

# Data Analysis in Biology

BIO144  
FS 2022

## Overarching goals of the course



BIO  
144

- ▶ Provide a [solid foundation](#) for answering biological questions with quantitative data.
- ▶ Help students to understand the [language of a statistician](#).
- ▶ Ability to understand and interpret results [in research articles](#).
- ▶ Give the students a [challenging, engaging, and enjoyable](#) learning experience.



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Zurich

BIO

144

## Why is statistical data analysis so relevant for the biological and medical sciences?

Only with knowledge of data and statistical data analysis will it be possible to analyze your data from Bachelor, Master or PhD theses....

- ▶ **Medicine:** What is the effect of a drug? Which factors cause cancer?
- ▶ **Ecology:** What is a suitable habitat for a certain animal? Which resources does it need or prefer?
- ▶ **Evolutionary biology:** Do highly inbred animals have decreased chances to survive or reproduce?



## Now also in Zürich!

**who?** genders underrepresented in the R community.  
R beginners to experts are welcome!

**why?** encouraging, inspiring and empowering  
R users from minority genders.

**how?** regular events where we learn more about R  
and grow as a community.

R help forum on Slack to promote exchange  
and mutual help among our members.

**Ladies, register for our first event on Nov 15th  
on MeetUp! We can't wait to get to know you!**





The “**hottest skill**”  
that got people  
**hired** in 2014?

## **Statistical Analysis**

Source: LinkedIn



0:06 / 3:00





# 6 Reasons To Learn R For Business [2021]

Written by Matt Dancho on December 17, 2020

## 6 Reasons to Learn R for Business

Why R Might Be the Right Choice for You

DS4B Tools: Capability Vs Learning Curve  
R has a longer learning curve but has a massive business capability rating

Learning Curve Rating

Data Science For Business Capability Rating

Cost Tool Trend

- Free Excel 2.5
- High Matlab 5.0
- Low PowerBI 7.5
- Python 7.5
- R 10.0
- SAS 10.0

Business Science [www.business-science.io](http://www.business-science.io)

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Get Articles

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Search

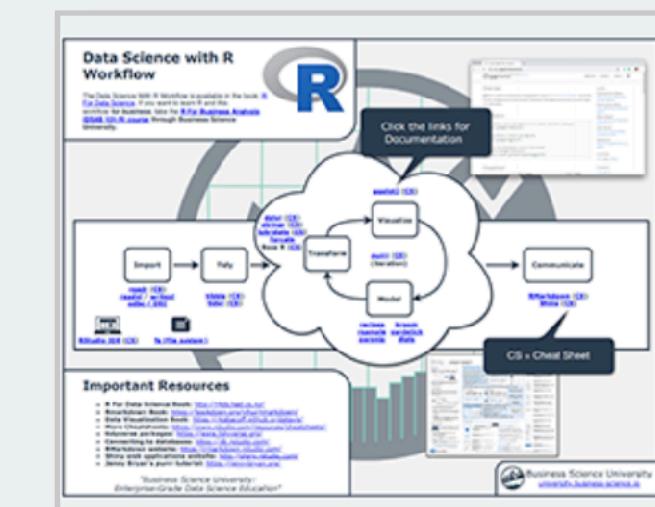


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Learning Hub

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Cheat Sheets

# — BETTER DATA. BETTER DECISIONS. BETTER LIVES. —

A global network using data to achieve the Sustainable Development Goals - improving lives, fighting inequality, and promoting environmental sustainability.

## Who We Are

The Global Partnership for Sustainable Development Data is a global network working together to ensure the new opportunities of the data revolution are used to achieve the Sustainable Development Goals.

[ABOUT US](#)

## Our Community

Our hundreds of partners from governments, the private sector, and civil society organizations are joining forces to take action, galvanize political commitment, build trust, and spur innovation in the booming data ecosystems of the 21st century.

[SEE OUR PARTNERS](#)

## Our Impact

Since our founding in 2015, our network has improved data to monitor and achieve the Sustainable Development Goals, created incentives for new commitments to fund and share data, and enabled knowledge-sharing, bringing partners together to make change.

[LEARN MORE](#)

## Examples of insights from data

### Otter (*lutra lutra*)



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**Research questions:** What is the preferred habitat by otters? How do otters adapt to human altered landscapes?

**Method:** Study in Austria, 9 Otter were radio-tracked and monitored during 2-3 years.



Flexible habitat selection paves the way for a recovery of otter populations in the European Alps

Irene C. Weinberger<sup>a,b</sup>, Stefanie Muff<sup>a,b</sup>, Addy de Jongh<sup>c</sup>, Andreas Kranz<sup>d</sup>, Fabio Bontadina<sup>e,f</sup>  
<sup>a</sup>Institute of Ecology and Evolutionary Biology, University of Zurich, Winterthurerstrasse 190, 8057 Zurich, Switzerland  
<sup>b</sup>Ecological Institute, University of Zurich, Winterthurerstrasse 190, 8057 Zurich, Switzerland  
<sup>c</sup>Dutch Ornithology Foundation, Spoorweglaan 13, 8917 AX Groningen, The Netherlands  
<sup>d</sup>GlobAustria Agrarwissenschaft für Wildbiologie und Naturschutz, Am Wallgraben 25, 8004 Graz, Austria  
<sup>e</sup>ÖAW, Institute for Animal Ecology and Biodiversity, Innsbruck, Austria  
<sup>f</sup>Swiss Federal Research Institute WSL, Biodiversity and Conservation Biology, 8903 Birmensdorf, Switzerland

<http://www.prolutra.ch/>

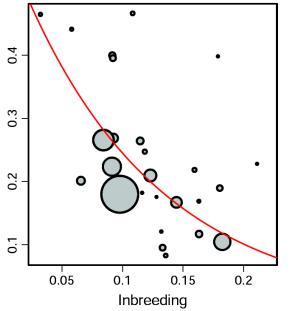
6 / 19

Lecture 1: Introduction and Outlook

### Inbreeding in Alpine ibex

**Research question:** Does inbreeding in Alpine ibex populations have a negative effect on long-term population growth? Inbreeding depression!

**Methods:** Genetic information from blood samples allow to quantify the level of inbreeding in each ibex population. In addition, long-term monitoring of population sizes and harvest rates.



## Mercury (Hg) in the soil



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### Wohnzone im Wallis von Quecksilber vergiftet

Vor über vierzig Jahren hatten 3.1 Tonnen Quecksilber einen Abflusskanal nahe der Walliser Gemeinde Visp verschmutzt. Noch heute müssen die Einwohner mit den Folgen leben.



Aktuelles Thema:  
Konvention gegen Quecksilber verabschiedet  
Ein neues internationales Abkommen schafft eine endgültige Reduzierung von Quecksilber in der Industrie ein. Besonders betroffen ist die Schweiz. Mehr...  
19.01.2013

**Research question:** Is the Hg level in the environment (soil) of people's homes associated to the Hg levels in their bodies (urin, hair)?

**Method:** Measurements of Hg concentrations on people's properties, as well as measurements and survey of children and their mothers living in these properties.

Highly delicate, emotionally charged, political question! [+ Schweiz Aktuell, 20. Juni 2016](#)

Lecture 1: Introduction and Outlook

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Physical activity in children (Splashy study)



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splashy.ch

*Research question:* Which factors influence physical activity patterns in children aged 2-6 years?

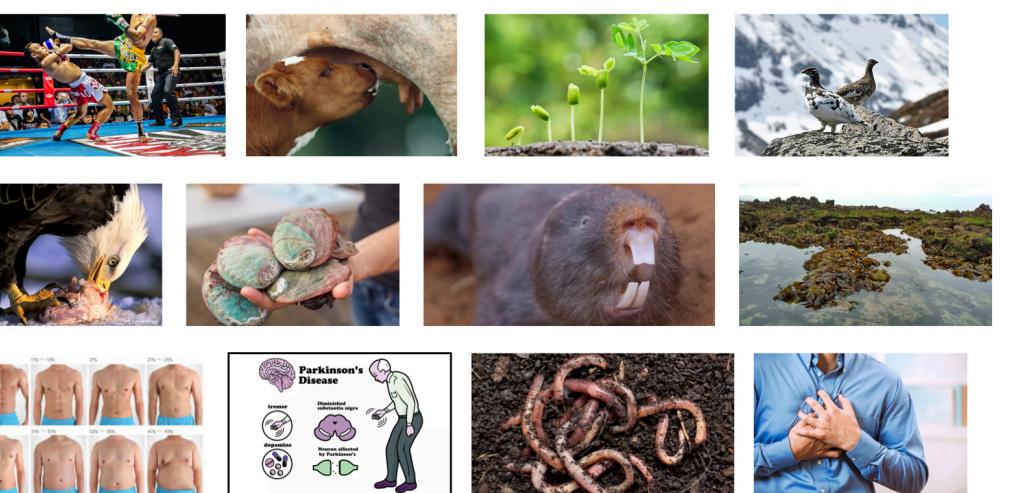
*Method:* The children had to wear accelerometers for several days. In addition, their parents had to fill in a detailed questionnaire.

Observed variables were, e.g., media consumption, behavior of the parents, age, weight, social structure,...

## Statistics in the news (April 2016)



Question you will work on



Producing nonsense with statistics . . .



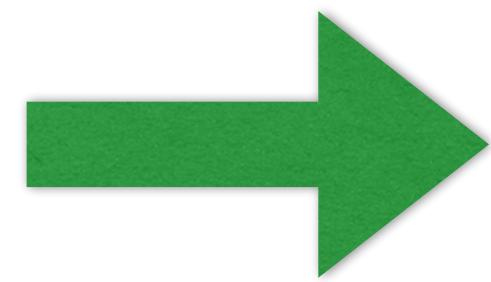
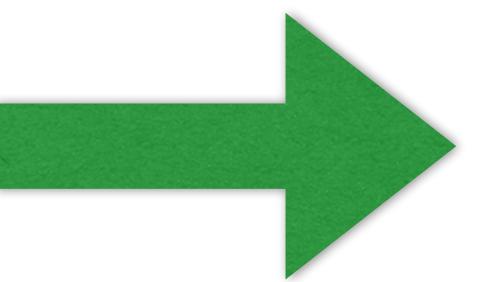
BIO  
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. . . is too easy . . .

[The risks of alcohol \(by David Spiegelhalter, 23. August 2018\)](#)

["Calling bullshit" course \(University of Washington\)](#)

A profound knowledge of data analysis and statistics protects you from producing nonsense – and helps to detect it. See for example:



Question  
Puzzle  
Problem

Data  
+  
Analysis

Answer  
Solution

How do we get insights from data...



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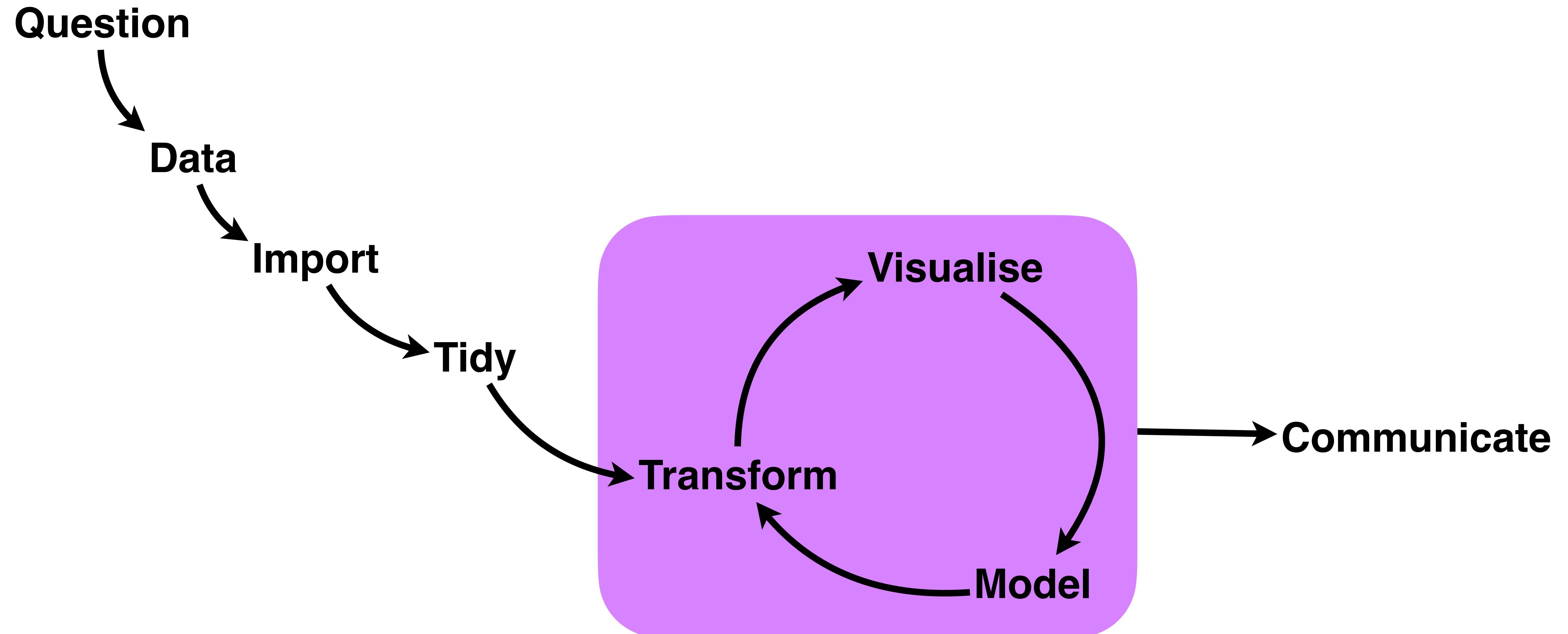
BIO  
144

... rather than nonsense.

- ▶ Excellent data management practices.
- ▶ Informative graphical visualisations to explore data.
- ▶ Informative numerical summarise to explore data.
- ▶ Appropriate transformations of data.
- ▶ Appropriate statistics tests / models.

Awareness of our "realm":

- ▶ Description of patterns, including associations (we will do this).
- ▶ Predicting (we will do this).
- ▶ Inferring causation (we will do this, by analysing experiments randomised manipulations).



**Efficient**  
**Consistent**  
**Repeatable**  
**Reliable**  
**Readable**  
**Robust**  
**Persistent**  
**Sharable**  
**Scalable**

—  
—  
—





"Failure is an opportunity to grow"

## GROWTH MINDSET

"I can learn to do anything I want"

"Challenges help me to grow"

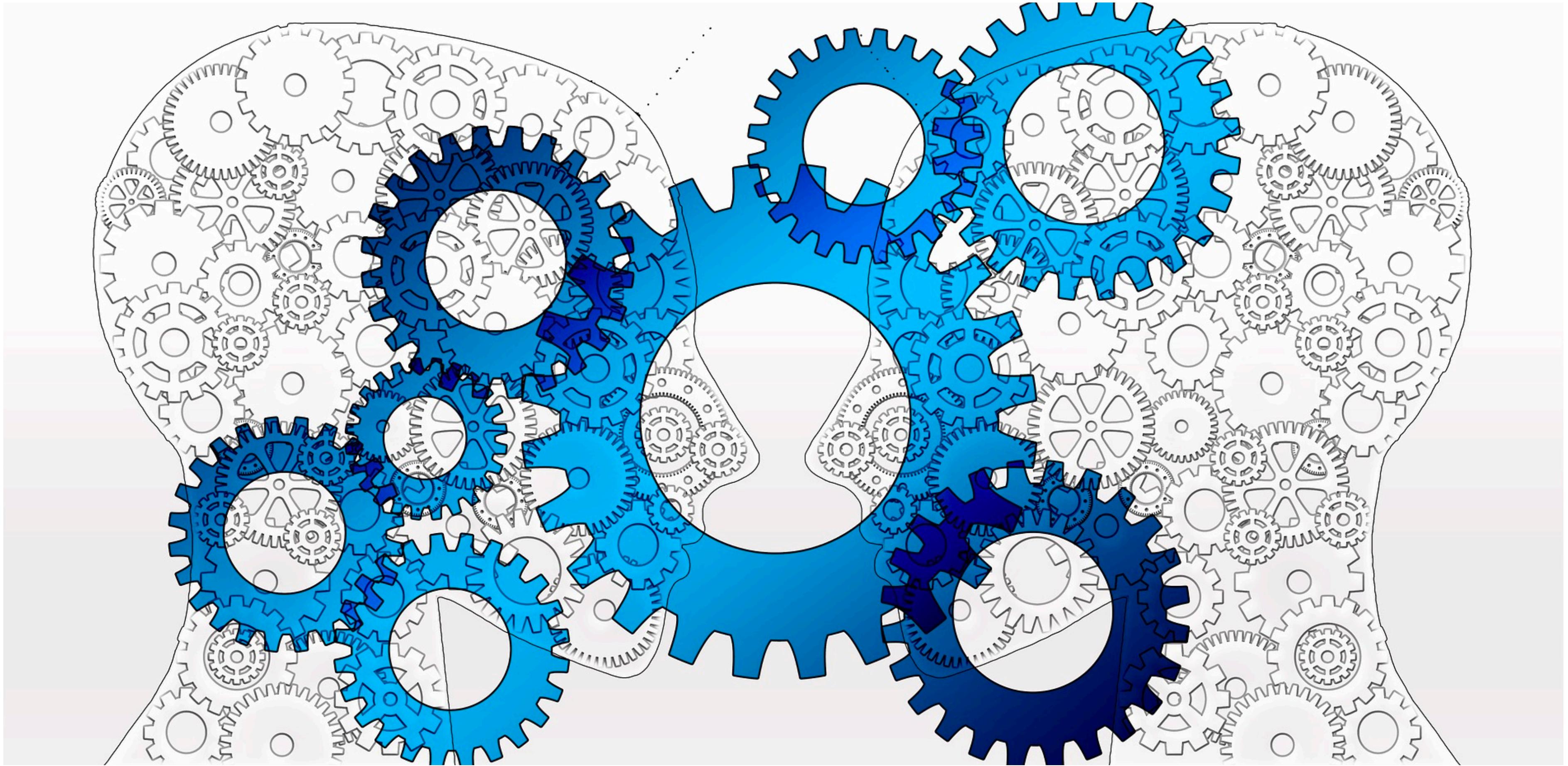
"My effort and attitude determine my abilities"

"Feedback is constructive"

"I am inspired by the success of others"

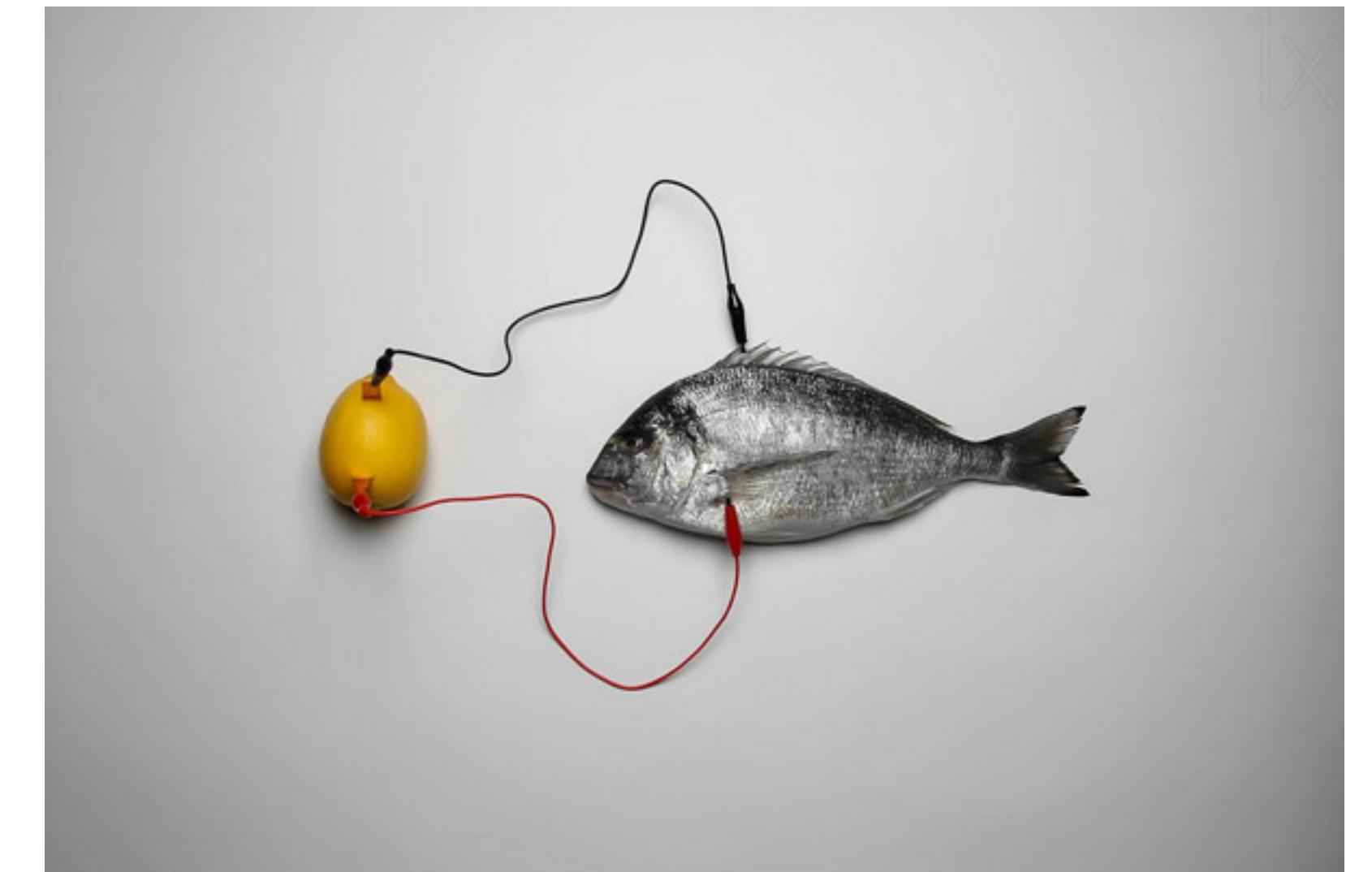
"I like to try new things"

Equip you with the knowledge of how to learn more.  
And the confidence that you can.



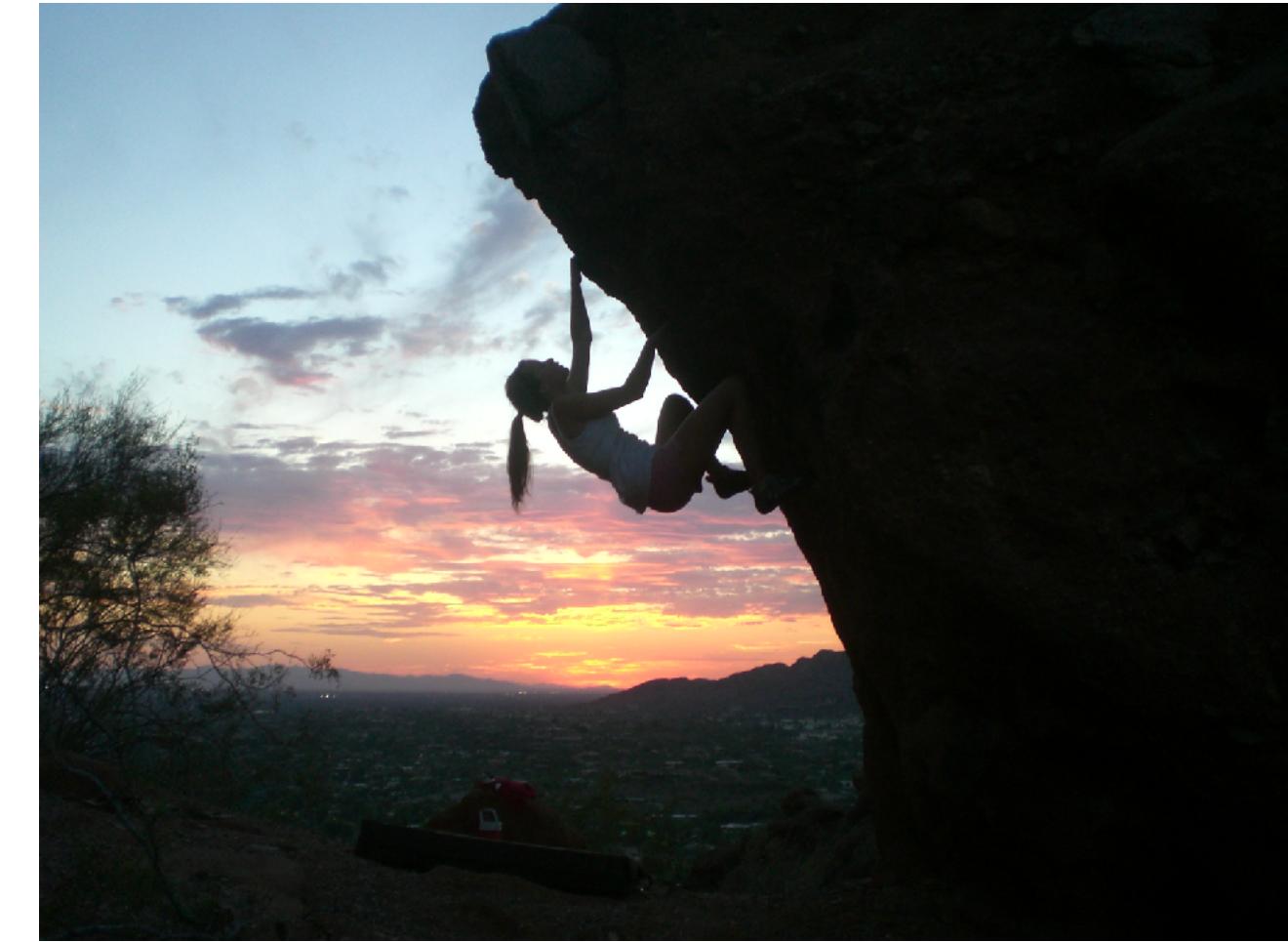
# How the course is organised

# The conceptual side



1 - 2:45pm Mondays

# The practical side



**1 - 3pm Thurs. or Fri.**

# Schedule (12 lecture units + 2 self-study weeks)

**Unit 1** Introduction and outlook

**Unit 2** No lecture

**Unit 3** Simple linear regression

**Unit 4** Residual analysis, model validation

**Unit 5** Multiple linear regression

**Unit 6** ANOVA

**Unit 7** ANCOVA; Matrix Algebra

**Unit 8** Model selection

**Unit 9** Interpretation of results, causality

**Unit 10** Count data (Poisson regression)

**Unit 11** Binary Data (logistic regression)

**Unit 12** Measurement error, random effects, selected topics

# Details on OLAT

The screenshot shows the OLAT interface for a course titled "22FS BIO144 Da...". The top navigation bar includes links for Courses, Groups, Authoring, Campus courses, Question bank, and a search bar. Below the navigation is a toolbar with icons for Administration, Status, Course info, Calendar, Participant list, Participant infos, E-Mail, Blog, Wiki, Forum, User role, and My course. A sidebar on the left lists course sections: BIO144, About the course, Previous knowledge, Wiki: FAQ, Forum, Unit 01, Unit 02, Unit 03, Unit 04, Unit 05, Unit 06, and Unit 07. The main content area displays a list of preparation items:

- Aims and learning outcome
- Course schedule
- Preparing for the course
- Expected workload
- Bring your own laptop
- What to do each week
- Course texts
- Getting datasets
- Attendance

Learning objectives

Schedule

Weekly structure / activities

Assessment

Getting help

Giving feedback

Attendance

Etc...

Owen sent a welcome email

# Activate your prior learning!

22FS BIO144 Datenanaly

- About the course
- Previous knowledge
  - Introduction
  - Notation review
  - Self-tests
  - Getting R & RStudio
  - Getting to know R
  - Help about R and RS
  - What are add-on pac
- Wiki: FAQ
- Forum
  - Unit 01
  - Unit 02
  - Unit 03
  - Unit 04
  - Unit 05

## Introduction

The aims for this section are:

1. To help you know about your knowledge of some of the things you should already know before you start BIO144.
2. To give you a chance to refresh your knowledge about some of the things you don't recall so well.
3. **Important:** Multiple choice questions with little squares in which you need to tick the correct answers can have any number of correct answers. Such questions with little circles have only one correct answer. (See the illustrative examples in the next page.)

Please note that the things covered in this section are not exhaustive, i.e. there might be other things you've previously learned about useful for BIO144.

Your score in the quizzes here doesn't contribute to anything. It's just for you!

## Notation review

## Self-tests

## Getting R & RStudio

## Getting to know R

## Help about R and RStudio

How to get help about R and RStudio

## What are add-on packages?

Use the resources on OLAT

You should have already done this.  
If you have not, you still have time

# Online learning until further notice

Lectures:

- by ZOOM, recorded, and available to watch later  
(be patient with me for making them available).
- Mics off, *cameras on is better.*  
Speak up if you have a question.  
(I likely won't see a raised hand or ZOOM chat comment).
- Google doc is another way for comments,  
questions, jokes.  
(show link and doc)

**This can be very monotonous:**

- reading
- watching videos
- doing online exercises

It would be really nice  
for us to see each other  
(cameras on would be  
very nice!)

And likely makes for  
better learning:

such as the value of nonverbal cues in communication (Miller, [1988](#)), improved instructor effectiveness (Mottet, [2000](#)), and building instructor–student and student–student relationships (Falloon, [2011](#); Mottet, [2000](#)).

# Online learning until further notice

## Practicals:

- You call in to us to ask questions.
- I and a team of TAs will be waiting in online rooms.
- Online rooms will be listed in a google doc (show link and doc)
- You will very likely need to share your screen, perhaps even give control.

“I really appreciate the effort of making online video calls available, but in this case I didn't really know what exactly to ask.”  
- A student, FS 2020

## What worked well last year:

- Some students called in together, pairs, threes, fours (they organised this).
- Some students compiled a list of questions to ask.

## Remember:

- We love to talk with you!
- For us, you are the main thing that makes the course interesting!!!
- You can call in to talk about anything... you may have a specific question, but “I just don't get it” and “my head feels like its gonna explode” are also great ways to start a conversation.
- **TAs have been trained in how to help.**



# Online learning until further notice

This can be rather monotonous

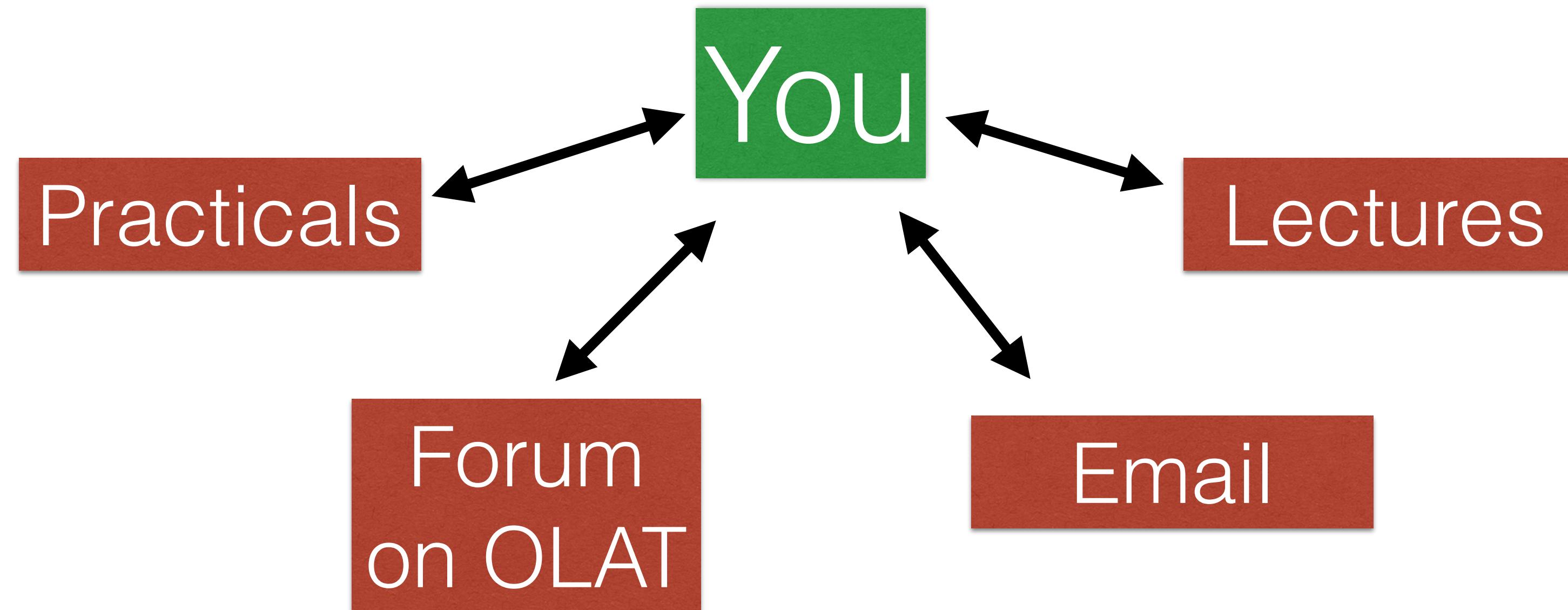
reading  
watching videos  
doing online exercises

Low diversity in your environment.

We will return to on-site, in-person, when we can.

*We strongly advise you to form working groups and do practicals together. (And call in to TAs together also.)  
(And in lectures even—side comms.)*

# Communications and the course team



Dr Hanja Brandl  
Lecturer



Prof. Damien Farine  
Lecturer



Prof. Owen Petchey  
Director  
Instructor



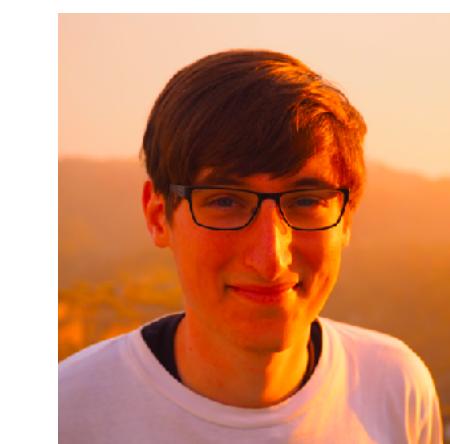
Uriah Daugaard  
Practicals  
Teaching Assistants  
Statistics consultant



Dr Frank Pennekamp  
Assessment  
Examinations



Dr Rainer Krug  
Computing consultant



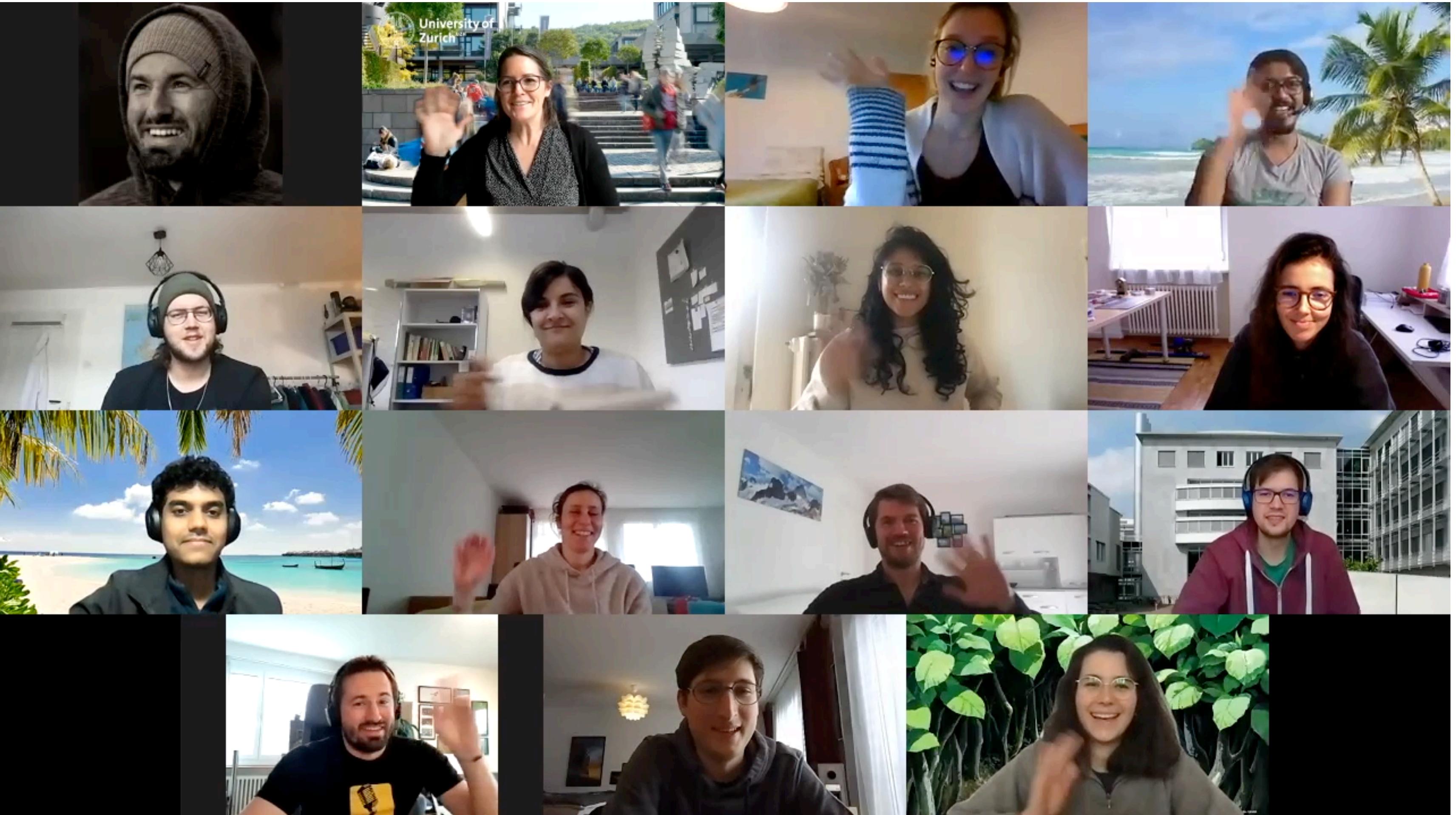
David Hofman



Ewa Merz

Numerous  
teaching  
assistants

# Numerous teaching assistants



# Graded assessment questions

The screenshot shows a course navigation bar on the left and an assessment page on the right.

**Course Navigation Bar:**

- BIO144
- About the course
- Previous knowledge
- Wiki: FAQ
- Forum
- Unit 01** (selected)

  - Lecture 1
  - Important info
  - Homework
  - Practical

- Graded Assessment 1** (selected)

  - Assessment 1 (graded)** (selected)

- Unit 02
- Unit 03
- Unit 04

**Assessment 1 (graded) Page Content:**

**Information:**

- This is a graded test.
- You can start the test only once, but once you started it you can suspend it if you need to. This pauses the test and you can leave it. Once you start the test again you will pick it up exactly where you left it.
- For each question you have 2 attempts (unless otherwise specified).
- If not specified otherwise, each question gives 1 point.
- The solutions are given after you submit the test.

Good luck!

There is no score information of this test since you have not taken it yet.  
Maximum number of attempts: 1

Press the start button to begin with your test.  
Results of this test are visible to administrators and tutors of this course.

**Start**



Hyperlink

Some “play” questions



## FEEDBACK

Lots of good feedback, but here is the more critical/constructive:

### Feedback

What is in the course and exam was unclear.

Some variation in amount and type of BC material.

A summary of R commands and corresponding library would be good.

Diverse resources: various books, documents, videos, seem a bit thrown together.

Solution scripts: Please give us solution scripts (promptly). Having to wait a week for help is demotivating (please give solution scripts).

Lack of feedback with IC exercises: some do not have instant-feedback, no way to check if we made the correct analysis or graph (give us a solution script). "Felt a bit alone."

Amount of work: The IC parts were too short, add 30 mins. All the material is a bit too much. BC reading sometimes rather long. Some variation in amount and type of BC material.

Video/podcast quality: in 2020, podcasts from 2019 had to be used. They were of poor quality. In 2021 all lectures will be live and recorded, with good quality.

Critical analysis: would be good to work through a paper together, to assess the data analytic methods used.

Prof. Petchey talks for hours on end.

### Mitigation

**Learning Objectives. Mock exam.**

**Refer to Learning Objectives for what is core.  
Please ask if you are uncertain.**

**Students should make one as they go along.**

**Refer to Learning Objectives for what is core.  
Please ask if you are uncertain.**

**Example solution scripts available for first time in 2021.**

**Work on the practical parts at the same time that help is available,  
i.e. during the scheduled practical sessions.**

**Work together in study groups**

**Work steadily, attend live lectures, attend practicals,  
keep up, ask for help.**

**All lectures will be live (synchronous), will be recorded, and will be made available.**

We have not had time to implement this.  
It would require removing other content, so is not a simple change to make.

**Prof. Petchey tries to be more concise.  
We have other lecturers in 2021: Prof. Damien Farine, Dr Hanja**

You

Us





The screenshot shows the OLAT course interface for '22FS BIO144 Data Analysis in Biology (Preparation)'. The left sidebar contains navigation links for 'BIO144', 'About the course', 'Previous knowledge', 'Wiki: FAQ', 'Forum', 'Unit 01' through 'Unit 05'. The main content area displays the 'Overview of topics' forum with 3 entries. The first entry is a sticky topic titled 'Sticky: Hyperlinks in OLAT' by Daugaard, Uriah, last modified on 10/29/2021, 10:20 PM. The second entry is a sticky topic titled 'Sticky: Guidelines for posting code in the forum (read before posting)' by Daugaard, Uriah, last modified on 9/15/2021, 5:08 PM. The third entry is a sticky topic titled 'Sticky: What is this Discussion Forum for? (read before posting)' by Daugaard, Uriah, last modified on 9/15/2021, 4:52 PM. A large black arrow points upwards from the bottom of the page towards the sticky topics in the forum list.

Courses Groups Authoring Campus courses Question bank 22FS BIO144 Da... X

Course info Calendar Participant list Participant infos E-Mail Blog Wiki Forum Documents Glossary User role My course

Course chat Course search

BIO144

About the course Previous knowledge

Wiki: FAQ

Forum

Unit 01 Unit 02 Unit 03 Unit 04 Unit 05

## Overview of topics

Open new topic Archive forum

Search

3 Entries

Type	Discussion topics	Author	Last modified	Marked	New	Posts
Sticky	<a href="#">Hyperlinks in OLAT</a>	Daugaard, Uriah	10/29/2021, 10:20 PM	0	0	1
Sticky	<a href="#">Guidelines for posting code in the forum (read before posting)</a>	Daugaard, Uriah	9/15/2021, 5:08 PM	0	0	1
Sticky	<a href="#">What is this Discussion Forum for? (read before posting)</a>	Daugaard, Uriah	9/15/2021, 4:52 PM	0	0	1

Ask questions / make requests here.

Short break

# Live data analysis demonstration

BIO144  
Week 1

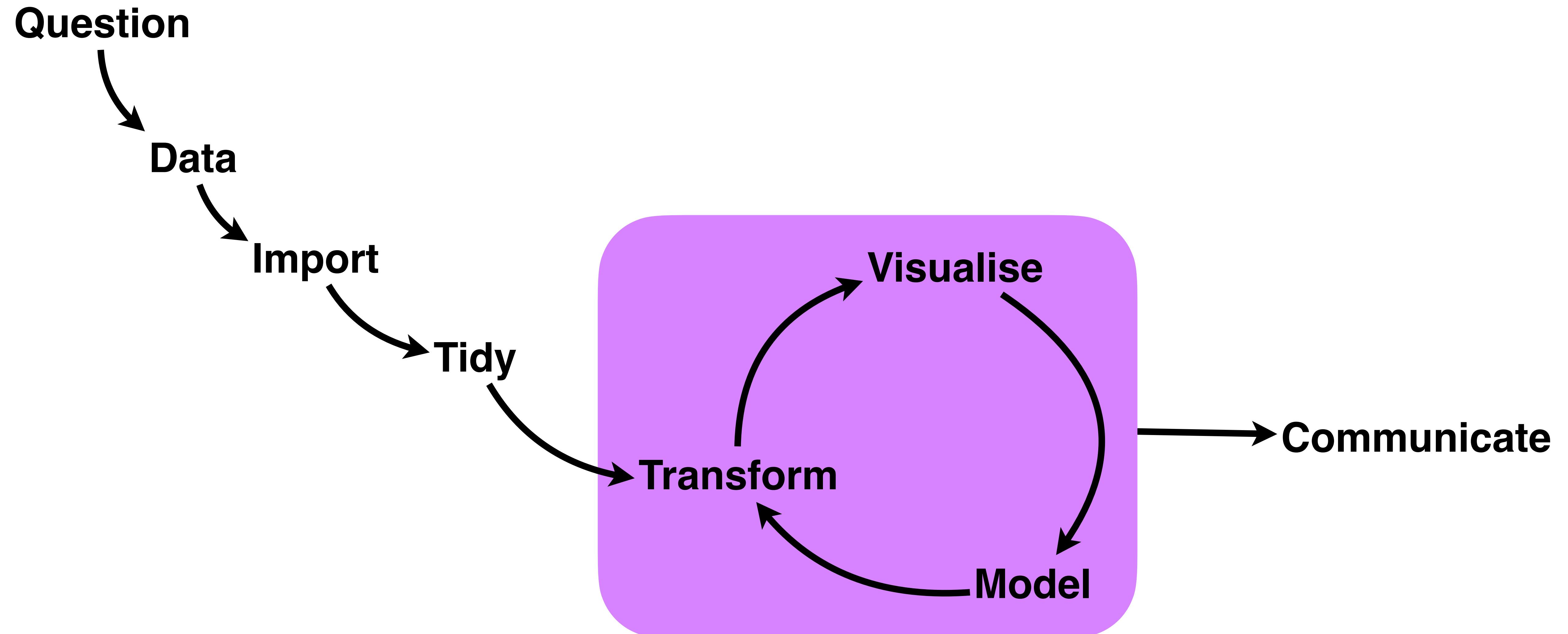
## **Its a demonstration...**

The idea is to give you a feel of what is involved in data analysis.

You will understand some of the demonstration.

You will not understand some of it.

Keep notes about what you don't understand.



# Live data analysis demonstration

The whole data analysis workflow in one hour!!!

## Question

Expectation

Planned presentation & analysis

Selection of subjects

How will data be collected?

Ethics / permissions

Data collection

Data wrangling

Visualise

Statistical test

Critical thinking

Report / communicate

# Live data analysis demonstration

The whole data analysis workflow in one hour!!!

## Question

Expectation  
Planned presentation & analysis  
Selection of subjects  
How will data be collected?  
Ethics / permissions  
Data collection  
Data wrangling  
Visualise  
Statistical test  
Critical thinking  
Report / communicate

## The question

- What should be our question?
- As always, there are some influences and some constraints.
- We should ask a question of interest to us, and of some importance.
- And we should be able to collect the data, within our current constraints, necessary to answer the question.
- The question we will address is "***do male and female reaction times of students at the University of Zurich differ?***".
- Why this question? Reaction times are important, safety, sport...

# Live data analysis demonstration

The whole data analysis workflow in one hour!!!

Question

## Expectation

Planned presentation & analysis

Selection of subjects

How will data be collected?

Ethics / permissions

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Data wrangling

Visualise

Statistical test

Critical thinking

Report / communicate

## Expectation

- Quite a lot of work on this already.
- Generally, males tend to have faster reaction times than females. So we expect that to be the same for students at the University of Zurich.
- Given that you know this pattern, and you are the subjects, its interesting to see if you women can buck the trend, perhaps by trying especially hard. Though now the men know you might do this, it probably won't work!

# Live data analysis demonstration

The whole data analysis workflow in one hour!!!

Question

Expectation

## Planned presentation & analysis

Selection of subjects

How will data be collected?

Ethics / permissions

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Data wrangling

Visualise

Statistical test

Critical thinking

Report / communicate

What graph?

# Live data analysis demonstration

The whole data analysis workflow in one hour!!!

Question

Expectation

## Planned presentation & analysis

Selection of subjects

How will data be collected?

Ethics / permissions

Data collection

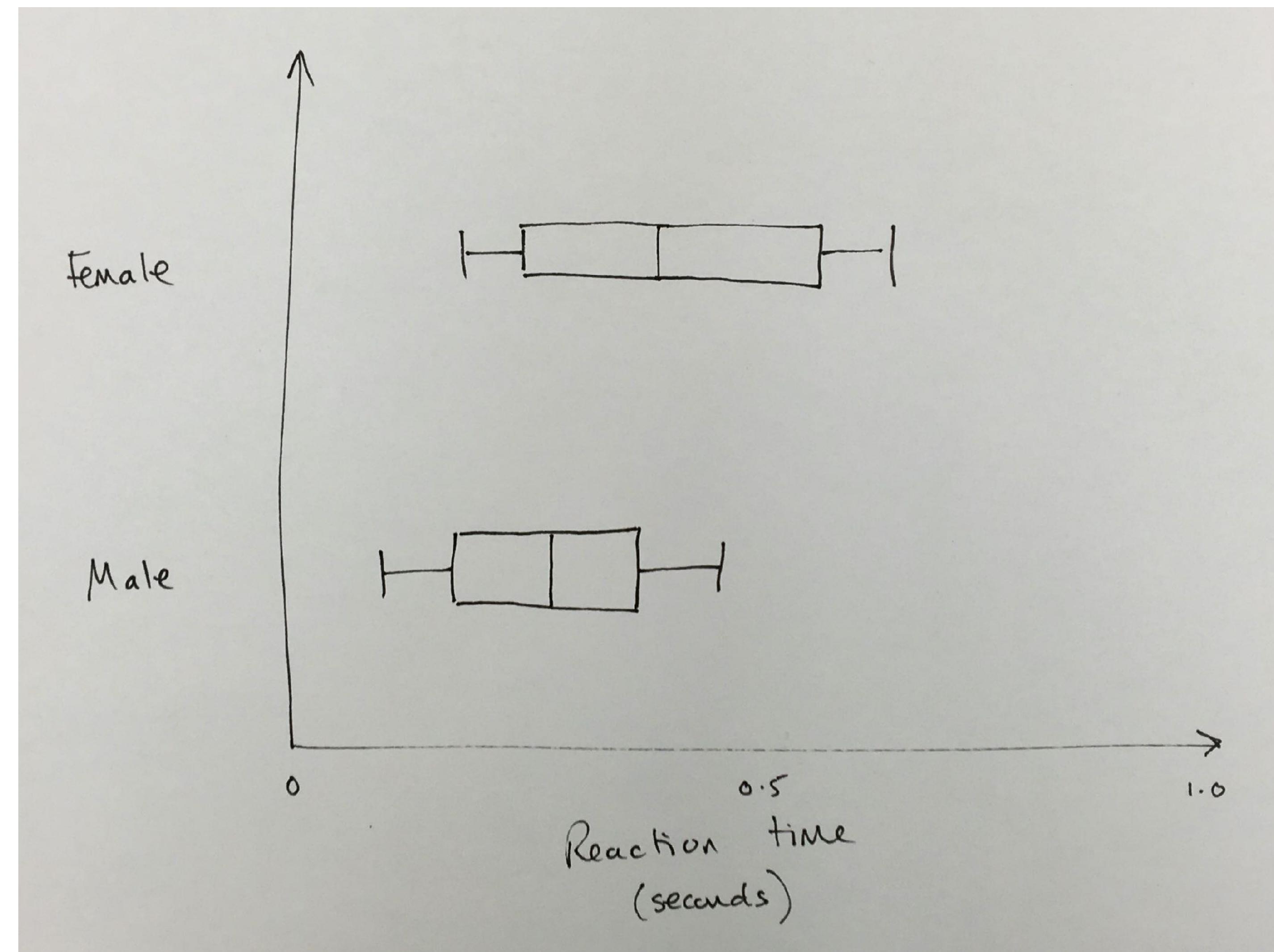
Data wrangling

Visualise

Statistical test

Critical thinking

Report / communicate



# Live data analysis demonstration

The whole data analysis workflow in one hour!!!

Question

Expectation

## Planned presentation & analysis

Selection of subjects

How will data be collected?

Ethics / permissions

Data collection

Data wrangling

Visualise

Statistical test

Critical thinking

Report / communicate

What statistical test?  
What assumptions?

# Live data analysis demonstration

The whole data analysis workflow in one hour!!!

Question

Expectation

Planned presentation & analysis

## **Selection of subjects**

How will data be collected?

Ethics / permissions

Data collection

Data wrangling

Visualise

Statistical test

Critical thinking

Report / communicate

# Live data analysis demonstration

The whole data analysis workflow in one hour!!!

- Question
- Expectation
- Planned presentation & analysis
- Selection of subjects
- How will data be collected?**
- Ethics / permissions
- Data collection
- Data wrangling
- Visualise
- Statistical test
- Critical thinking
- Report / communicate

# Live data analysis demonstration

The whole data analysis workflow in one hour!!!

- Question
- Expectation
- Planned presentation & analysis
- Selection of subjects
- How will data be collected?

## **Ethics / permissions**

- Data collection
- Data wrangling
- Visualise
- Statistical test
- Critical thinking
- Report / communicate

Make up a unique ID code for yourself.  
It should not be anything that could identify you.  
Keep it safe.

# Live data analysis demonstration

The whole data analysis workflow in one hour!!!

Question

Expectation

Planned presentation & analysis

Selection of subjects

How will data be collected?

Ethics / permissions

## Data collection

Data wrangling

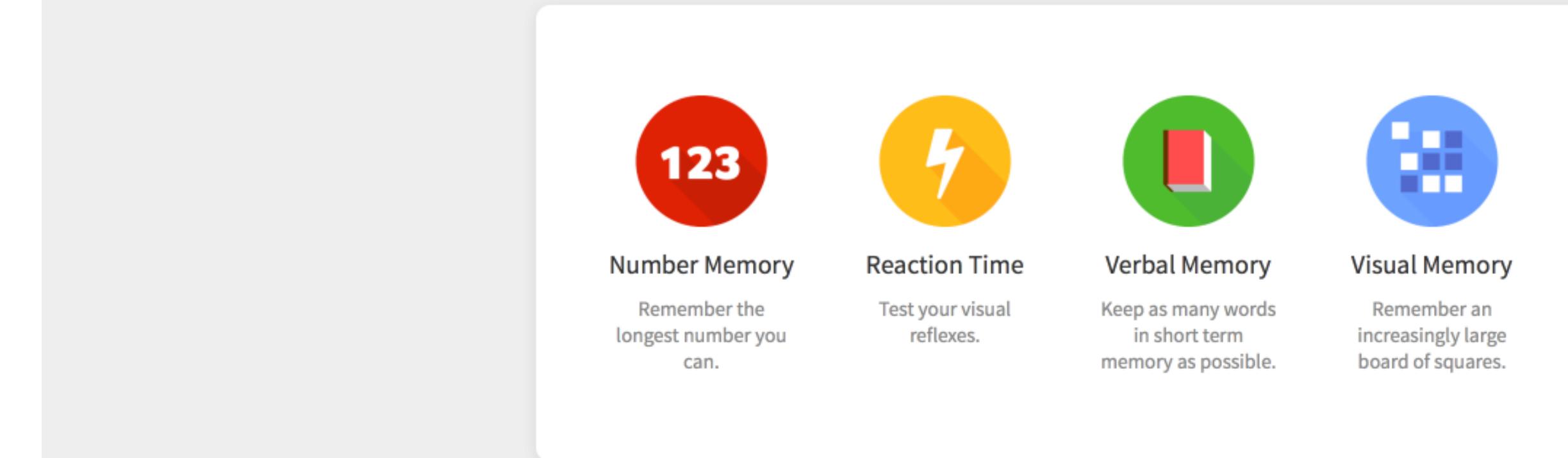
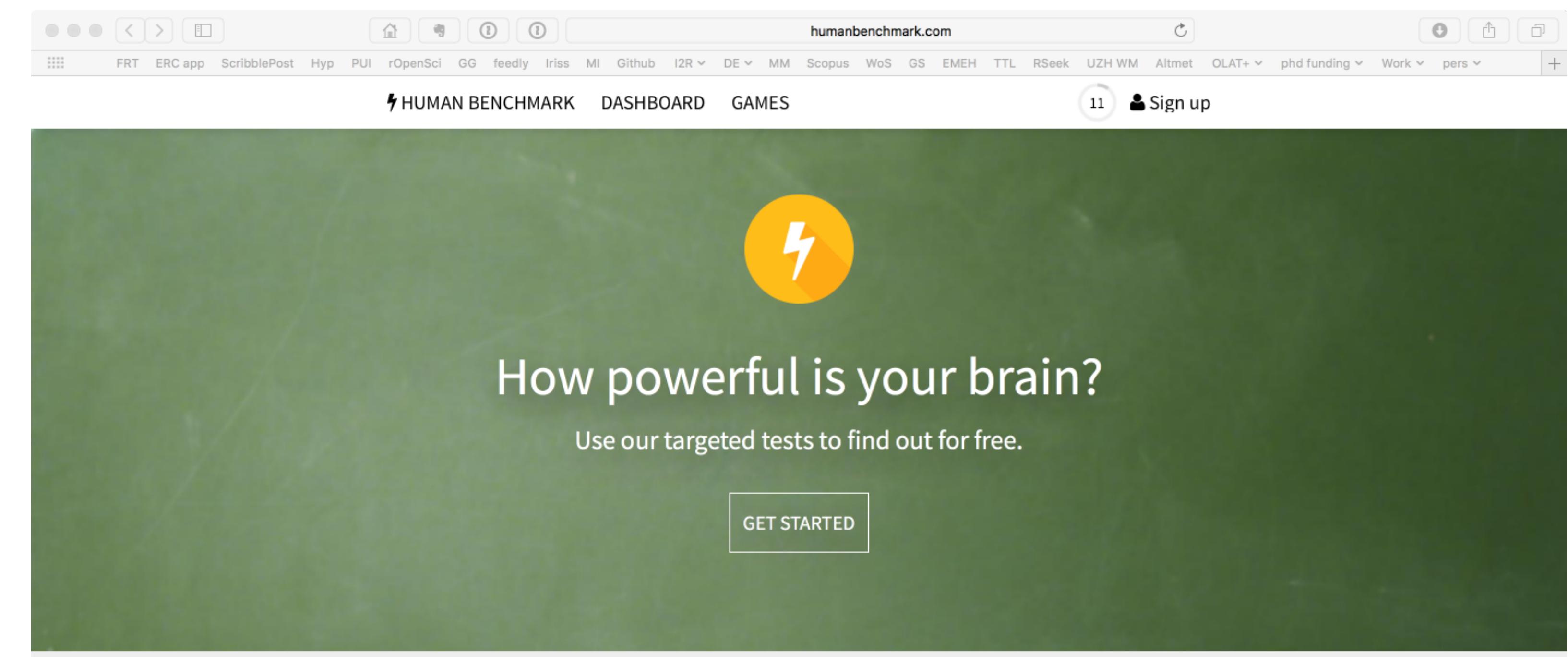
Visualise

Statistical test

Critical thinking

Report / communicate

humanbenchmark.com



# Live data analysis demonstration

The whole data analysis workflow in one hour!!!

Question

Expectation

Planned presentation & analysis

Selection of subjects

How will data be collected?

Ethics / permissions

## Data collection

Data wrangling

Visualise

Statistical test

Critical thinking

Report / communicate

<https://forms.gle/XE88JJXrUdNSD4Vy5>

(Link also in OLAT, Lecture 1 page)

The screenshot shows a Google Forms survey titled "My Human Benchmark results". The survey is intended for a live data analysis demonstration in BIO144, Data Analysis in Biology. It includes fields for entering a unique ID code, gender (Female, Male, Other), average reaction time in seconds, verbal memory test score, and number memory test score.

**My Human Benchmark results**

For live data analysis demonstration, BIO144, Data Analysis in Biology

\*Required

Please enter the unique ID code you gave yourself. \*

Your answer

What is your gender? \*

Female

Male

Other: \_\_\_\_\_

Please enter your average reaction time in seconds (e.g., 0.326). \*

Your answer

Please enter your score on the Verbal Memory test. \*

Your answer

Please enter your score on the Number Memory test

Your answer

# Live data analysis demonstration

The whole data analysis workflow in one hour!!!

- Question
- Expectation
- Planned presentation & analysis
- Selection of subjects
- How will data be collected?
- Ethics / permissions

## **Data collection**

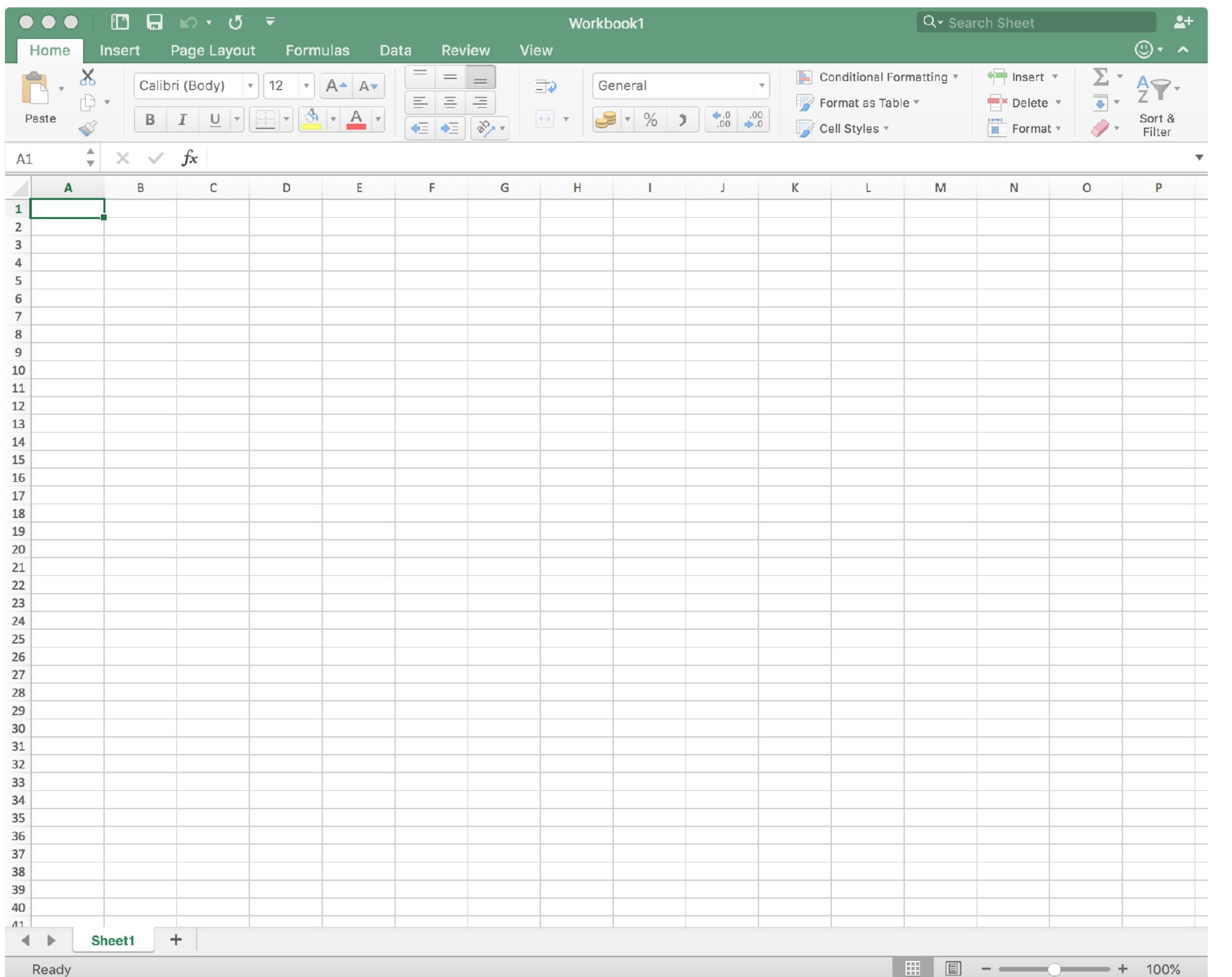
- Data wrangling
- Visualise
- Statistical test
- Critical thinking
- Report / communicate

Check the data in the spreadsheet

**Efficient**  
**Consistent**  
**Repeatable**  
**Reliable**  
**Readable**  
**Robust**  
**Persistent**  
**Sharable**  
**Scalable**

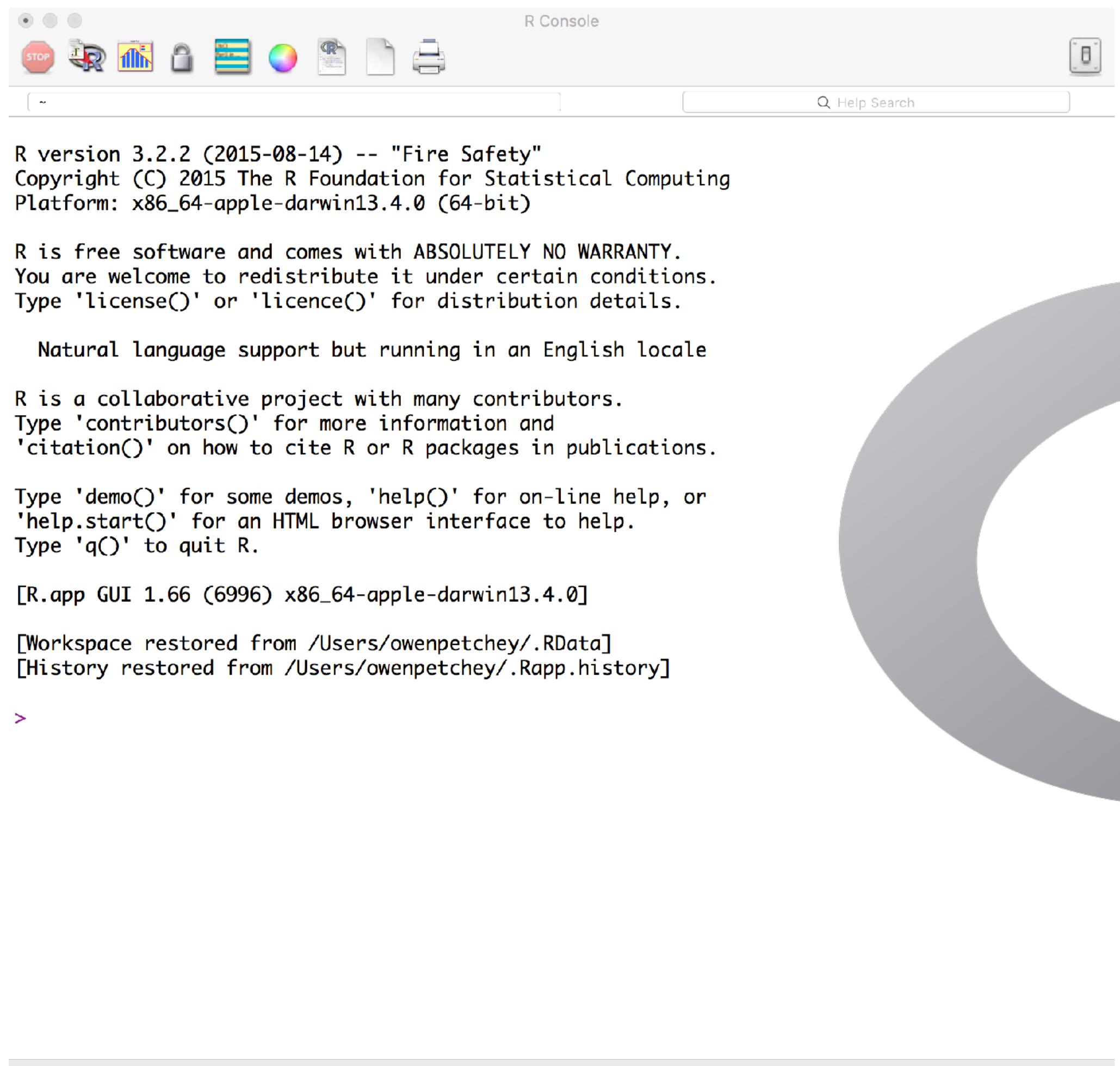
—  
—





**Efficient**  
**Consistent**  
**Repeatable**  
**Reliable**  
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# Live data analysis demonstration

The whole data analysis workflow in one hour!!!

Question  
Expectation  
Planned presentation & analysis  
Selection of subjects  
How will data be collected?  
Ethics / permissions  
Data collection  
**Data wrangling**  
**Visualise**  
**Statistical test**  
Critical thinking  
Report / communicate

Live in RStudio

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