# BayesCog:
# Bayesian Statistics and Hierarchical Bayesian Modeling for Psychological Science

## Lecture 01


Lei Zhang

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https://github.com/lei-zhang/BayesCog_Wien



universität wien
Fakultät für Psychologie

# Conduct at the University

- Read the current information provided on u:find and u:space. Information at short notice is sent via e-mail.
- Register for courses and exams.
- Always maintain a distance of 1-metre from other persons.
- Wear a face mask during courses and if the minimum distance of 1 metre cannot be kept.
- Wash your hands regularly and thoroughly and sanitise work areas.
- Please do not use lifts, if possible.
- Do not come to the University when sick. In case of a suspected COVID-19 infection, call the hotline 1450 immediately.
- For further information, please go to studying.univie.ac.at/info.
- Register for the vaccination, http://impfservice.wien/

# About me: Dr. Lei Zhang

- Current: Postdoc @ SCAN-Unit, with Prof. Claus Lamm
- Ph.D. Cognitive computational neuroscience, *summa cum laude*
- M.Sc. Cognitive neuroscience
- B.Sc. Psychology

# My research

**Overarching goal:**

**Uncover the neuro-computational mechanisms underlying social affective decision-making and flexible behavior**

# My research:

- I ask people to make decisions

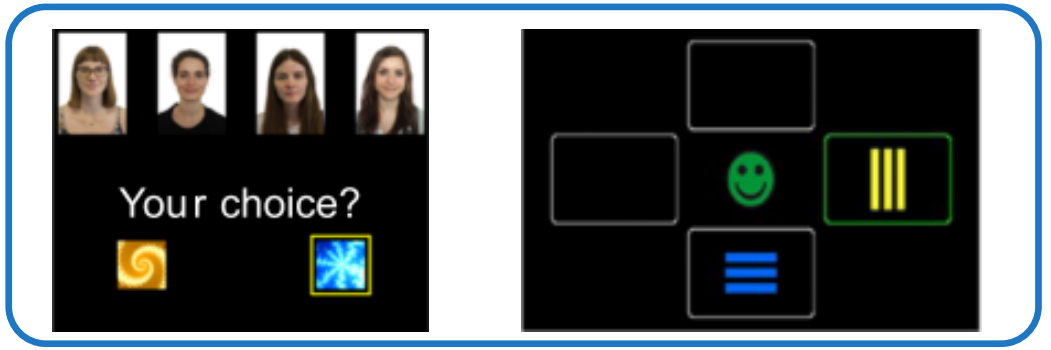
  **Computation**

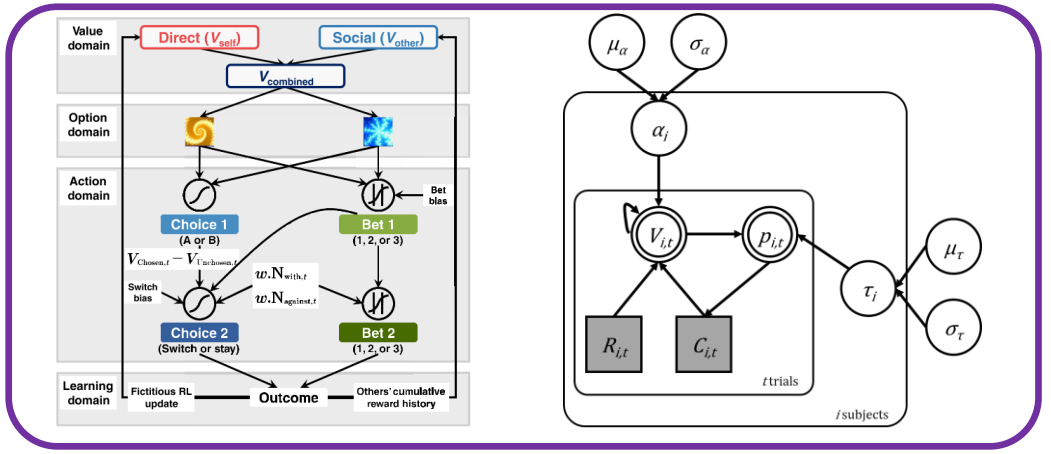
- I build computational models

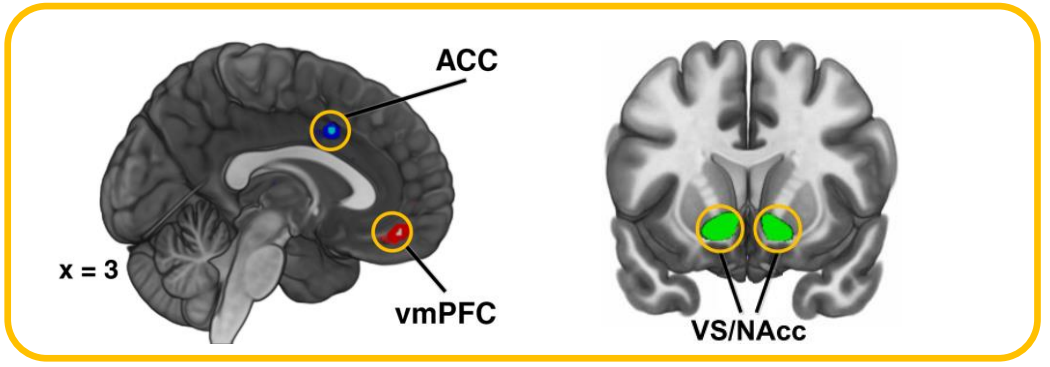
  **Algorithm**

- I examine neural mechanisms

  **Implementation**



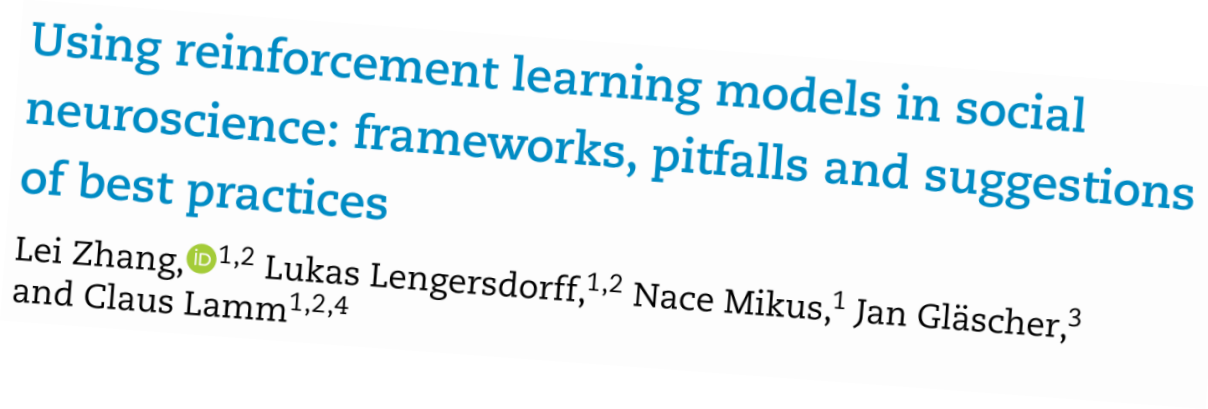
# My research


SCIENCE ADVANCES | RESEARCH ARTICLE

COGNITIVE NEUROSCIENCE

A brain network supporting social influences in human decision-making

Lei Zhang[1,2]* and Jan Gläscher[1]*†


Using reinforcement learning models in social neuroscience: frameworks, pitfalls and suggestions of best practices

Lei Zhang,[1,2] Lukas Lengersdorff,[1,2] Nace Mikus,[1] Jan Gläscher,[3] and Claus Lamm[1,2,4]


Research Articles

Revealing Neurocomputational Mechanisms of Reinforcement Learning and Decision-Making With the hBayesDM Package

Authors: Woo-Young Ahn, Nathaniel Haines, Lei Zhang


PLOS BIOLOGY

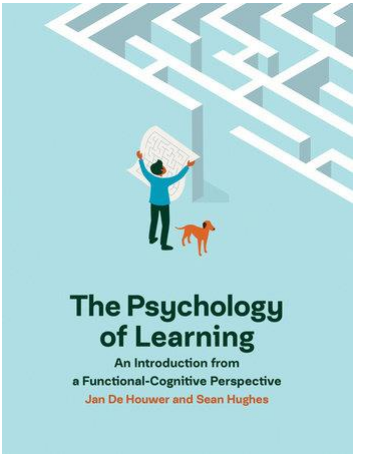
RESEARCH ARTICLE

Modeling flexible behavior in childhood to adulthood shows age-dependent learning mechanisms and less optimal learning in autism in each age group

Daisy Crawley[1‡*], Lei Zhang[2,3,4‡], Emily J. H. Jones[5], Jumana Ahmad[1,6], Bethany Oakley[1], Antonia San José Cáceres[1,7], Tony Charman[8,9], Jan K. Buitelaar[10,11,12], Declan G. M. Murphy[1,9,13], Christopher Chatham[4], Hanneke den Ouden[10‡], Eva Loth[1,13‡], the EU-AIMS LEAP group[¶]

# Want to work with me?

- For planning your own experiments
  - decent understanding of learning theories




Get started?
free textbook available

- For helping with data collection
  - excellent planning and organizing skills

Get started?
Online planning tools or simply excel

- For analyzing our/my existing data
  - great programming skills, e.g., R, Python
  - Ideally, have taken my SE or TEWA1

Get started?
datacamp.com

# Shameless self promotion

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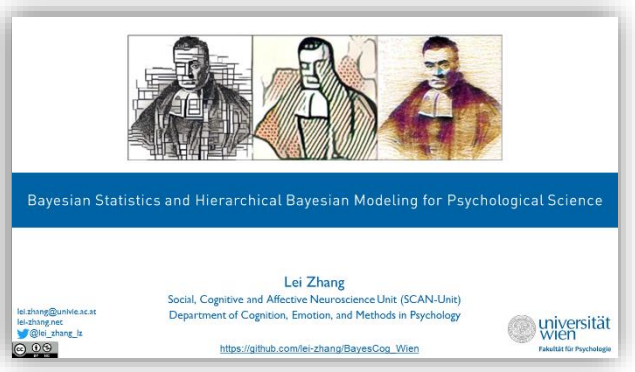
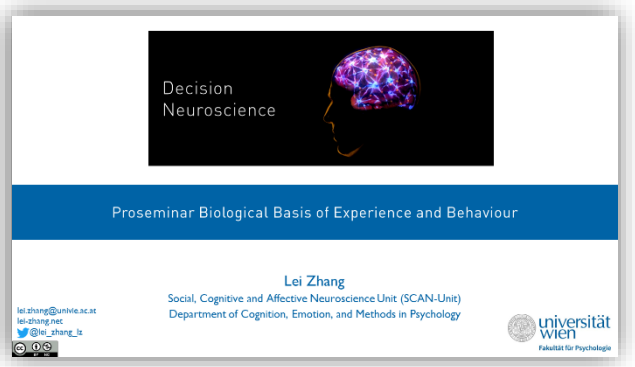
https://lei-zhang.net/

@lei_zhang_lz

@LeiZhang

@lei-zhang



# Goal of this course

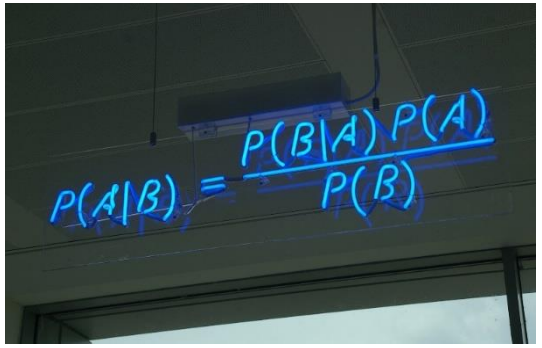
- Practical R programming, with DataCamp
- Practical model-building in Stan, model diagnostics
- (Enough) theory to ground you
- Be comfortable to use R/Stan for your own work + very basic knowledge of GitHub

# Goal of this course

This course is NOT about…

… Bayes in the brain (e.g. predictive coding)

… Bayesian statistics to supersede classic statistics




However, Bayesian statistics offer great tools to analyze cognitive processes!

- Construct cognitive models
- Estimate posterior distributions of parameters
- Compare models: which is the best one, given the data
- Perform model-based analysis, e.g. model-based fMRI/EEG/eye-movement

# A clear goal depends on knowledge & expectations

## Pre-course survey

- sent to 20 (+5) registered students
- received 13
- 52% return rate, many thanks!

spontaneous feedback are still welcome at any time!

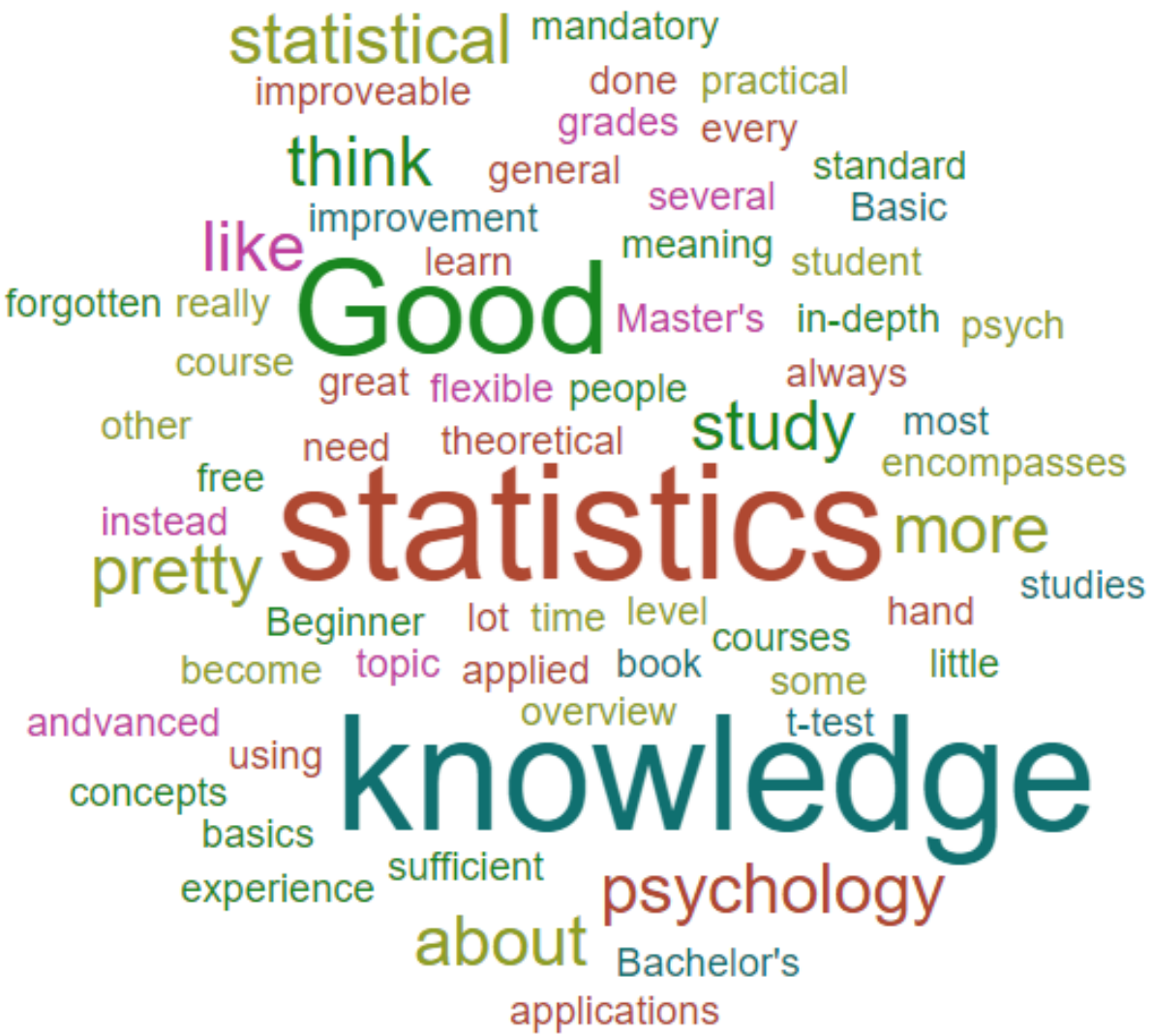
What is your experience with…

- Statistics?
- R? (and / or Matlab?)
- Cognitive Modeling?

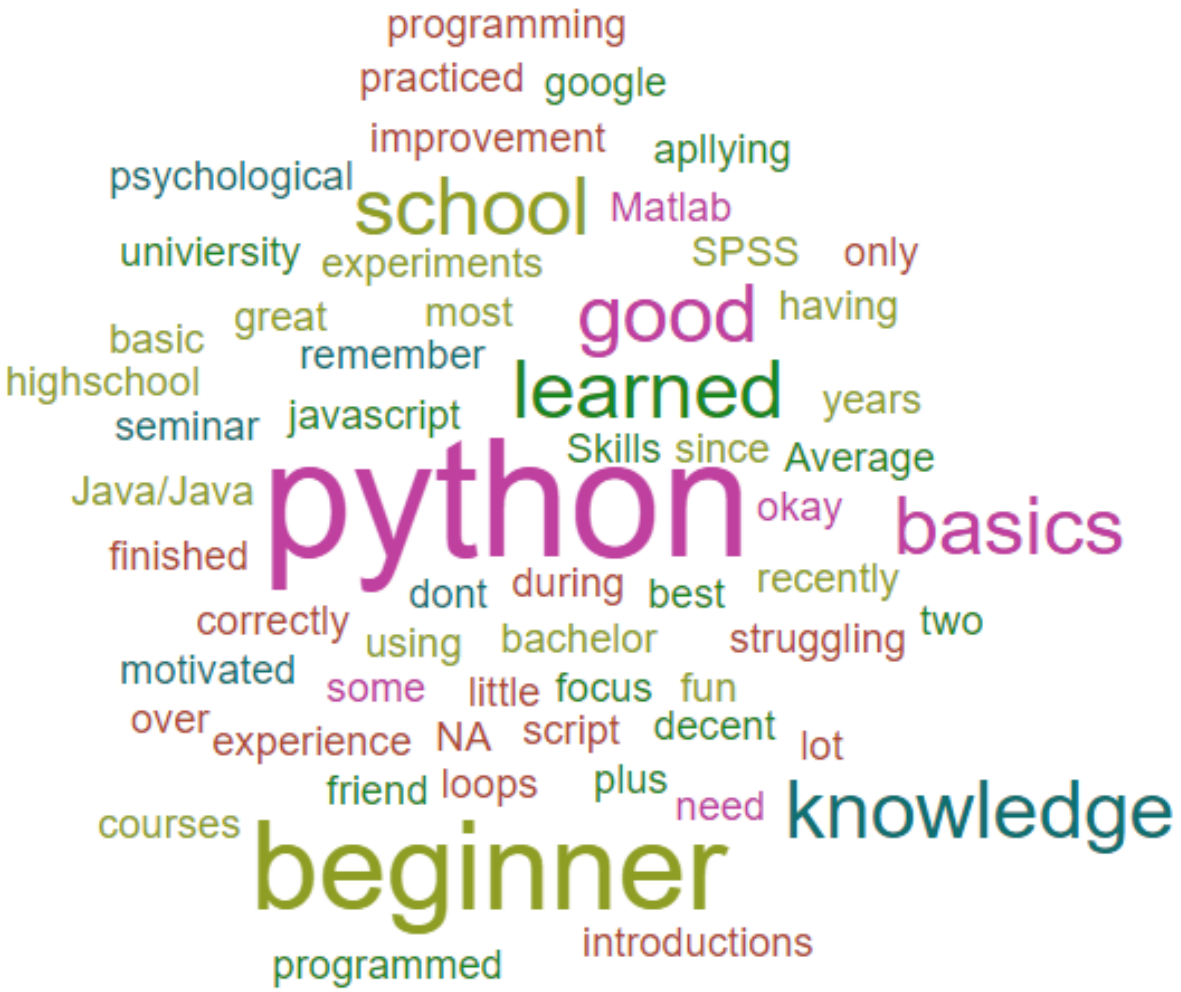
You would like to…

- gain knowledge of Bayesian stats?
- be able to read "computational modeling" section in papers?
- write your own model?

# Your knowledge of stats



# Your knowledge of programming



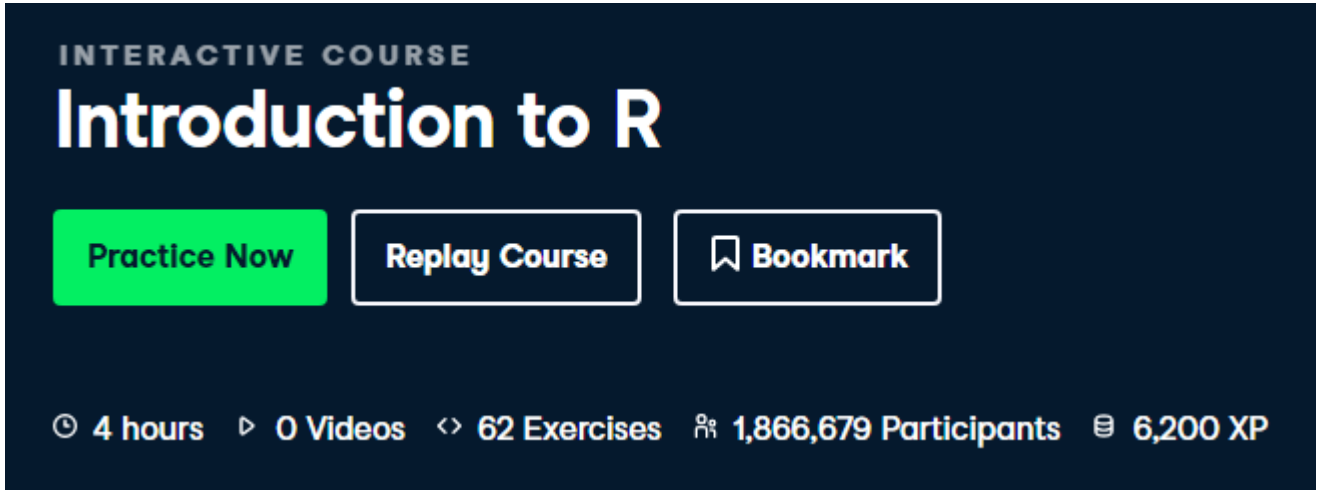
# Your expectations

# Schedule of Lectures

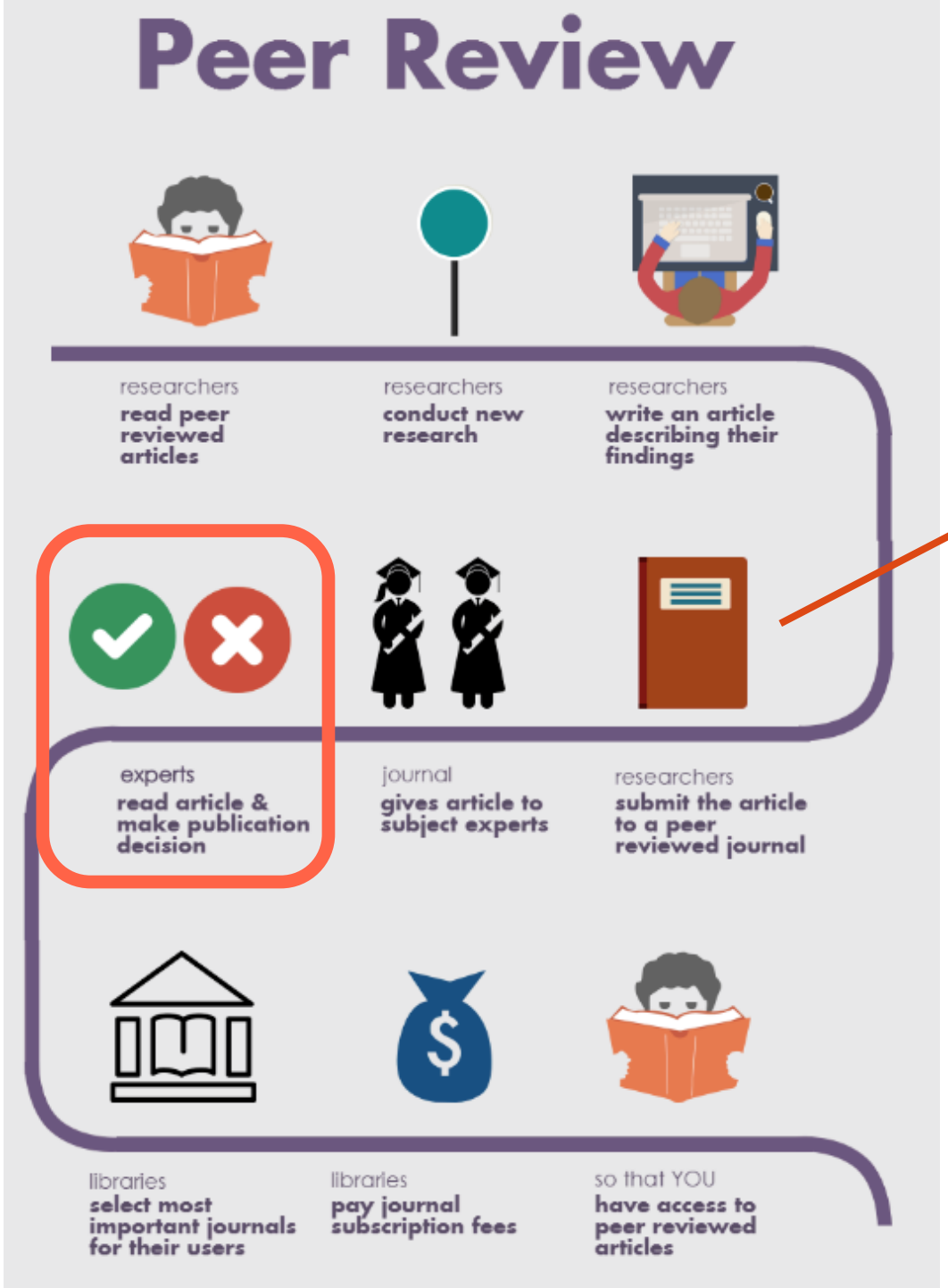
| | | | |
|---|---|---|---|
| 19.03 | L01 | Introduction and overview | |
| 26.03 | L02 | Introduction to R | |
| 16.04 | L03 | Probability; Bayes' Theorem | |
| 23.04 | L04 | Binomial model; MCMC & Stan | |
| 30.04 | L05 | Simple linear model | |
| 07.05 | L06 | Cognitive Modeling; Reinforcement learning model | On-going R tutorials on DataCamp |
| 14.05 | L07 | More on RL model | |
| 21.05 | L08 | Hierarchical modeling | |
| 28.05 | L09 | More on hierarchical modeling | |
| 04.06 | L10 | Optimizing Stan codes | Review a paper |
| 11.06 | L11 | PRL task & model comparison | |
| 18.06 | L12 | Stan style tip & debugging | |
| 25.06 | L13 | Programming project + summary + HPC demo | Programming project |

# Course structure (from L02)

# R Tutorials on DataCamp




datacamp




preprint

bioRxiv beta
THE PREPRINT SERVER FOR BIOLOGY

PsyArXiv

# How to review a paper?

- Suppose you are invited by a journal editor to review a paper
- Of course, you have to read it☺, carefully and critically
- Then write a review report to the editor
  - (1) Make a summary. What is this paper about? What was done? What was the conclusion?
  - (2) List your concerns. Is the design appropriate? Are the analyses sound? Do their data support the conclusion? What can be done better?
- For this course:
  - up to 3 pages (11pt, 1.5 space)
  - be independent: okay to discuss HOW to review, but do NOT discuss WHAT to review

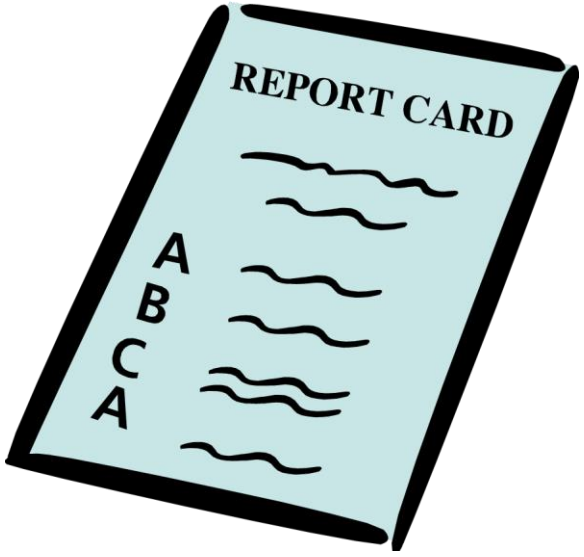
# Programming project

- already on Github
- should be summitted before the end of semester (31.07.2021)
- use R and RStan
- will be a real-world cognitive modeling problem

- hand in the *.R and *.stan files in a ZIP file
- name as: lastname_matriculatenumber_200077.ZIP
- no need to write a report

# Gradings

- Regular participation (25%; counting from the 26/03)
  - using Google Sheets (later via email); Be honest ☺
- Regular programming tutorials (datacamp.com) (25%)
- Review a paper, 10 (25%), due on 23.05.2021*
- Programming project, 10 (25%), due on 31.07.2021*




- Grades: >87% 1, >75% 2, >63% 3, >50% 4, <=50% 5
- At least 51% to obtain 4 ECTS

*flexible deadline due to Covid-19

# More survey results.

# More Qs about the course

NA

In the course description on u:find it says that basic knowledge of R is a must. I have never worked with R, however, but I'm very interested in this course. If I put in some extra work alongside this course, is it still possible to achieve a good grade in your opinion?

Yes

No

Is it ok if your´e not that experiencend in R yet, but are willing to learn it during the semester on your own?

# Q regarding the instructor

NA

No

Recording our sessions might be helpful to look something up afterwards

# misc.

NA

No

I'm very excited for this course!

# Further questions

- What knowledge is expected as a prerequisite?
  - some stats, some programming. I'll start from the beginning, but the pace may be fast
- How many R skills will we get taught?
  - As much as I could, but fit everything in one semester is difficult
- Is this course difficult?
  - this varies from person to person, but from my experience this course is indeed demanding, and can be overwhelming

# What do other people say?

- SIPS commendation award
- UNIVIE teaching award for early career researchers

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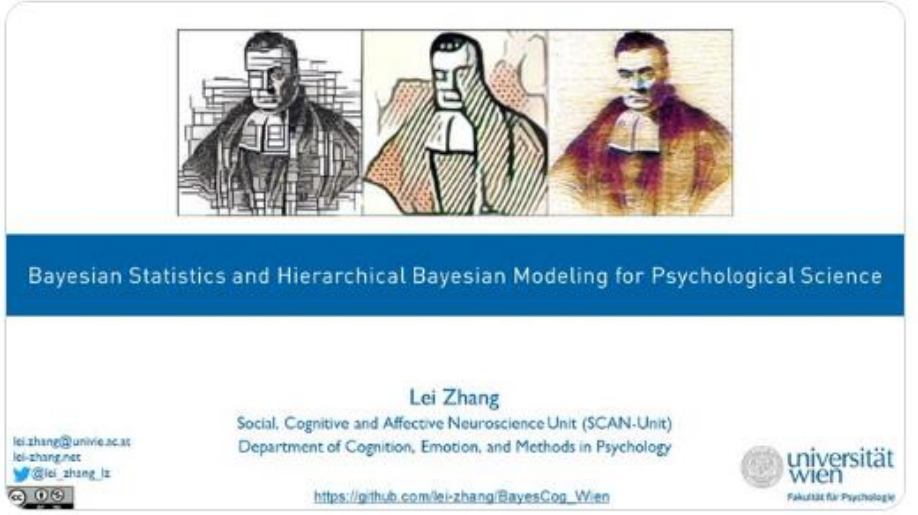
1/13) This semester's teaching on Bayesian stats and cognitive modeling is over! Thanks to COVID (ironically!), I recorded all my teaching sessions w/ @zoom_us, and they are available on #Youtube.

Wondered what have we covered to the cog-neuro audience? A thread.




3:24 PM · Jun 26, 2020 · Twitter Web App

View Tweet activity

**174** Retweets **14** Quote Tweets **634** Likes

**Richard McElreath**
@rlmcelreath

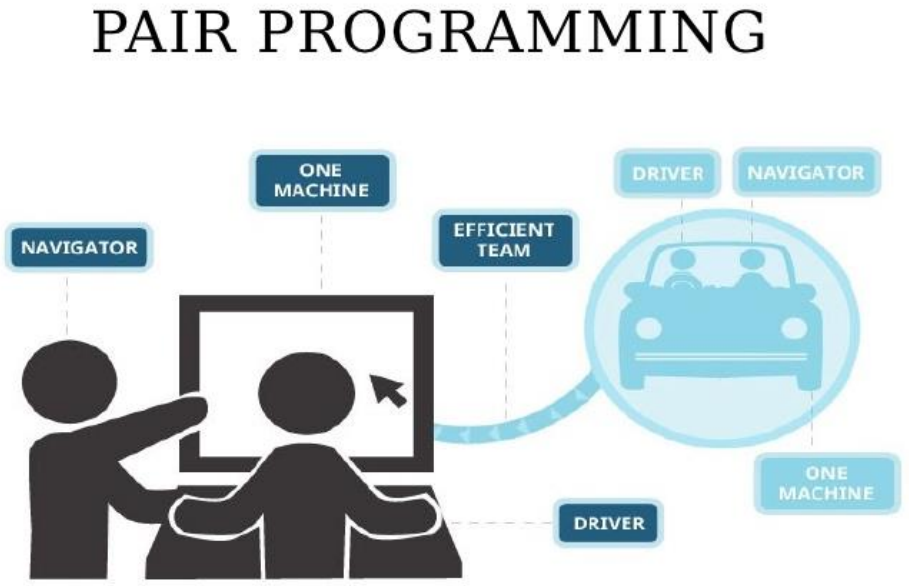
I say this a lot, bc I am also confused quite often.

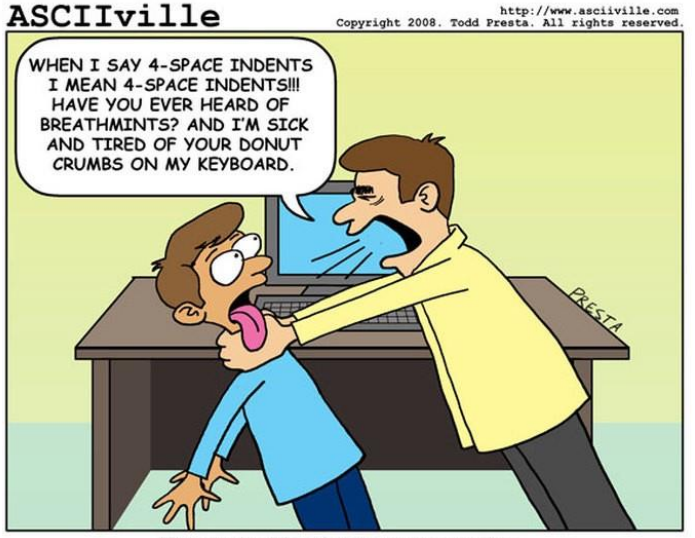
> 
> **Anna Jacobson** @AnnaChingChing · Feb 21
>
> "If you are confused, it is only because you are trying to understand." - @rlmcelreath in Statistical Rethinking

# Anything else?

# How to Get the Most out of the course

- Lecture structure: 60min theory + demo, 20-30min exercise + discussion
- Work in pairs: Talk to each other & help each other
- Ask questions
- Try the exercises



The dark side of pair programming.

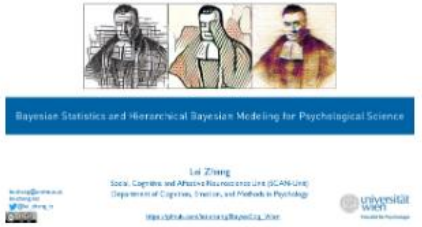
# A very quick look at GitHub

## BayesCog

Bayesian Statistics and Hierarchical Bayesian Modeling for Psychological Science

repo size 234 MB | languages 2 | last commit october 2020

@lei_zhang_lz 2.1k | @ScanUnit 1.1k

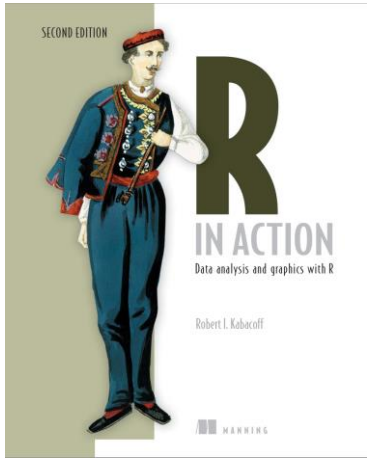


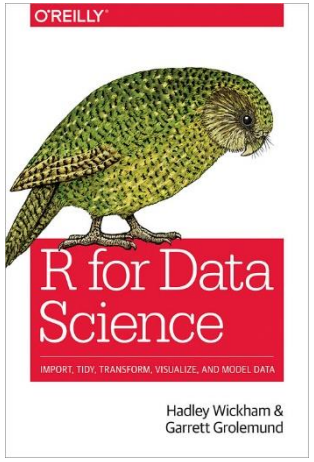

master | Go to file | Code

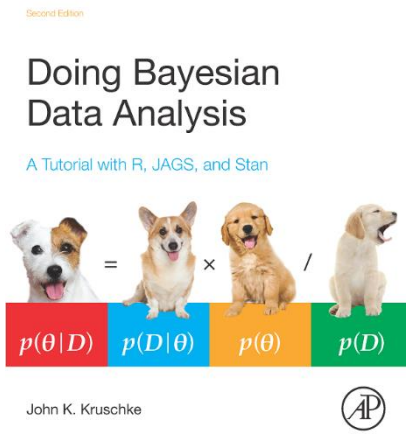
lei-zhang update ... on Oct 5, 2020 92

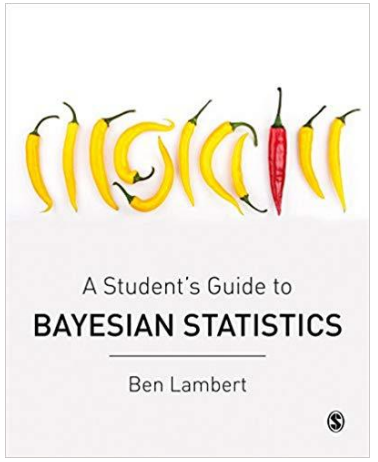
| | | |
|---|---|---|
| 00_R_cheatsheet | R | 2 years ago |
| 01.R_basics | update | 10 months ago |
| 02.binomial_glo... | update | 10 months ago |
| 03.bernoulli_coin | update | 10 months ago |
| 04.regression_h... | update | 10 months ago |
| 05.regression_h... | update | 10 months ago |
| 06.reinforceme... | update | 10 months ago |
| 07.optm_rl | update | 10 months ago |
| 08.compare_m... | update | 9 months ago |
| 09.debugging | update | 10 months ago |
| Programing_pr... | update | 9 months ago |
| review_a_paper | update | 12 months ago |
| slides | update | 9 months ago |
| .gitignore | update | 10 months ago |
| LICENSE | update | 7 months ago |
| Thumbnail.png | update | 7 months ago |
| description.txt | update | 7 months ago |
| readme.md | update | 5 months ago |

# Resources



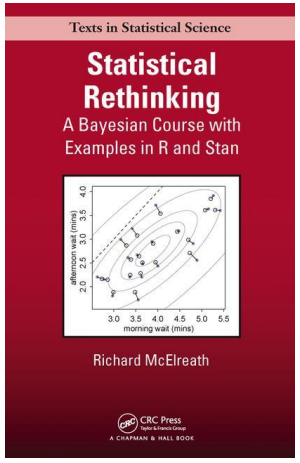



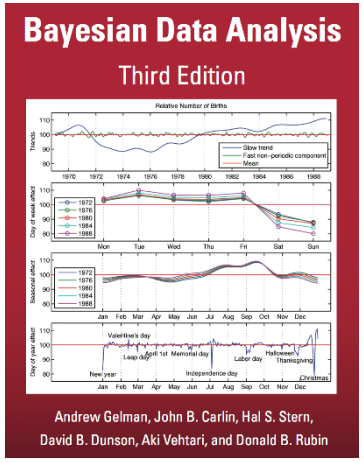



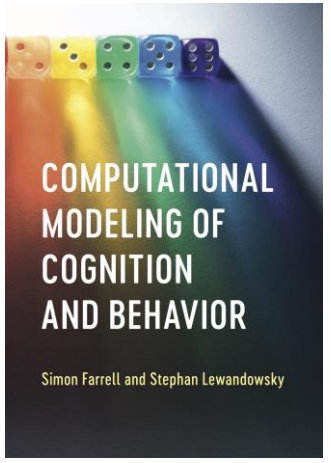



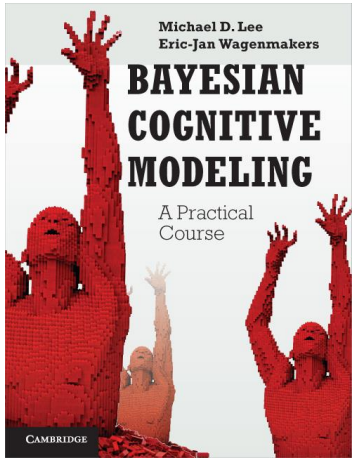


http://statsthinking21.org/




datacamp

https://www.datacamp.com/

JASP

https://jasp-stats.org/

# Now welcome to Bayesland!


ANY
QUESTIONS
?

Happy Computing!