my-ebook

Parmeshvar

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Table of contents

1 Introduction

2 Introduction

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Academic Profile

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3 Bayesian data analysis for cognitive science

3.1 Introduction: What this course is about

This course provides an introduction to Bayesian data analysis using the probabilistic programming language **Stan**.
We will use a front end software package called **brms**.

This course is for:

- Linguistics (MM5, MM6)
- Cognitive Systems
- Cognitive Science

Please see the PULS FAQs to find out how the sign-up system works (in German).

We will be using the software R and RStudio, so make sure you install these on your computer.

Topics to be covered:

1. Basic probability theory, random variable theory (including jointly distributed RVs), probability distributions (including bivariate distributions)
2. Using Bayes' rule for statistical inference
3. An introduction to (generalized) linear models
4. An introduction to hierarchical models
5. Measurement error models
6. Mixture models
7. Model selection and hypothesis testing (Bayes factor and k-fold cross-validation)

3.2 Teaching

Science and statistics is/are one unitary thing; you cannot do one without the other. Towards this end, I teach some (in my opinion) critically important classes that provide a solid statistical foundation for doing research in cognitive science. Free online course, four weeks

(MOOC), enrollments open: Introduction to Bayesian Data Analysis. Short (four-hour) tutorial on Bayesian statistics, taught at EMLAR 2022: here Introduction to (frequentist) statistics Introduction to Bayesian data analysis for cognitive science BDA cover

3.3 Lecture notes

Download from here.

3.4 Moodle website

All communications with students in Potsdam will be done through this website.

4 Schedule

Week	Lecture	Main Topic	Sub Topic	Video	PDF Resource
Jan 30 + Feb 4	-	Model Selection & Hypothesis Testing	-	-	HW 13
Week 2	1	Descriptive Statistics	Central Tendency	Link	Week 2.pdf
	2	Descriptive Statistics	Measure of Variability	Link	Week 2.pdf
	3	Descriptive Statistics	Describing Data	Link	Week 2.pdf
	4	Probability	-	Link	Week 2.pdf
	5	Distribution	-	Link	Week 2.pdf
Week 3	1	Probability	Z Table (Normal Distribution)	Link	Week 3.pdf
	2	Divergence	Measuring Divergence	Link	Week 3.pdf
	3	Inferential Statistics	Sample and Population	Link	Week 3.pdf
	4	Model Fit	-	Link	Week 3.pdf
	5	Hypothesis Testing	Hypothesis and Error	Link	Week 3.pdf
Week 4	1	Statistical Terms	Terms of Statistics	Link	Week 4.pdf
	2	Hypothesis Testing	T-Test	Link	Week 4.pdf
	3	Hypothesis Testing	T-Test in Detail	Link	Week 4.pdf
	4	ANOVA	ANOVA	Link	Week 4.pdf
Week 5	1	ANOVA	Example of ANOVA	Link	Week 5.pdf
	2	ANOVA	Types of ANOVA	Link	Week 5.pdf

Week	Lecture	Main Topic	Sub Topic	Video	PDF Resource
	3	Correlation	Introduction to Correlation	Link	Week 5.pdf
	4	Regression	Regression	Link	Week 5.pdf
	5	Regression	Regression	Link	Week 5.pdf
Week 6	1	Regression	R Script for Regression	Link	Week 6.pdf
	2	Chi-Square	Chi Square	Link	Week 6.pdf
	3	Chi-Square	Chi Square Test	Link	Week 6.pdf
	4	Logistic Regression	Logistic Function	Link	Week 6.pdf
	5	Distribution	-	Link	Week 6.pdf
Week 7	1	Time Series	Intro to Time Series	Link	Week 7.pdf
	2	Probability	Conditional Probability	Link	Week 7.pdf
	3	Additional Concepts	-	Link	Week 7.pdf
	4	Distribution	-	Link	Week 7.pdf
	5	Poisson Distribution	-	Link	Week 7.pdf
Week 8	1	Libraries & Documentation	Effect Size and Packages	Link	Week 8.pdf
	2	Software Comparison	RStudio vs RKward	Link	Week 8.pdf
	3	Visualization	Flexplot	Link	Week 8.pdf
	4	Programming in R	Functions	Link	Week 8.pdf
	5	R Tools	R Shiny and R Markdown	Link	Week 8.pdf

Part I

Preface

5 Why Read This Book?

This book is intended for MSc Chemistry students who want to develop a deep understanding of core chemistry concepts.

5.1 Target Audience

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5.2 What Will You Learn?

- Conceptual clarity in acid-base theory
- Buffers and equilibrium
- Spectroscopy fundamentals
- Statistical mechanics basics

6 Developing the right mindset for this book

One very important characteristic that the reader should bring to this book is a can-do spirit. There will be many places where the going will get tough, and the reader will have to slow down and play around with the material, or refresh their understanding of arithmetic or middle-school algebra. The basic principles of such a can-do spirit are nicely summarized in the book by Burger and Starbird (2012); also see Levy (2021). Although we cannot summarize all the insights from these books in a few words, inspired by the Burger and Starbird (2012) book, here is a short enumeration of the kind of mindset the reader will need to cultivate:

Spend time on the basic, apparently easy material; make sure you understand it deeply. Look for gaps in your understanding. Reading different presentations of the same material (in different books or articles) can yield new insights. Let mistakes and errors be your teacher. We instinctively recoil from our mistakes, but errors are ultimately our friends; they have the potential to teach us more than our correct answers can. In this sense, a correct solution can be less interesting than an incorrect one. When you are intimidated by some exercise or problem, give up and admit defeat immediately. This relaxes the mind; you've already given up, there's nothing more to do. Then, after a while, try to solve a simpler version of the problem. Sometimes, it is useful to break the problem down to smaller parts, each of which may be easier to solve. Create your own questions. Don't wait to be asked questions; develop your own problems and then try to solve them. Don't expect to understand everything in the first pass. Just mentally note the gaps in your understanding, and return to them later and work on these gaps. Step back periodically to try to sketch out a broader picture of what you are learning. Writing down what you know, without looking up anything, is one helpful way to achieve this. Don't wait for the teacher to give you bullet-point summaries of what you should have learned; develop such summaries yourself. Develop the art of finding information. When confronted with something you don't know, or with some obscure error message, use google to find some answers. Do not hesitate to re-read a chapter; often, one only understands a topic after one revisits the material. As instructors, we have noticed over the years that students with such a mindset generally do very well. Some students already have that spirit, but others need to explicitly develop it. We firmly believe that everyone can develop such a mindset, but one may have to work on acquiring it. In any case, such an attitude is necessary for a book of this sort.

7 intro

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8 summary

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References