Bayesian Data Analysis
Psych 2030 – Fall 2021

Lecture Time: Thurs 9:45-11:45am
Location: WJH B6
For auditors:
https://harvard.zoom.us/j/93093982384?pwd=M3YvV3N4NXZ4RW9pS1gwbVU5QzlPUT09

Lab Section I: Thurs 3-4:15pm
Location: WJH 1550

Lab Section II: Fri 9-10:15am
Location: WJH B6
For auditors:
https://harvard.zoom.us/j/99060362447?pwd=Vlh4RDdtNUdGeE1PMWtqbWZXa1dhdz09

Lecturer: Dr. Patrick Mair (mair@fas.harvard.edu)
Student Hours: by appointment (online, just shoot me an email)
https://harvard.zoom.us/j/97869459317?pwd=WERWUWdMdHRHaTdsdk5QTjhmcFRlQT09

Teaching Fellow: Brandon Woo (bmwoo@g.harvard.edu)
Student Hours: Tues 9-10am (https://harvard.zoom.us/j/94823601369), pls RSVP via https://brandonpsy2030.youcanbook.me/

Course Description
Bayesian statistics is becoming more and more popular in psychology. This class covers basic and advanced topics of Bayesian statistics with a strong focus on applications in Psychology. Formulas and technical details are kept on a minimum — it is all about how to integrate Bayesian concepts into your everyday research.
The first part of the course introduces students to the Bayesian paradigm of inferential statistics (as opposed to the frequentist approach everyone should be familiar with). To have a good understanding of this idea, we need to elaborate on various concepts of probability theory (e.g., Bayes' theorem) and statistical distributions. We then introduce the key components of Bayesian inference (prior, likelihood, posterior), and discuss Bayesian hypothesis testing (Bayes factors).
Subsequent units focus on Bayesian regression (including model checks and model comparison) and mixed-effects models which, within a Bayesian context, belong to the family of Bayesian hierarchical models. There we also elaborate on modern approaches like integrated nested Laplace approximation (INLA) that allow us to efficiently estimate complex nonlinear, spatio-temporal models.
Finally, we introduce Stan, a probabilistic programming language for describing models in a Bayesian fashion. This way of overarching Bayesian thinking unifies approaches ranging from classical regression models to Bayesian cognitive models.
All topics covered will be supported by corresponding computations and illustrations in R.

Course Objectives
The primary objective of this course is to acquaint students with a large set of Bayesian methodology relevant for their future research in various areas of psychology and related fields.

Course Website
You can access course website through canvas. We will use the course website extensively, so check it regularly. I will disseminate readings, make weekly announcements, and post links to additional material online.

Course Prerequisites
This course is intended for Harvard doctoral candidates in Psychology. It is required that students completed Psych 1950 and Psych 1952. That said, other students (e.g. Harvard graduate students from other fields, MIT graduate students, Harvard undergraduates) might obtain permission to take the course if there is room.
Students need to have solid R knowledge. Make sure that you have the latest R and RStudio versions installed when you come to the first unit, as well as the latest versions of all packages.

Course Requirements/Grading

Problem Sets
Weekly problem sets will be assigned in the lab sections (see Table below). Late submissions are not acceptable and will be graded as "fail".

Midterm Examination
A take-home midterm exam where you work on your own data project in R and write a report.

Final Examination
A take-home final exam where you work on your own data project in R and write a report.

Exercises will be posted online on a biweekly basis.

Do not take this course if you cannot complete either examination due to other (curricular or extracurricular) commitments.

Lecture Slides
I will post annotated lecture slides as soon as possible prior to lecture and advise you to prepare for lecture. That said, these annotated slides are not meant to stand alone: Some of the material will only become clear after reviewing the readings, attending lecture, consulting online resources, or talking with your peers.

Textbooks

Lambert, B. (2018). A Student's Guide to Bayesian Statistics. Sage.

McElreath, R. (2020). Statistical Rethinking: A Bayesian Course with Examples in R and Stan (2nd ed.). CRC Press.

Weekly Readings
The recommended reading list can be found on the course website. As needed, I will upload non-textbook readings on the website.

Additional Notes
Since the methodological concepts elaborated in the lecture units will be heavily supported by the use of R, it is strongly suggested to bring a laptop with you to class.

Accommodations for Students with Disabilities
Students needing academic adjustments or accommodations because of a documented disability should present their Faculty Letter from the Accessible Education Office (AEO) and speak with Dr. Mair by the end of the second week of the term. Failure to do so may result in the course head's inability to respond in a timely manner. All discussions will remain confidential, although the AEO invites Faculty to discuss appropriate implementation with them.

Week	Day	Date	Event	Unit	Topic
1	Thurs	09/02/21	9:45-11:45	Unit 1	Course Introduction
2	Thurs	09/09/21	9:45-11:45	Unit 2 Lab 1	Probability Theory Bayesian Stats in Psychology, Probabilities
3	Thurs	09/16/21	9:45-11:45	Unit 3 Lab 2	Distribution Theory Probability Theory and Distributions (PS1)
4	Thurs	09/23/21	9:45-11:45	Unit 4 Lab 3	Principles of Bayesian Inference I Optional Q&A Frequentist (vs. Bayesian)
5	Thurs	09/30/21	9:45-11:45	Unit 5 Lab 4	Principles of Bayesian Inference II Bayesian Inference II (PS2)
6	Thurs	10/07/21	9:45-11:45	Unit 6 Lab 5	Bayesian Linear Modeling Bayesian Linear Modeling
7	Thurs	10/14/21	9:45-11:45	No Class No Lab	Midterm Project
8	Thurs	10/21/21	9:45-11:45	Unit 7 Lab 6	Bayesian Hierarchical Modeling Bayesian Hierarchical Modeling
9	Thurs	10/28/21	9:45-11:45	Unit 8 Lab 7	Priors and MCMC Priors (PS3)
10	Thurs	11/04/21	9:45-11:45	Unit 9 Lab 8	INLA Introduction to Stan
11	Thurs	11/11/21	9:45-11:45	Unit 10 Lab 9	Modeling with Stan I Stan (PS4)
11	Thurs	11/18/21	9:45-11:45	Unit 11 Lab 10	Modeling with Stan II Stan
12	Thurs	11/25/21	9:45-11:45	No Class	Thanksgiving
13	Thurs	12/02/21	9:45-11:45	Unit 12	Review
		12/08/21			Final Project Due