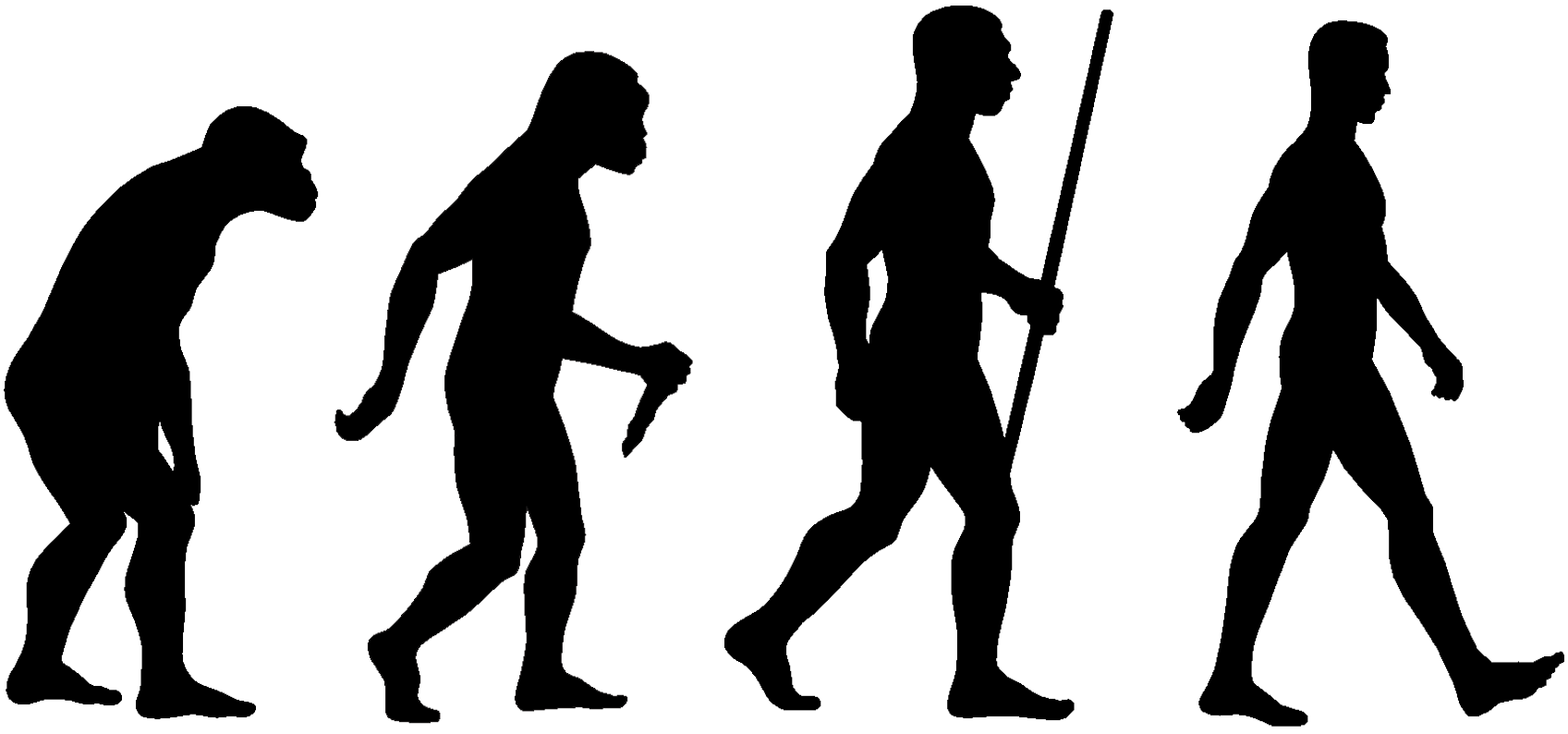
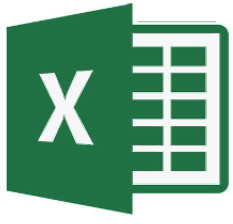
R^4H_2O: R for Water Professionals

Dr Peter Prevos

My Data Science Evolution





Day 1 Program

- Data science principles
- Basics of R and Tidyverse
- Water quality case study
- Lunch
- Data visualisation
- Data products

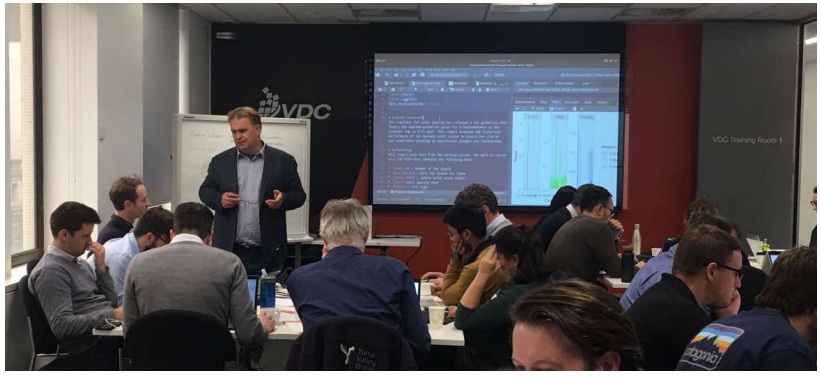
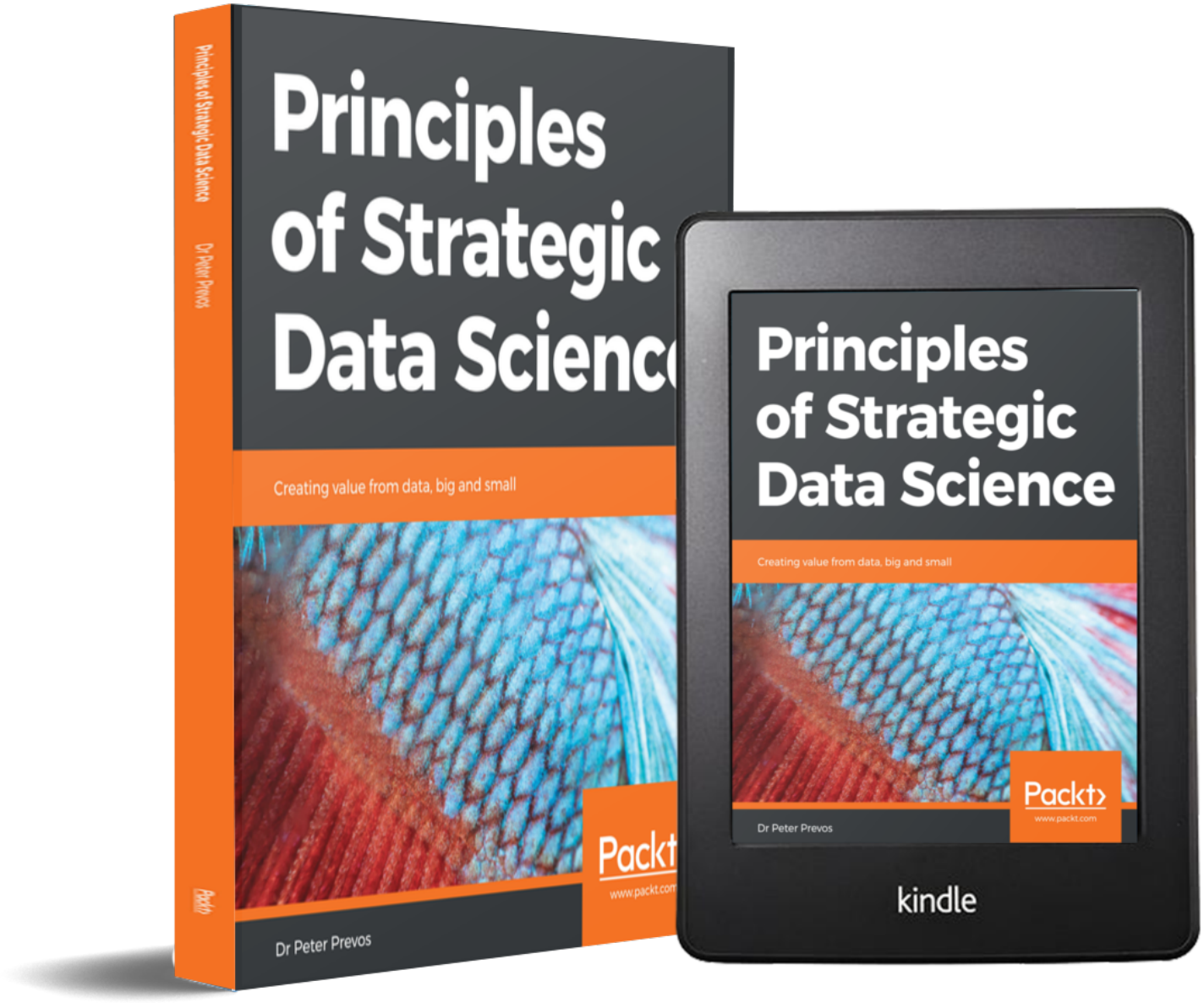


Figure 1: R for Water Professionals workshop (Melbourne, 2019).

Resources

Figure 2: Register to get access to the on-line syllabus: https://leanpub.com/c/R4H2O/c/waterra

Principles of Data Science



What is Data Science?

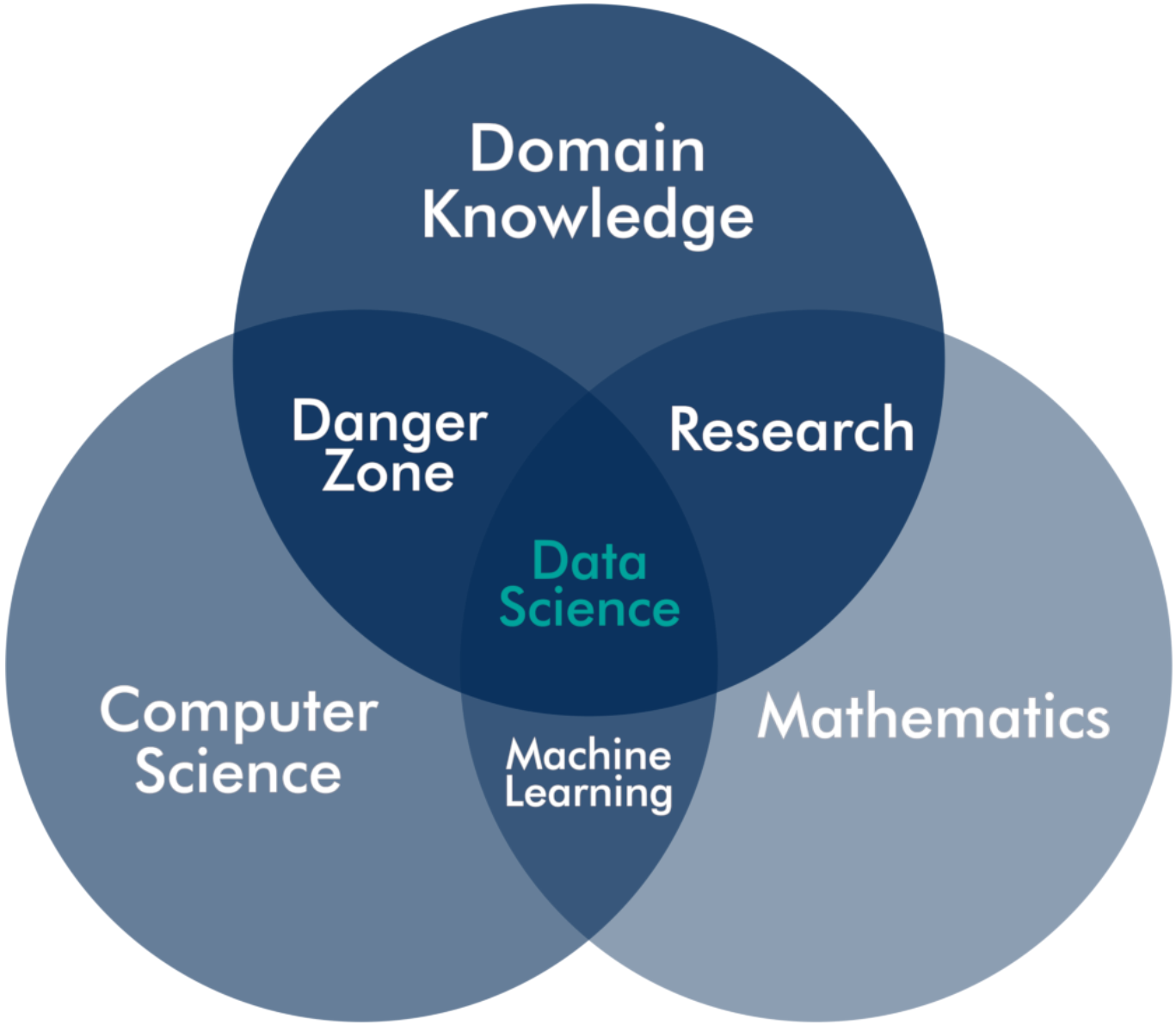


Figure 3: The Conway Venn Diagram (Drew Conway, 2013).

What is good data science?

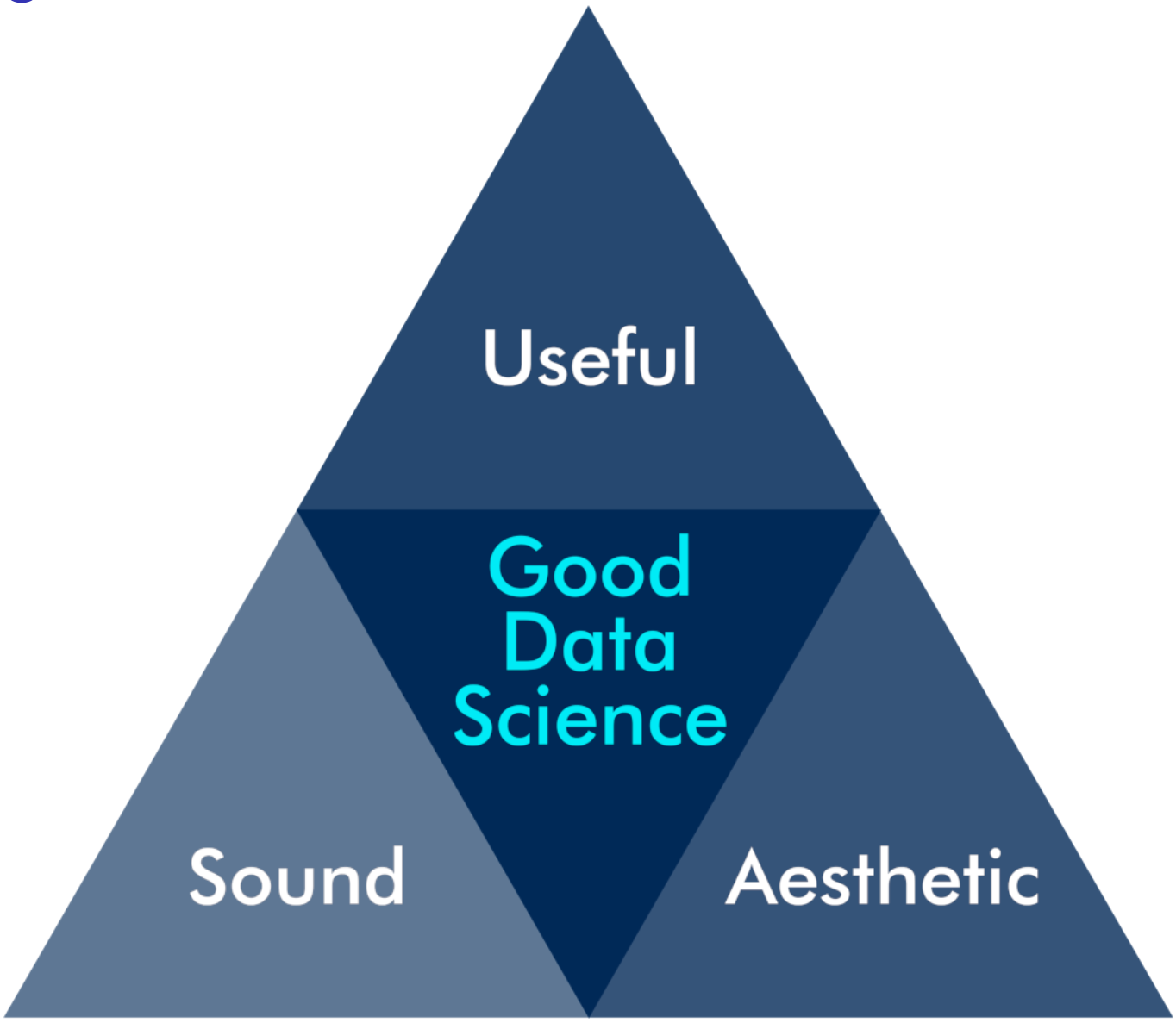


Figure 4: The Vitruvian triangle of good data science.

What is useful data science?

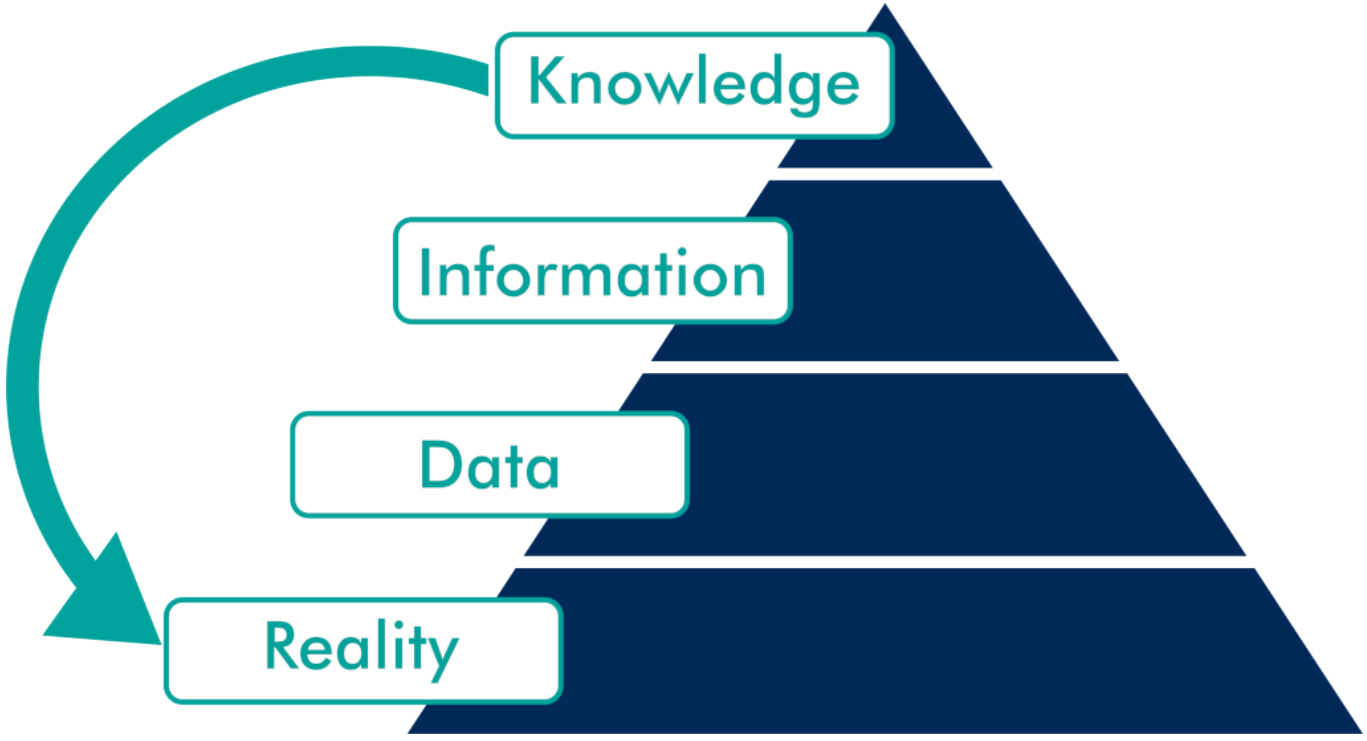


Figure 5: Modified version of the DIKW model.

What is sound data science?

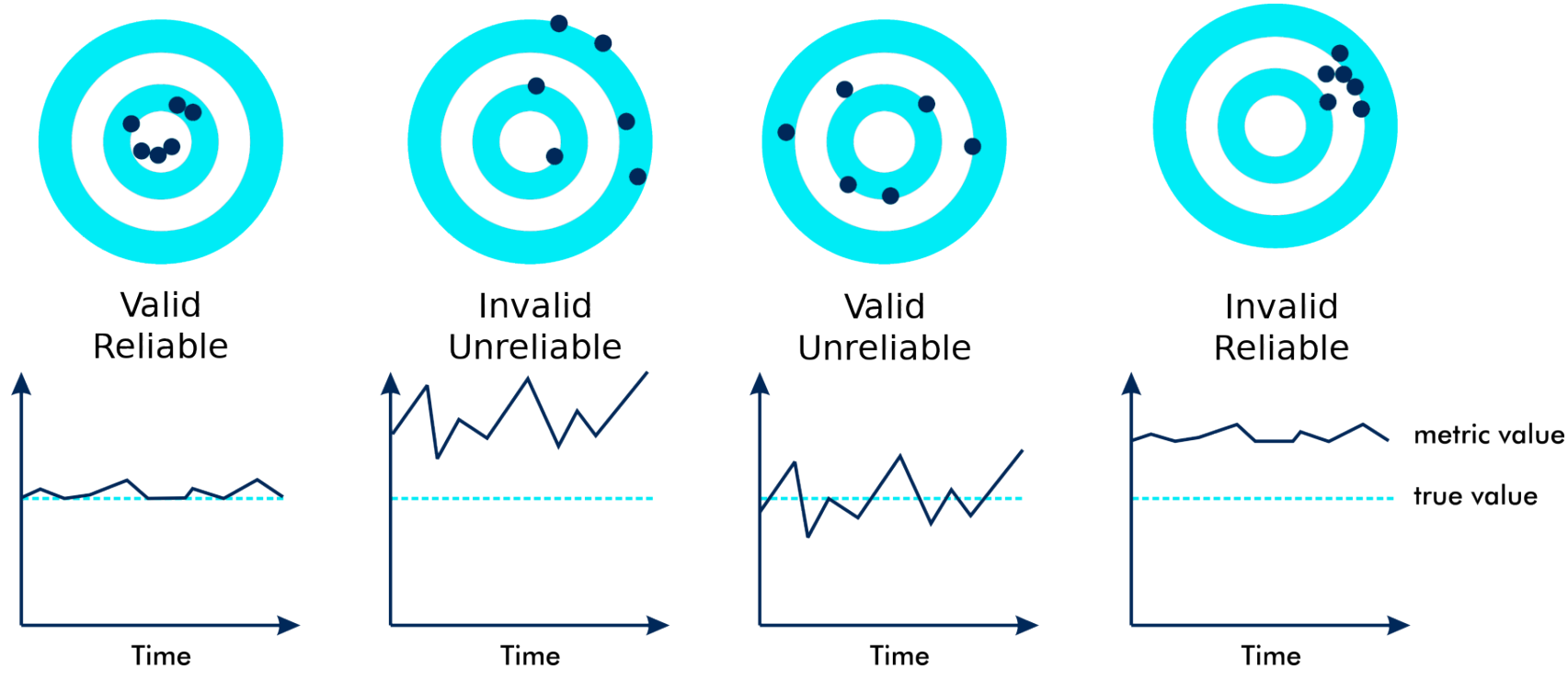


Figure 6: Validity and reliability.

What is sound data science?

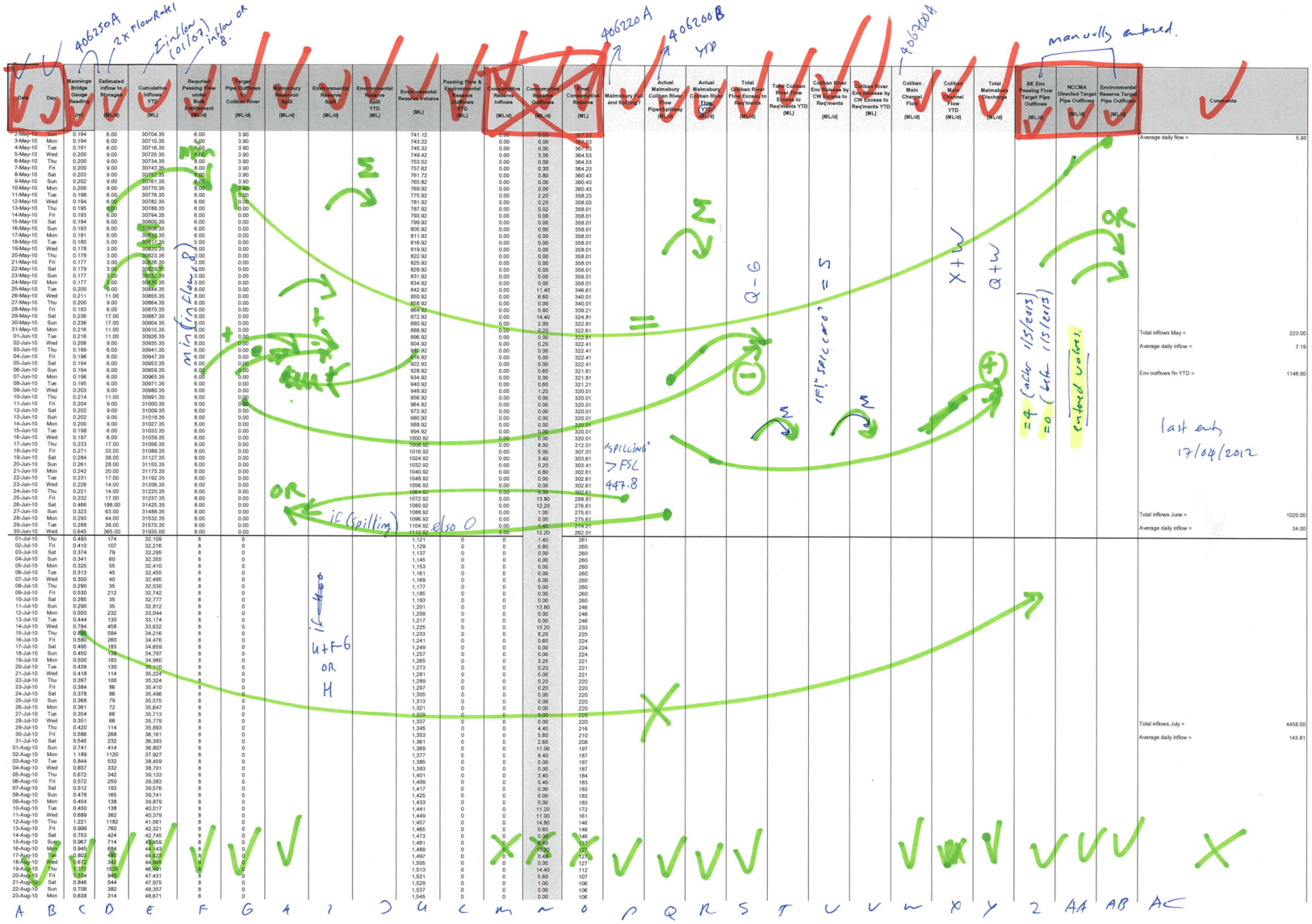


Figure 7: Reverse-engineering a spreadsheet.

What is sound data science?

Reproducible code:

```
reserve %>%
    select(Date, River_Flow, Natural_Flow, ERV) %>%
    mutate(Date = as.Date(Date, format = "%d %m %Y")) %>%
    gather(Source, Value, -Date) %>%
    mutate(type = factor(Source == "ERV"),
           type = fct_recode(type, Flow = "FALSE",
                                   Volume = "TRUE")) %>%
    ggplot(aes(Date, Value, col = Source)) +
    geom_line() +
    facet_grid(type~., scales = "free_y")
```

What is aesthetic data science?

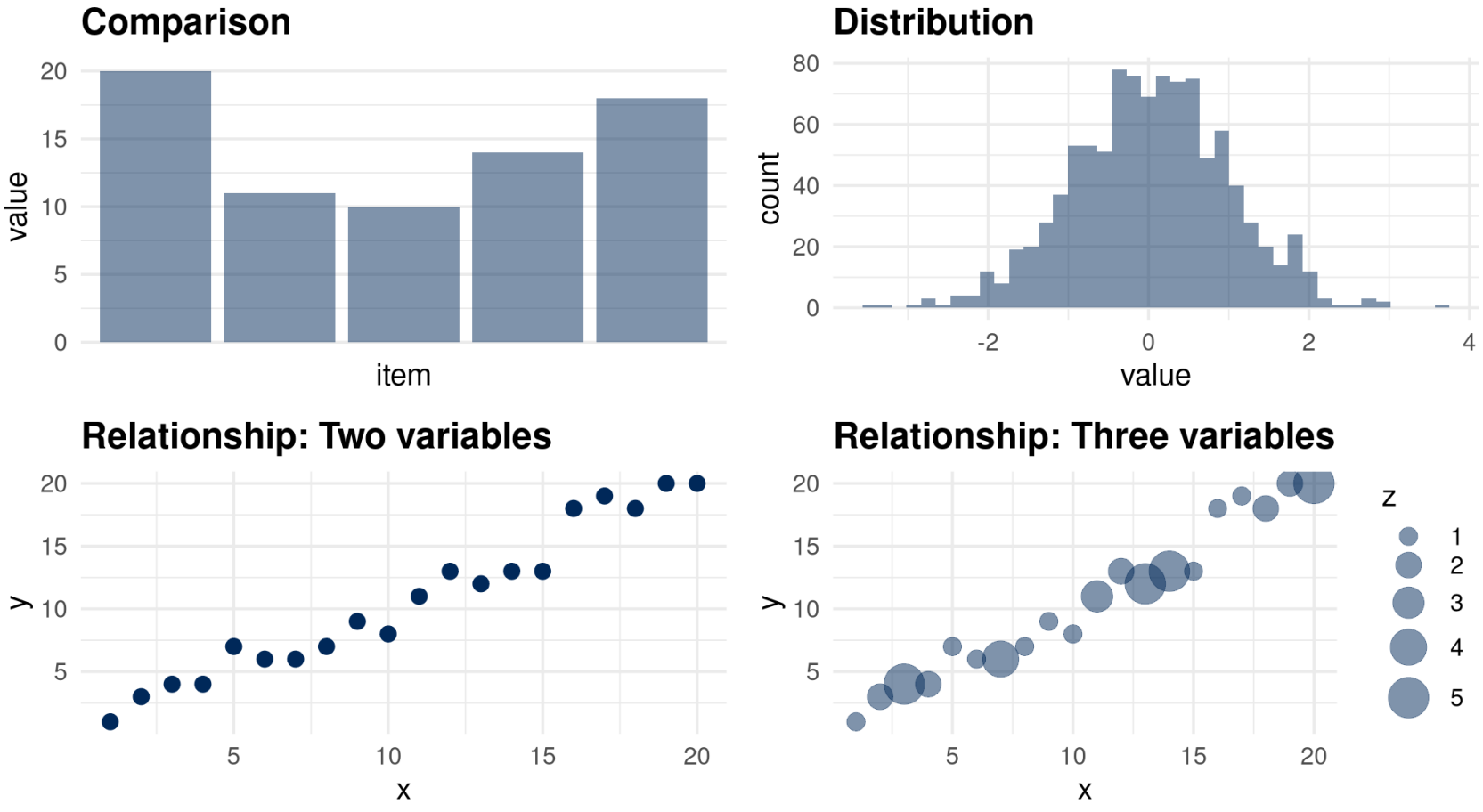


Figure 8: Data visualisation is about telling stories.

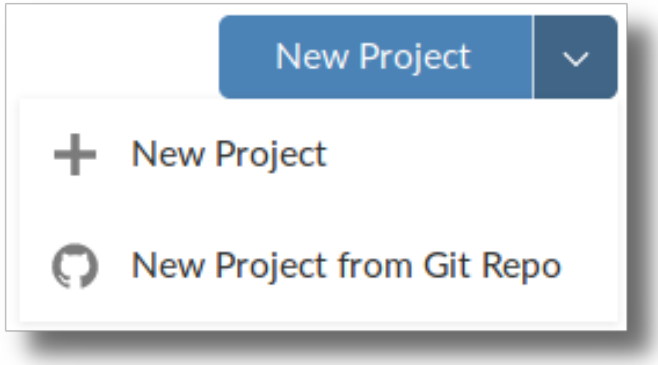
Configure R Studio

Desktop

- Install R and RStudio
- Download and unzip materials from https://github.com/pprevos/r4h2o
- *File* > *Open Project*
- Open the `r4h2o.Rproj` file in the downloaded folder

Cloud

- Sign-up at: rstudio.cloud
- *New Project* > *New Project from Git Repo*



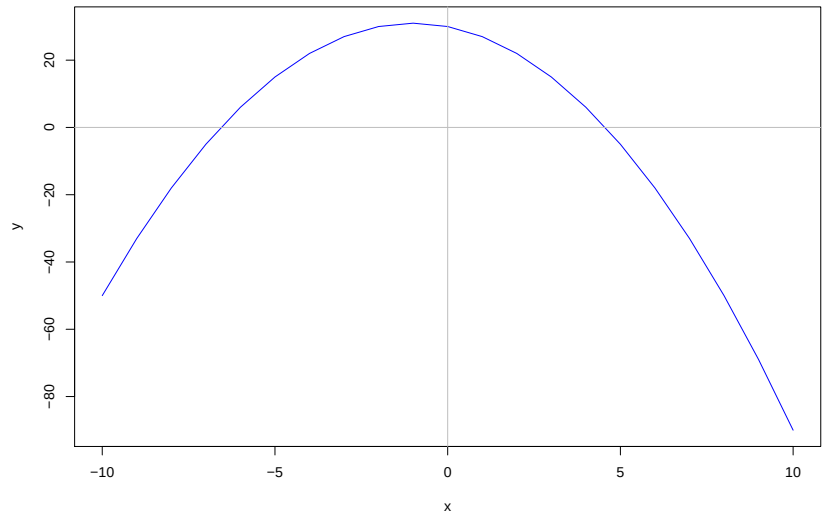
- Enter GitHub URL: https://github.com/pprevos/r4h2o

Console exercise

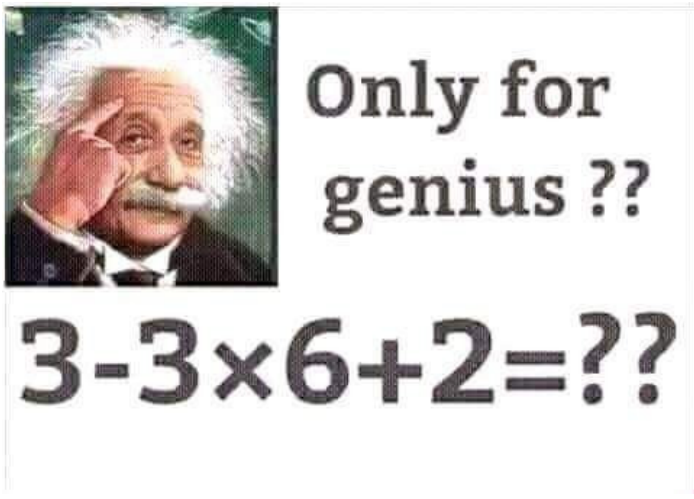
1. Enter sample code into the console (see syllabus for examples)
2. Observe the output in the console
3. Observe the environment
4. Use ↑↓ to scroll history
5. Use TAB for completion
6. Play with variations

```
x <- -10:10
y <- -x^2 -2 * x + 30

plot(x, y, type = "l",
     col = "blue")
abline(h = 0, col = "grey")
abline(v = 0, col = "grey")
```



R is Meme-Proof



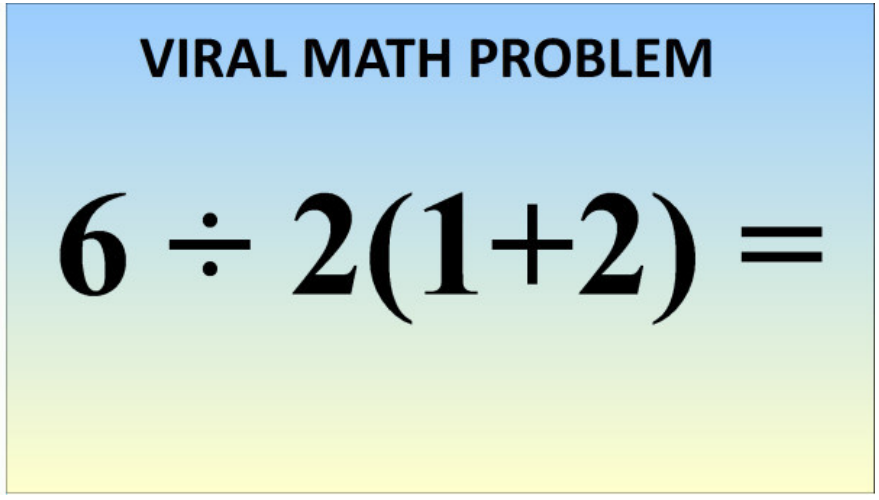
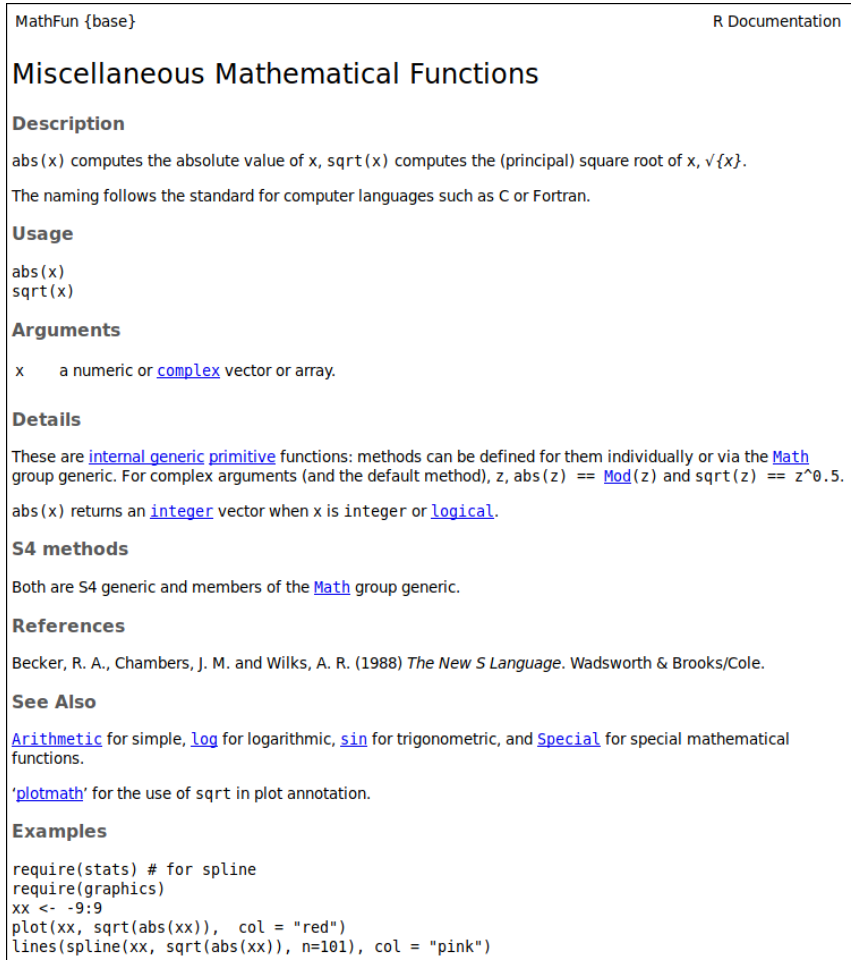


Figure 9: Aritmetic memes.

Finding Help

- Built-in *help()* function
- Cheat sheets (RStudio and Tidyverse websites)
- Twitter #rstats
- Reddit rstats, rlanguage
- stackoverflow.com
- Google the problem



MathFun {base} R Documentation

Miscellaneous Mathematical Functions

Description

`abs(x)` computes the absolute value of x, `sqrt(x)` computes the (principal) square root of x, $\sqrt{x}$.

The naming follows the standard for computer languages such as C or Fortran.

Usage

```
abs(x)
sqrt(x)
```

Arguments

x	a numeric or `complex` vector or array.

Details

These are internal generic primitive functions: methods can be defined for them individually or via the `Math` group generic. For complex arguments (and the default method), `z`, `abs(z) == Mod(z)` and `sqrt(z) == z^0.5`.

`abs(x)` returns an `integer` vector when x is `integer` or `logical`.

S4 methods

Both are S4 generic and members of the `Math` group generic.

References

Becker, R. A., Chambers, J. M. and Wilks, A. R. (1988) *The New S Language*. Wadsworth & Brooks/Cole.

See Also

`Arithmetic` for simple, `log` for logarithmic, `sin` for trigonometric, and `Special` for special mathematical functions.

'plotmath' for the use of `sqrt` in plot annotation.

Examples

```
require(stats) # for spline
require(graphics)
xx <- -9:9
plot(xx, sqrt(abs(xx)),  col = "red")
lines(spline(xx, sqrt(abs(xx)), n=101), col = "pink")
```

Figure 10: screenshot of help window

Exercise: Calculate Channel Flows

Determine the flow in a channel. Go to exercise 1 and answer the questions.

$$q = \frac{2}{3} C_d \sqrt{2g} b h^{3/2}$$

- q: Flow $[m^3/s]$.
- $C_d \approx 0.6$: Constant.
- $g = 9.81 m/s^2$
- b: Width of the weir $[m]$
- h: Water depth over weir $[m]$

Figure 11: Photo: Coliban Water

Scripts versus Console

- Store all code in a text file with `.R` extension
- Output in console, plots and viewer
- Use comments (start with #) to explain the code
- *File* > *New File* > *R Script*
- Open the `channel_flow.R` script in `inroduction` folder.
- Reverse-Engineer the code

Reproducible Code

- Give meaningful names
- Use a consistent method, e.g.:
  - Only lower case: `channelflow`
  - Underscore for spaces: `channel_flow`
  - Camel case: `ChannelFlow`
- Use comments to explain the process
- Add links to documentation
- Automate as much as possible

Case Study 1: Water Quality

Safe Drinking Water Regulations 2015:

> *"the 95th percentile of results for samples in any 12 months must be less than or equal to 5.0 Nephelometric Turbidity Units."*

Guidance document:

> *"The method recommended by the department is described as the Weibull method and is the method adopted by the National Institute of Standards and Technology (NIST)."*

Percentiles

1. The data are placed in ascending order:
   $y_1, y_2, \ldots y_n$.
2. Calculate the rank of the required percentile
   - Weibull: $r = p(n+1)$
   - Excel: $r = 1 + p(n-1)$
3. Interpolate between adjacent numbers: $X_p = (1 - r_{frac})Y_{r_{int}} + r_{frac} Y_{r_{int}+1}$

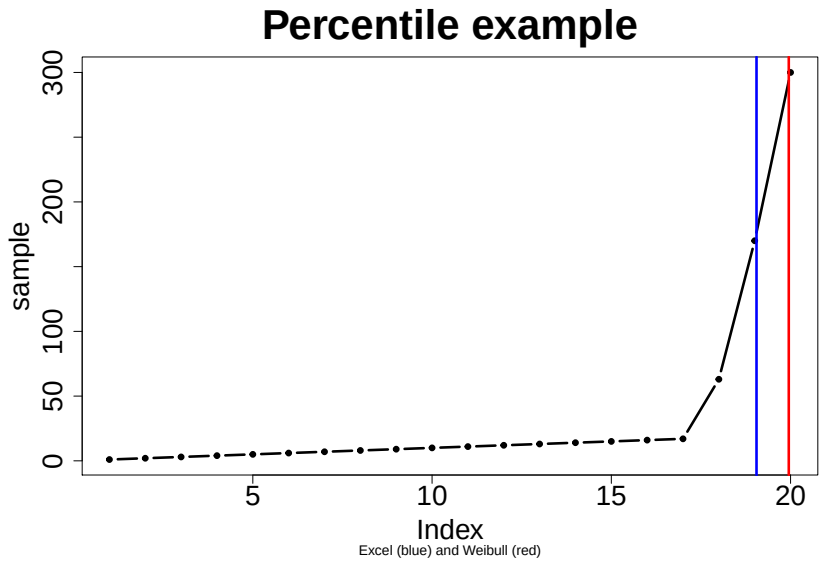


Figure 12: Explore the `percentiles.R` script in the `casestudy1` folder.

The Tidyverse

An opinionated collection of R packages optimised for data science. All packages share an underlying design philosophy, grammar, and data structures.

```
install.packages("tidyverse")
library(tidyverse)
```

Load the `casestudy1.R` script in the `casestudy1` folder.

Data frames or 'tibbles'

- Rectangular data
- Variables in columns
- Observations in rows
- One variable in R environment
- Tidy data
- Read data:

```
dataframe <- read_csv(filename)
```

group	var	val
1	B	12
2	B	34
1	C	43
2	C	76
1	D	5
2	D	12

Figure 13: Data frame structure.

Filter a data frame

```
filter(df, var == "B")
```

group	var	val
1	B	12
2	B	34
1	C	43
2	C	76
1	D	5
2	D	12

group	var	val
1	B	12
2	B	34

Grouping

```
group_by(df, var)
```

group	var	val
1	B	12
2	B	34
1	C	43
2	C	76
1	D	5
2	D	12

group	var	val
1	B	12
2	B	34

group	var	val
1	C	43
2	C	76

group	var	val
1	D	5
2	D	12

Exercise

- Load the CSV file for the Gormsey system in the `casestudy1` folder.
- Explore the data.
- Answer the questions in Exercise 2 in your syllabus.
- You can cheat by opening the `gormsey_quiz.R` script.

Data Visualisation

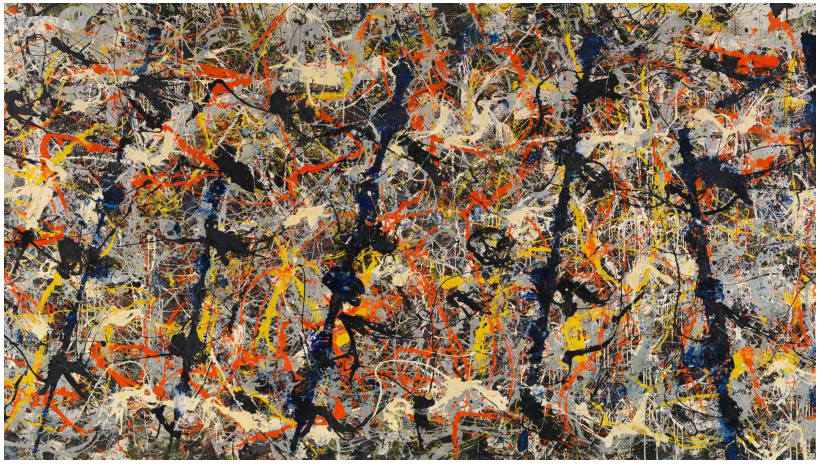


Figure 14: Jackson Pollock, *Blue Poles* (1973).

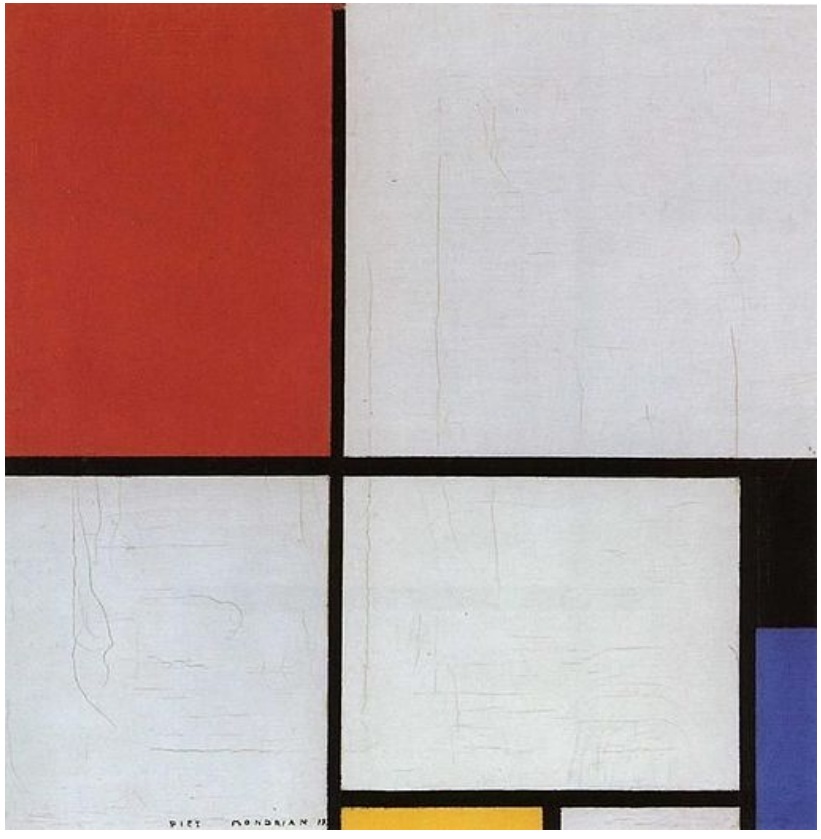


Figure 15: Piet Mondrian, *Composition in Red, Yellow and Blue* (1928)

Data-to-Pixel Ratio

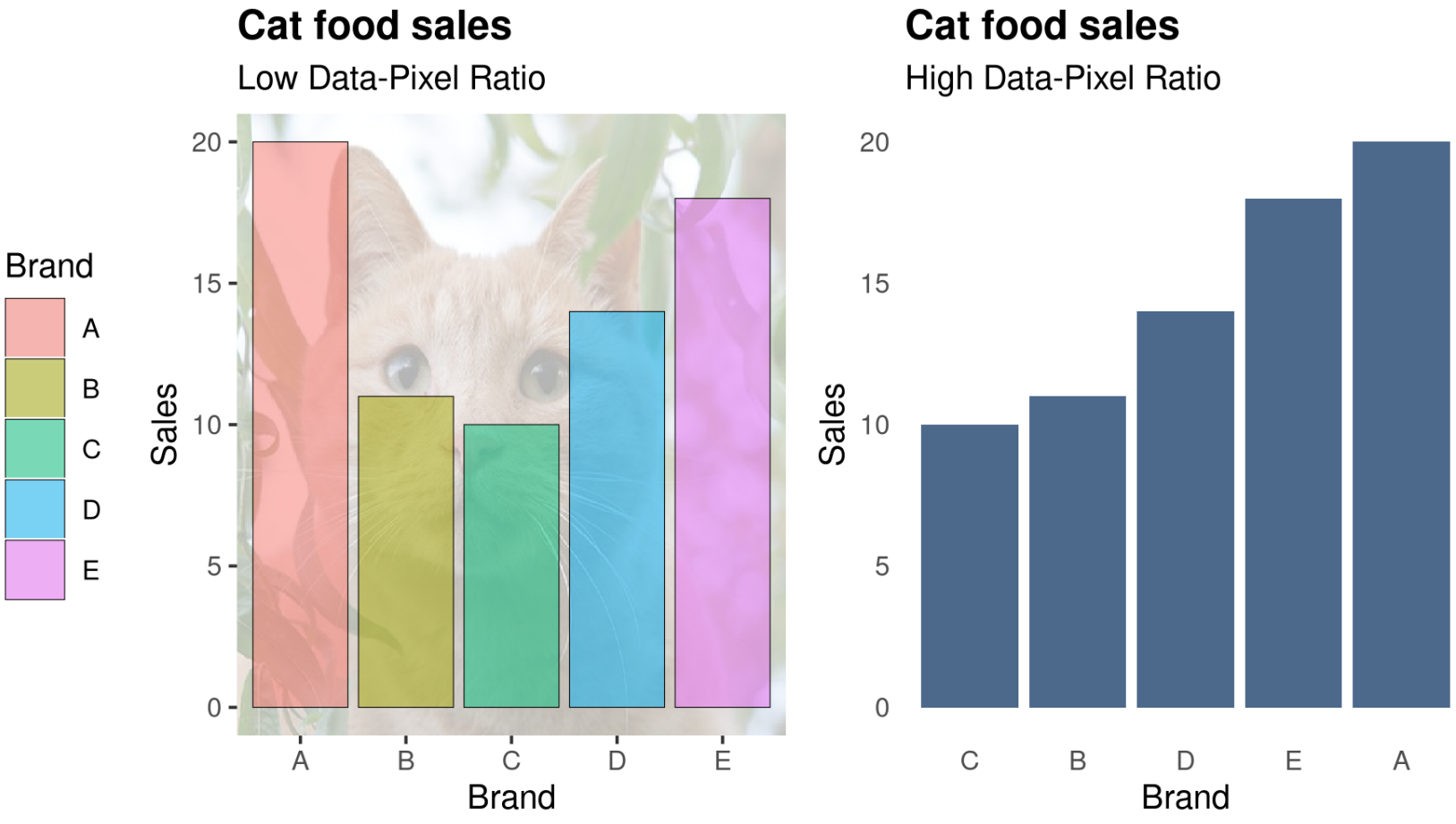


Figure 16: Maximise the data to pixel ratio for aesthetic visualisations.

Chart Chooser

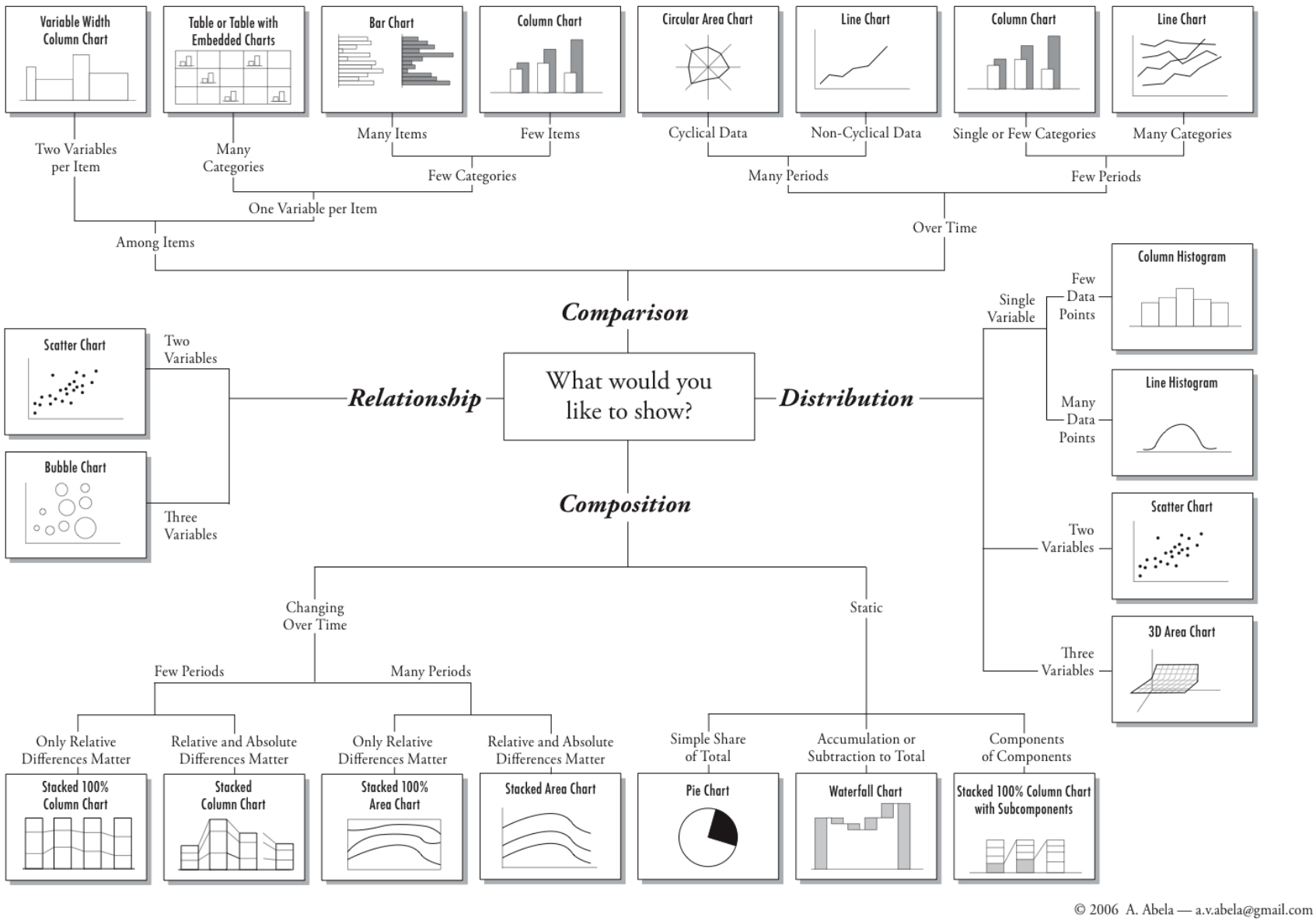


Figure 17: Chart suggestions by Andrew Abela.

Use Colours Sparingly

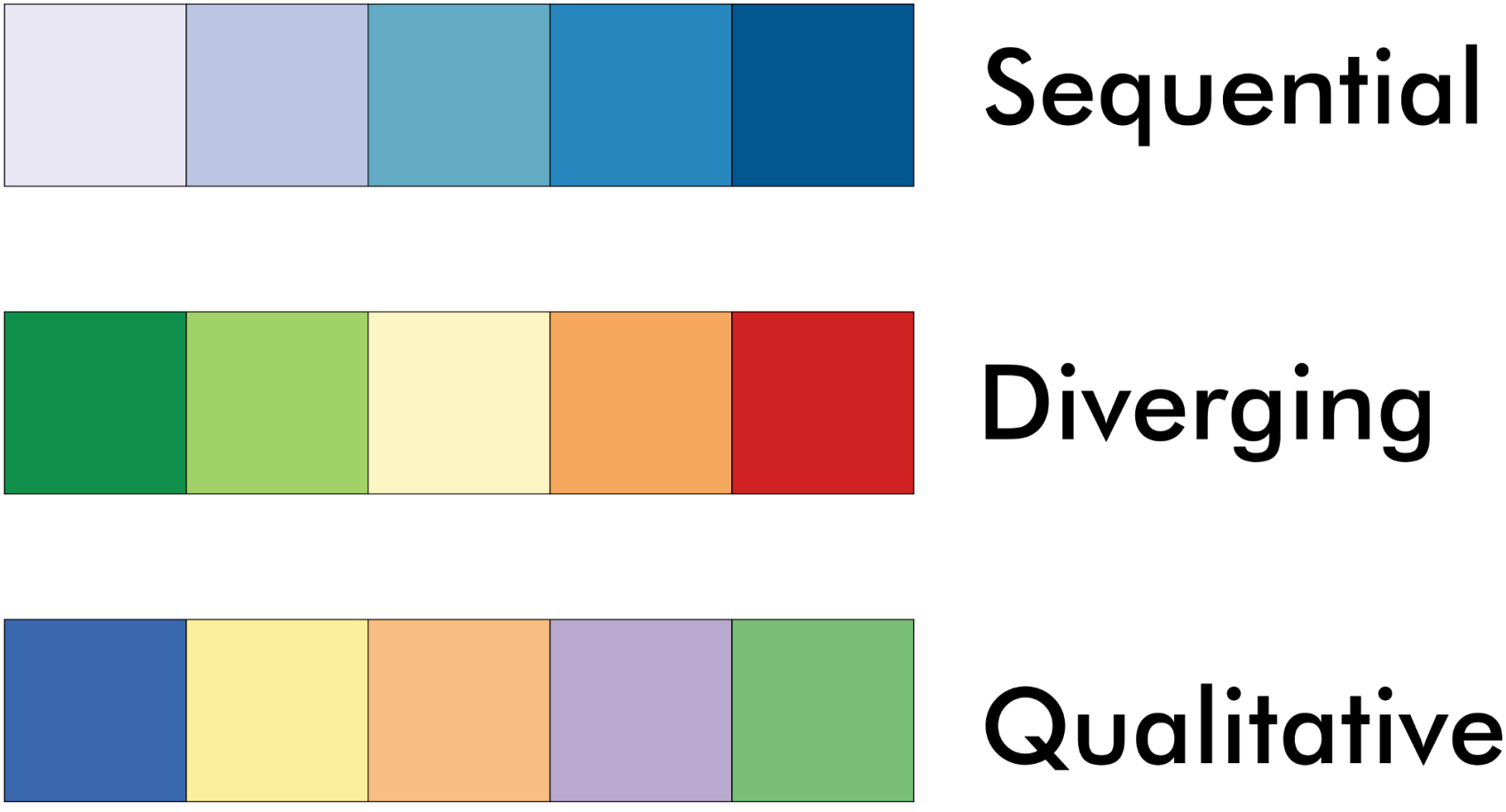
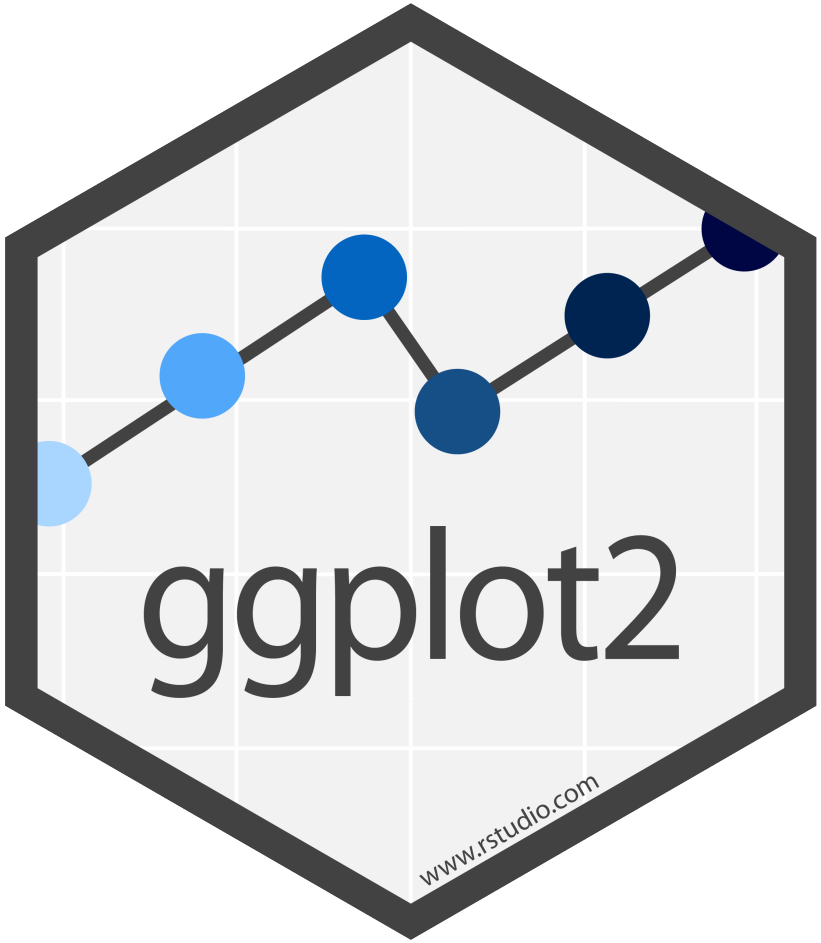


Figure 18: Types of colour pallets. Go to colorbrewer2.org for details.

ggplot2

- System for creating graphics, based on *The Grammar of Graphics*.
- Go to ggplot2.tidyverse.org for documentation.
- Included in the Tidyverse. You can call it separately with:

```
library(ggplot2)
```



Grammar of Graphics

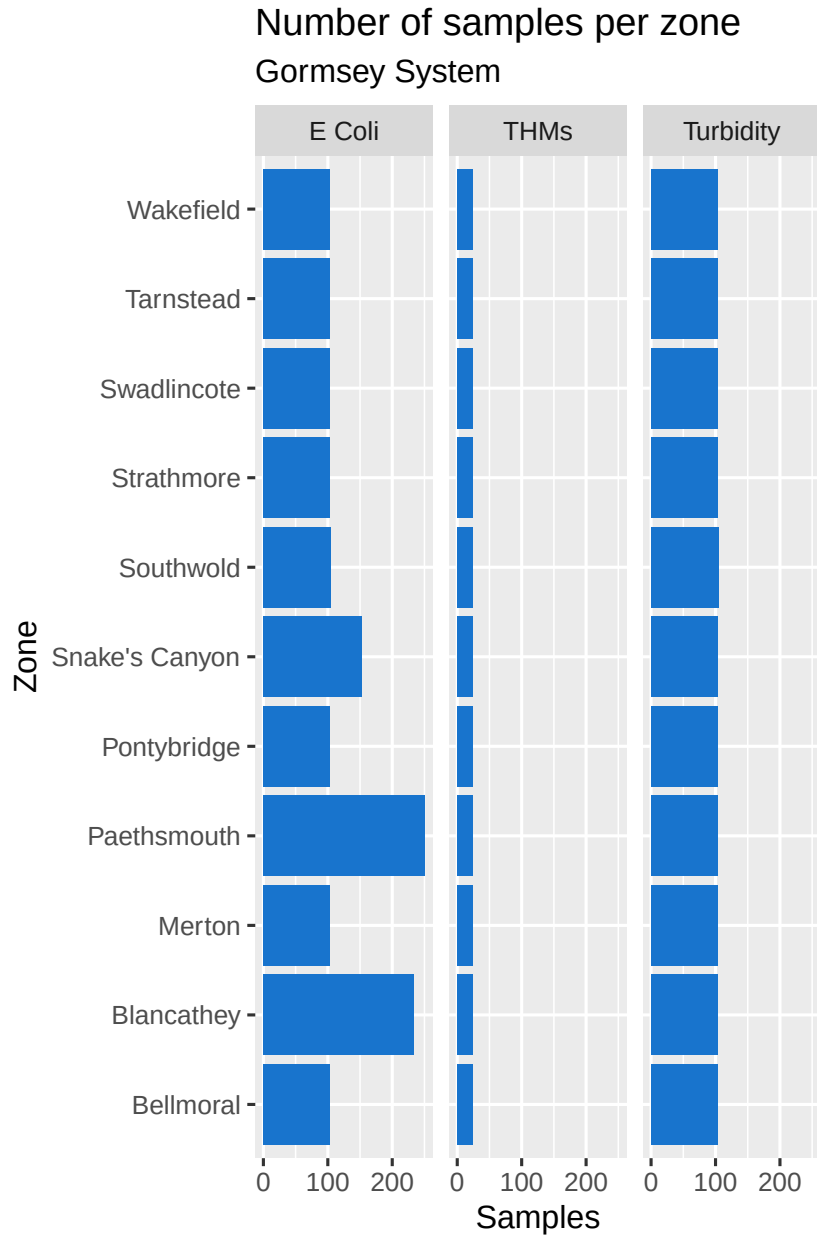
Figure 19: Leland Wilkinson, *Grammar of Graphics* (2005).

ggplot2 Example

Visualisation Exercise

Use your knowledge of the Gormsey data to create two visual data stories. Use the following four steps:

1. Explore the data and define the story you want to tell.
2. Decide on the best way to visualise the story.
3. Develop the basic visualisation.
4. Select a theme and annotate the graph.



Data Science Workflow

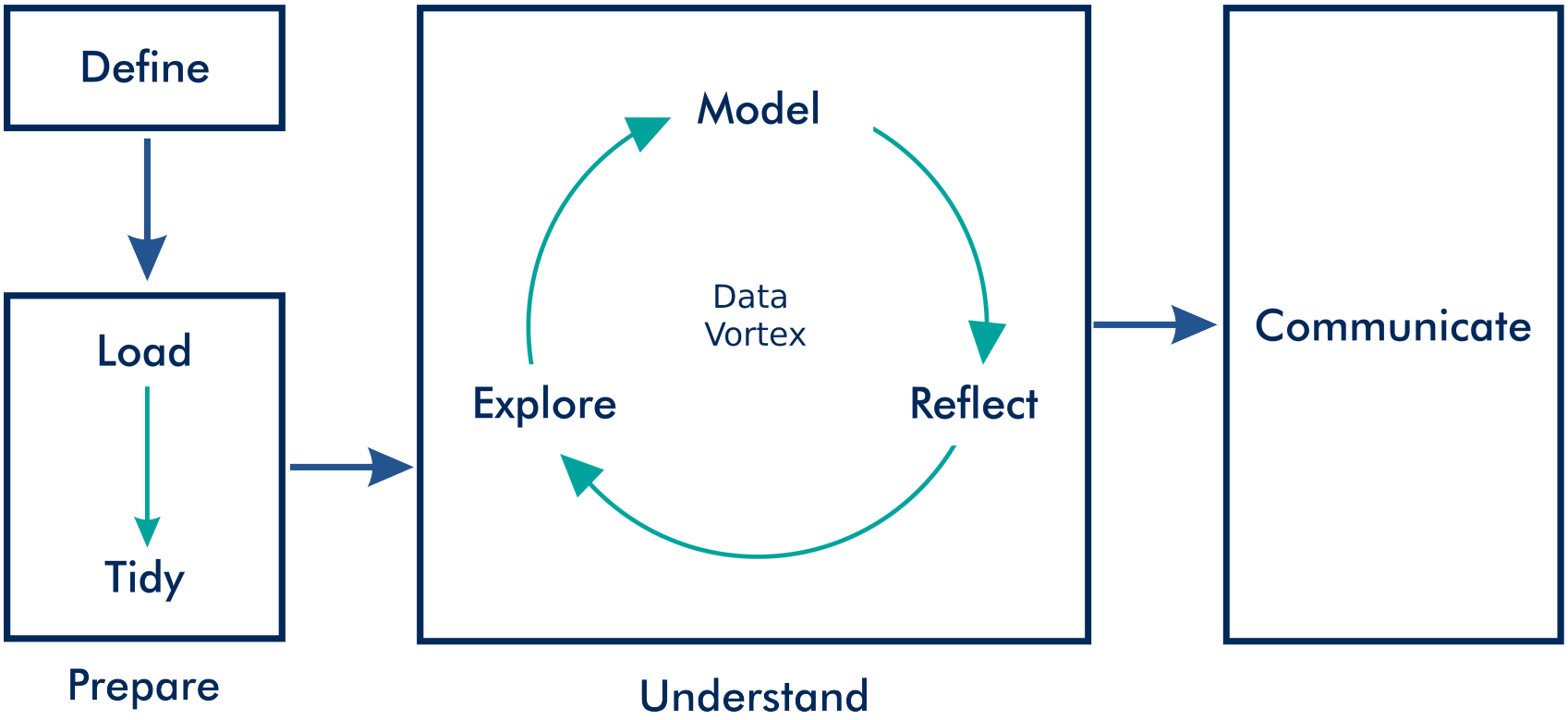


Figure 20: Data science wokflow

Data Products

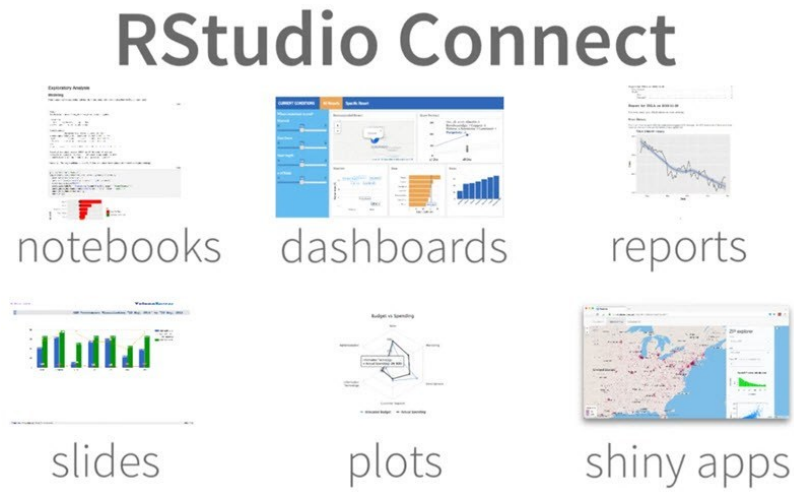
Static

- Word documents
- PowerPoint presentaions
- Web pages

Dynamic

- Shiny application
- Shiny presentation

Share - RStudio Connect - Your own server



RMarkdown

Literate programming:

- Combine prose with code
- Link the code to dynamic data
- Generate shareable output from code

Data products:

- Reports
- Web sites
- Presentations
- Applications (dashboards)

RMarkdown Syntax

```
---
title: "Untitled"
author: "Peter Prevos"
date: "11/12/2019"
output: powerpoint_presentation
---

```{r setup, include=FALSE}
knitr::opts_chunk$set(echo = FALSE) # Set various options
```

Heading
This is an R [Markdown Example](http://rmarkdown.rstudio.com). When you click the
Knit button, RStdio combines the text with the result of the analysis.

- Bullet 1
- Bullet 2

Slide with R Output
```{r cars, echo = TRUE}
summary(cars)
```

```

Figure 21: RMarkdown syntax example

# Mini Hackathon

To close this day, we will do a mini hackathon.

1. Create a script that results in a PowerPoint presentation about the Gormsey data.
2. Pick a story you like to tell about this data.
3. Create a RMarkdown script that results in a Powerpoint presentation.
   - Add an introduction.
   - Explore the data.
   - Share the story.

# Further Study


Figure 22: tidyverse.org

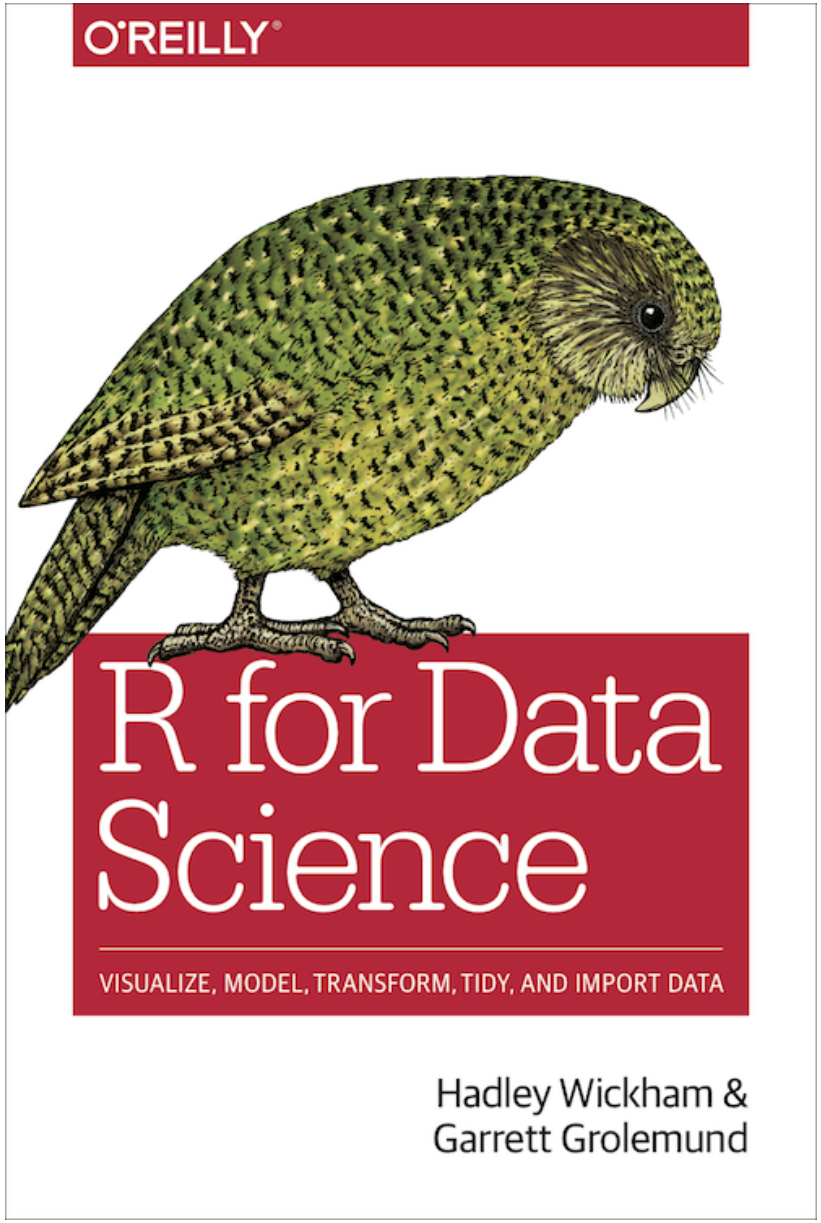



Figure 23: r4ds.had.co.nz