```
course = "Improving your statistical inferences through simulation studies in R"

lesson_iteration = 1
lesson_title = "orientation + foundational concepts"

auth = "Ian Hussey"
dept = "Psychology of Digitalisation"
```

Background

of the course

Why am I here?

- I'm a user of stats, not a statistician or mathematician.

- I'm a user of code. I'm self taught, not a Computer Science graduate or trained coder.

- I use simulations to teach myself, and others, about quantitative methods to use them in research.

Background

of the course

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Communication
within the course

Duzen

Call me Ian

Please use a name card so I know yours 😊

Pronunciation & Pronouns

Accessibility

Please contact me if you encounter barriers that need to be overcome
Including English!

Contact

Slack where possible
ian.hussey@unibe.ch

Background

of the course

Why are you here?

- What do you want to get from this course?

- What is your existing skill level?
  - Programming languages
  - Confidence

- What career directions interest you?

- If R was an animal, what animal would it be?

Background

of the course

Why simulate?

- It gives you access to ground truth

- Take no-one's word, not even R's

- Helps you avoid unintentional p-hacking
  - Learn how to use a method before applying it to your real data.
  - Significant results no longer function as a stop signal for you to consider the analysis correct/complete.

Content
of the course

What we will cover

- Data simulation from scratch, with a focus on:
    - Visibility of intermediate steps and data
    - Maximising code reusability

- Very little math
    - Often the point of simulation is to avoid math

- Lots of code
    - tidyverse wherever possible

Content

of the course

SCHEDULE

#	Date	Topic
1	19.02.2025	Introduction + foundational concepts
2	26.02.2025	Writing functions
3	05.03.2025	General structure of a simulation
4	12.03.2025	Understanding *p*-values
5	19.03.2025	Factorial vs. one-at-at-time simulations
6	26.03.2025	Hidden multiplicity in ANOVA
7	02.04.2025	What does it mean to violate assumptions?
8	09.04.2025	<<Probably no class - Ian at a conference. To be confirmed.>> Otherwise: Simulating causal models
9	16.04.2025	The difference between significant and non-significant is not itself significant
	23.04.2025	No class (spring break)
10	30.05.2025	Understanding Confidence Intervals via sequential testing
11	07.05.2025	Should we test our statistical assumptions?
12	14.05.2025	How standardized are ‘standardized’ effect sizes?
13	21.05.2025	Meta-analysis and bias
14	28.05.2025	The impact of careless responding on correlations

Content

of the course

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Content

of the course

SCHEDULE

The content and pacing of the course will be adapted, to some degree, to students' needs and wants. There is a selection of other topics that we could cover instead of the listed topics if you prefer, including:

- Simulating individual datasets that meet the specific experimental design of your real-world study to allow you to write your analysis code before the data is collected.
- The impact of different p-hacking strategies on false positive rates.
- The impact of different data tampering strategies on false positive rates.
- Why most psychology research is statistically unfalsifiable.
- The reliability paradox: why unreliable measures can sometimes produce replicable effects
- How confounding can produce replicable but incorrect conclusions.
- Using simulation studies to understand Bayesian estimation methods and the influence of the choice of prior.
- The impact of confusing SE and SD when extracting effect sizes for meta-analysis
- The efficacy of different methods to correct for bias in meta-analysis

Requirements & assessment

Assessment

of the course

- Laptop + recent version of R, RStudio, & {tidyverse}

- Weekly attendance (80% minimum)

- 3 at-home assignments during teaching term
  - Best 2 scores count towards your grade (20% each)

- 1 larger assignment to be completed by <<agreed date>> (60%)
  - Choose, design, implement, and report a simulation study
  - Scope to be determined in class
  - Start early! Ask questions!

- Assignments in English (preferably) or German (if necessary)

aut = "Ian Hussey";

dept = "Psychology of Digitalisation || Digitalisation of Psychology"

Requirements & assessment

- All assessments must be licensed CC BY 4.0
- i.e., can be used or modified with attribution

Assessment

of the course

How to succeed

in the course

What is difficult about this course

- This course does not require you to be expert in R
- But it does require that you want to *become* expert in R

- You will learn about coding concepts and statistical concepts *at the same time*

- Like any spoken language, ‘speaking’ is harder than ‘understanding’
  - You have to practice writing code from nothing
  - Don’t just read and run my code

How to succeed

in the course

How to succeed in this course

- Practice at home
- Ask questions
- Use AI (chatGPT, Gemini, codepilot, etc) the *right amount*

Foundational Concepts

in Monte Carlo Simulation Studies

What is a Monte Carlo simulation?

- There is no consensus on how Monte Carlo should be defined!
  - Monte Carlo methods for quantitative (social) science methods research
    - This course
  - Monte Carlo methods as part of data analysis (e.g., MCMC in Bayesian data analysis)
  - Monte Carlo methods for the solution of general numerical problems (e.g., Monte Carlo integration)
    - Not this course

Foundations
of Monte Carlo Simulation Studies

Core components of a simulation

1. Generate pseudo-random data set with known properties

2. Analyse data with a statistical method

3. Repeat 1 & 2 many times (‘iterations’)

4. Summarize results across iterations

5. Make it an experiment
   - Systematically vary parameters in Step 1 (between factor)
   - Compare different ways to do Step 2 (within factor)

Simulations to increase understanding

What is the distribution of *p* values under the null hypothesis?

Simulations to increase understanding

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```r
res <- replicate(10000, t.test(rnorm(n = 50, m = 0, sd = 1), rnorm(n = 50, m = 0, sd = 1))$p.value)

res |> hist()
```

Simulations to increase understanding

What is the distribution of *p* values under the null hypothesis?

do it many times

analyze

```
res <- replicate(10000, t.test(rnorm(n = 50, m = 0, sd = 1), rnorm(n = 50, m = 0, sd = 1))$p.value)
```

generate

generate

```
res |> hist()
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summarise across iterations

Foundations

of Monte Carlo Simulation Studies

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generate

generate

```
res ▷ hist()
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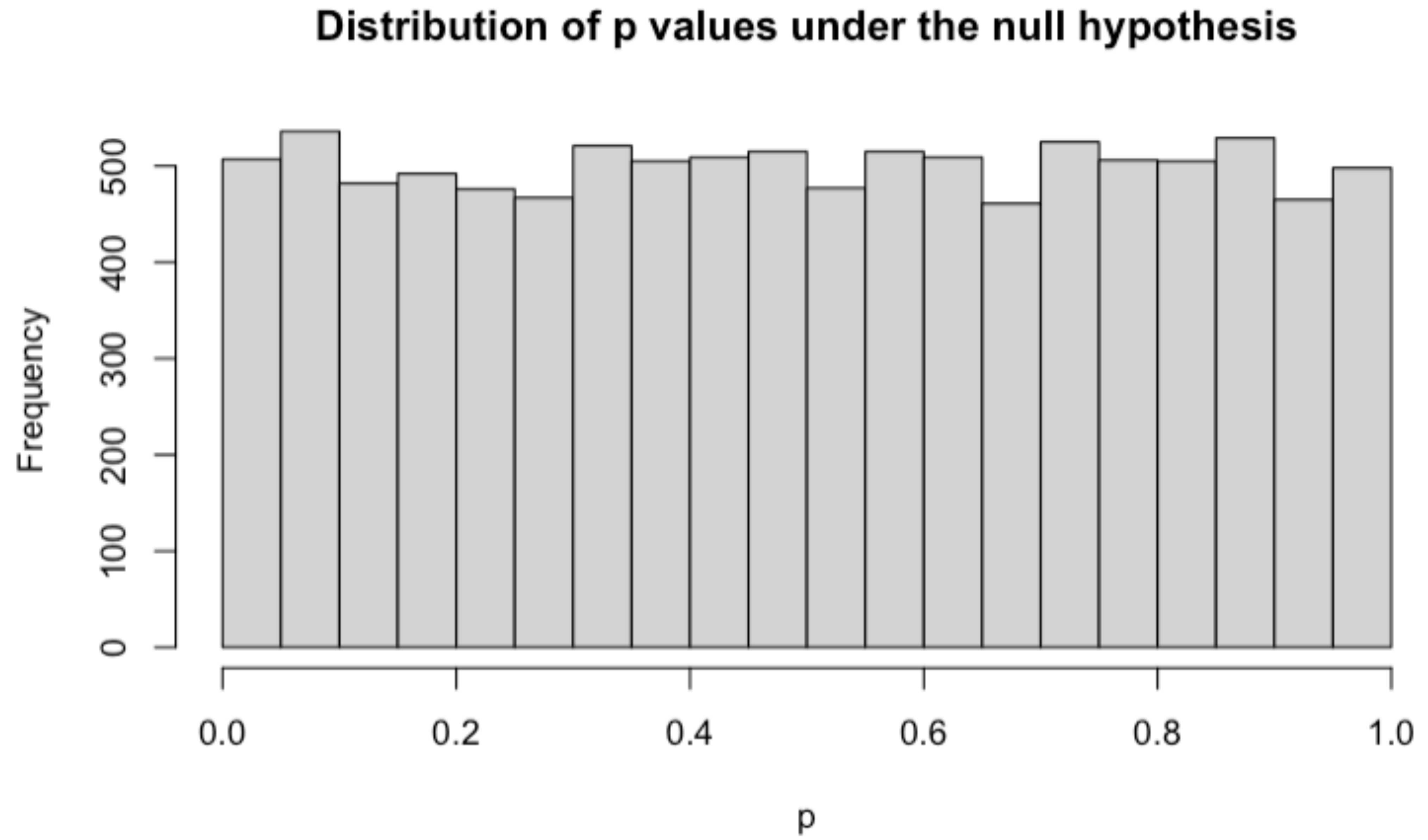
summarise across iterations



Preparation
for next lesson

Homework

> 1_foundational_concepts__homework.html

If aren't already familiar with data processing/wrangling in dplyr/tidyr, use the Lesson 0 resources

> data_wrangling_lesson_and_exercises.Rmd

> data_wrangling_lesson_with_answers.html