ```

You need to have your categories as factors in order to analyse and to plot the data by group!

Reshaping data

```
library(data.table)
```



```
melt(data=chrData, id.vars=c("region"))
```

Long Format

region	variable	value
chr1	gc.content	0.43
chr4	gc.content	0.38
chr8	gc.content	40.00
chr1	mappability	63.00
chr4	mappability	47.00
chr8	mappability	40.00

Legend

🟦	Value
🟪	Variable Name
🟩	ID Variable

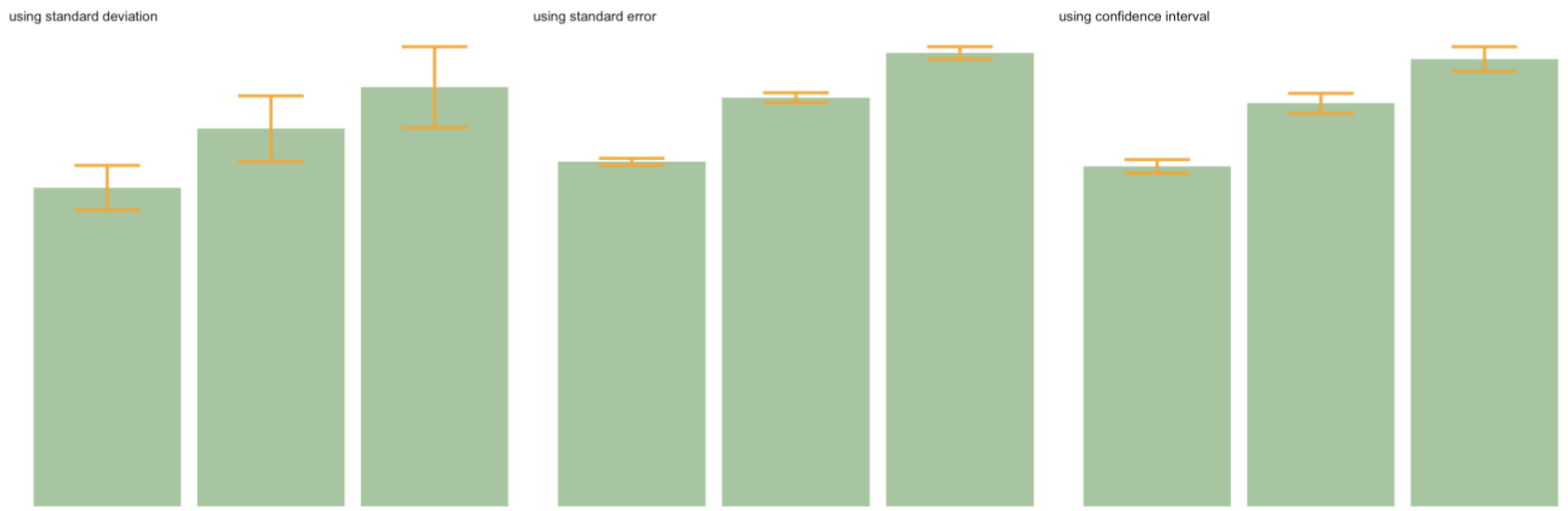
region	gc.content	mappability
chr1	0.43	63
chr4	0.38	47
chr8	40.00	40

Wide Format

```
dcast(data=chrData, region ~ variable, value.var="value")
```

To plot by groups we need our data to be in a long format!

Error bars – geom_bar()



```
ggplot(data)
+ geom_bar( aes(x=group, y=mean), stat="identity",
fill="forestgreen", alpha=0.5)
+ geom_errorbar( aes(x=group, ymin=mean-sd, ymax=mean+sd),
width=0.4, colour="orange", alpha=0.9, size=1.5) +
ggtitle("using standard deviation")
```

SD, SE, CI

- Standard Deviation (SD) represents the amount of dispersion of the variable. Calculated as the root square of the variance:

```
sd <- sd(vec)
sd <- sqrt(var(vec))
```

- Standard Error (SE) is the standard deviation of the vector sampling distribution. Calculated as the SD divided by the square root of the sample size.

```
se = sd(vec) / sqrt(length(vec))
```

- Confidence Interval (CI).

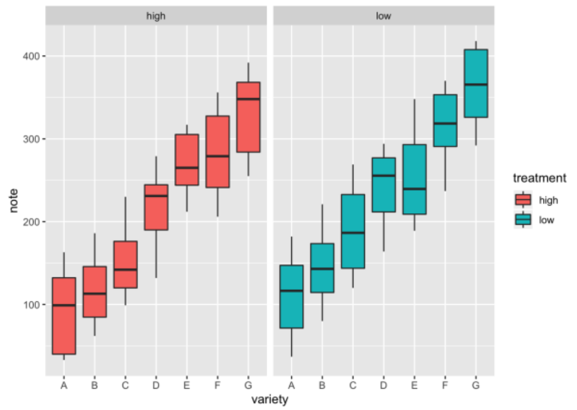
This interval is defined so that there is a specified probability that a value lies within it. It is calculated as t * SE. Where t is the value of the Student's t-distribution for a specific alpha.

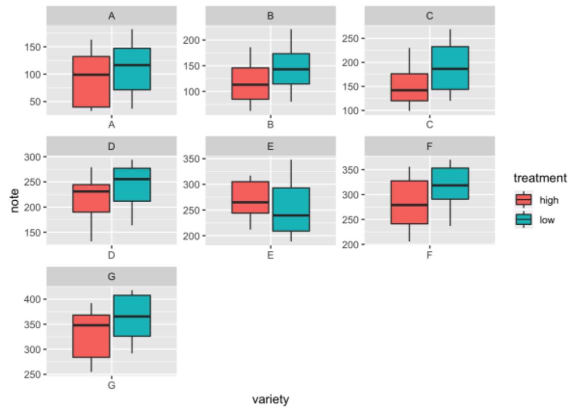
```
alpha=0.05
t=qt((1-alpha)/2 + .5, length(vec)-1)    # tend to 1.96 if
sample size is big enough
CI=t*se
```

Hint: easier way to add error bars without calculation! Explore **`stat_summary()`**

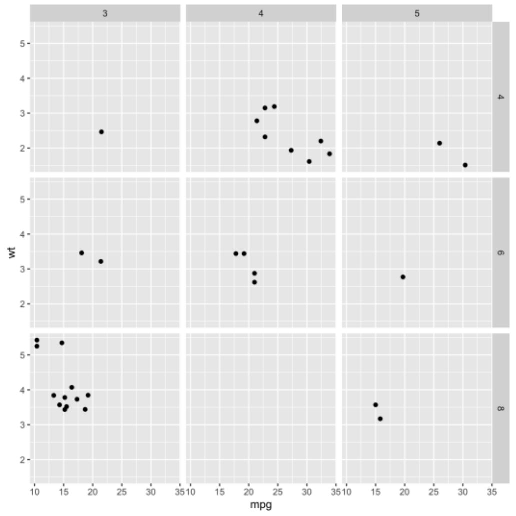
Faceting

`facet_wrap(~var)` builds a new chart for each level of a categorical variable





`facet_grid(var1~var2)` builds one chart for each combinations of 2 categorical variables



Let’s explore practically

Let’s explore practically

Address the tasks in breakout rooms!

Useful references

- R Graph Gallery – Examples of the kinds of graphs and plots possible in R (+ the code to create them)
- The Grammar of Graphics (Leland Wilkinson) – Theory of graphical visualisation (SpringerLink book – free access through Uni of Oxford Bodleian subscription)
- ggplot2 reference – Help and cheatsheet
- ggplot2 extensions – Additional packages that extend ggplot2 functionality
- From Data to Viz – Decision tree to choose an appropriate chart type for your data