



PSYC 573 Bayesian Data Analysis

Units: 4

Term–Day–Time: Fall 2024–Tues & Thurs–10:00-11:50 am

Location: SGM 911

Instructor: Hok Chio (Mark) Lai

Office: SGM 621

Office Hours: Tues 12:00–1:00 pm, and by appointment.

Contact Info: (Email) hokchiol@usc.edu, (Slack) <https://usc.enterprise.slack.com/>.

Timeline for replying to emails: within 48 hours.

IT Help: ITS, Brightspace

Contact Info:

ITS (Email, Monday – Friday, 8:00 A.M. – 6:00 P.M.) consult@usc.edu, (Phone, 24/7/365)

213-740-5555, (Online) [ServiceNow Portal](#)

Brightspace (Email, 24/7/365) usc@d2l.com, (Online Help) [Brightspace Student Guides](#)

Course Description

Bayesian statistics is a coherent framework of doing statistics. It has been one of the biggest ongoing revolutions in quantitative research methods and has been recommended as an alternative to the classical approach of hypothesis testing, as well as a computational device for some problems not easily handled in the classical approach. Students will learn about applications of Bayesian statistical methods specifically on behavioral and social science data and develop skills in conducting Bayesian analysis of real-life data.

The course begins with a brief discussion on the history of the Bayesian method and the Bayesian view of probability and some comments on the philosophical differences between Bayesian and classical statistical analyses. One-parameter models and group comparisons are then discussed, with an emphasis on how Bayesian analysis incorporates information from data to update researchers' beliefs about the world. After an introduction on Markov Chain Monte Carlo Estimation—the engine primarily responsible for the resurrection of Bayesian statistics, the course covers applications of Bayesian statistics in commonly used statistical models, including linear and generalized linear models. It also illustrates the components in the Bayesian workflow, such as the selection of priors, model checking and model comparisons, and missing data handling.

Learning Objectives

After the successful completion of this course, students will be able to

1. Describe the foundations of the Bayesian framework of statistics;
2. Explain to fellow researchers the terminologies in Bayesian analysis, such as prior, posterior, credible intervals, MCMC, etc.;
3. Explain and demonstrate in applications the advantages and disadvantages of the Bayesian approach in comparisons to classical approaches;
4. Independently perform Bayesian analyses covered in this class using statistical software on real data;
5. Conduct a research project involving Bayesian analysis and effectively communicate their findings/products in an oral presentation and a written report.

Prerequisite(s): None

Co-Requisite(s): None

Concurrent Enrollment: None

Recommended Preparation: PSYC 501: Classic and Modern Statistical Methods I; Experience with R

Course Notes

Students are expected to finish the reading assignments before class meetings and actively participate in class discussions and activities. A typical class meeting will include lectures, quizzes, software demonstrations, and small-group discussions/activities. Lecture slides/notes will be posted on the course website before class meetings, but please note that the lecture slides only serve to guide class discussions and cannot replace the assigned readings. Students are expected to bring laptops to class to follow the software demonstration and work on in-class exercises.

Communication

To promote independence and critical thinking, students are encouraged to work through the following process for obtaining answers to course-related questions before contacting the instructor:

- consult the course syllabus;
- consult a classmate or post your questions on Slack;
- meet with the instructor during office hours or Q&A sessions on Tuesdays;
- for personal questions, email the instructor at hokchiol@usc.edu

Technological Proficiency and Hardware/Software Required

- [R](#) and [RStudio](#) are needed to complete the course assignments. It is highly recommended that students update to the latest versions of both software (R 4.4.1, RStudio 2024.04.2, or above). We will briefly discuss setting up R and RStudio in Week 1.
- The textbook and most of the supplemental readings can be accessed through the USC Libraries at <https://libraries.usc.edu/>.

USC Computing Center Laptop Loaner Program

If you need a laptop to successfully participate in this class, you may be eligible for the [USC Computing Center Laptop Loaner Program](#).

USC Technology Support Links

[Zoom information for students](#)
[Brightspace Student Guides](#)
[Slack information for students](#)
[Software available to USC Campus](#)

Required Readings and Supplementary Materials

- McElreath, R. (2020). *Statistical rethinking: A Bayesian course with examples in R and Stan* (2nd ed.). CRC Press.
 - Available from [USC Libraries](#) (login required)
 - * To access, click on “O’Reilly Online Learning,” select “Institution not listed?” and then enter your usc email.

Optional Readings and Supplementary Materials

E-copies of all below are available at USC Libraries or publicly available.

- Johnson, A. A., Ott, M. Q., & Dogucu, M. (2022). *Bayes rules! An introduction to Bayesian modeling with R*. CRC Press. <https://www.bayesrulesbook.com/>
- Gelman, A., Hill, J., & Vehtari, A. (2021). *Regression and Other Stories*. Cambridge University Press. <https://doi.org/10.1017/9781139161879> [Very good book on regression]
- Gelman, A., Carlin, J. B., Stern, H. S., Dunson, D. B., Vehtari, A., & Rubin, D. B. (2014). *Bayesian data analysis* (3rd ed.). CRC Press. [For more technical depth]

- Kruschke, J. K. (2015). *Doing Bayesian data analysis: A tutorial with R, JAGS, and Stan* (2nd ed.). Academic Press.
- McGrayne, S. B. (2012). *The theory that would not die: How Bayes' rule cracked the Enigma code, hunted down Russian submarines, and emerged triumphant from two centuries of controversy*. Yale University Press. [A very nice historical account of the Bayes' theorem.]

Description and Assessment of Assignments

1. In-class exercises (10%). During some of the class sessions, students will participate in quizzes or group exercises. If students miss an exercise for participation credit, they can complete the exercise posted on Brightspace within 24 hours to get credits.
2. Homework problems (65%). There will be weekly homework assignments for students to apply the concepts and techniques discussed in class to analytic problems. The assignments typically involve performing data analyses using data sets of your own or provided by the instructor, and interpreting the results with guided questions. Please submit your work electronically to Brightspace by **Monday 11:59 p.m. Pacific Time** the week after the homework is assigned. See policy on [late work](#).
3. Final project (30%: 5% prospectus, 20% final presentation/report). Students will complete a research project related to Bayesian analysis, typically a report analyzing real data or a theoretical/methodological analysis of certain aspects of Bayesian data analysis. Students can choose to do either an oral presentation or a report to communicate their project findings. For empirical analyses, the focuses are (a) formulating and justifying prior distributions from a review of previous literature, (b) obtaining and interpreting posterior distributions, and (c) comprehensive reporting of methods and results. Students can also replicate the analyses of an existing study, as long as the chosen study shared sufficient data and materials and did not use a Bayesian analysis with informative priors. Students interested in project ideas other than an empirical research report (e.g., software package development, systematic review/meta-analysis) are encouraged to discuss their ideas with the instructor. Each student can choose to work on their own or in a group of up to three people.

There are two grading components for your final project:

- Prospectus (5%)
A prospectus about your project should be submitted by **Monday, October 28**. The prospectus should contain a concise description of what you (or your group) plan to do for your project, including a preliminary plan for statistical analysis. The prospectus should be limited to 1 single-spaced page (excluding tables, figures, references, and other supplemental materials).

- Final Presentation/Report (25%)

If you choose to do an oral presentation, on **December 3 or 5**, you or your group will give a 15-minute presentation on your project, similar to one given in a professional conference. You will also need to submit your slides to Brightspace for grading **on the day of your presentation**, which should include a link to the reproducible code for your analyses. A grading rubric on the final presentation will be posted on Brightspace.

If you choose to do a final report, your report will be due **Thursday, December 12, at 1:00 p.m. Pacific Time** (the assigned final exam time for the class). There should also be a link to the reproducible code for your analyses. The final paper should be 8-15 double-spaced pages of text (i.e., excluding title page, references, tables, figures, and appendices).

Participation

Participation accounts for 10% of the course grade. Students should complete and turn in all in-class exercises to earn full credit for participation.

Table 1: Grading Breakdown

Assignments	% of Grade
In-class exercises	10
Homework	65
Prospectus	5
Final Presentation/Report	20
TOTAL	100

Grading Scale

Course final grades will be determined using the following scale

Table 2: Course Grading Scale

A	93-100
A-	89-92
B+	85-88
B	81-84
B-	77-80
C+	73-76
C	70-72

C- Below 70 (failing)

Assignment Submission

The assignments should be submitted through Brightspace by Monday at 11:59 p.m. Pacific Time.

Grading Timeline

Generally, all graded work will be returned no later than one week from the submission deadline. However, given the high number of students in the class, the instructor may only grade selected questions in each assignment. Solutions will be posted so that students can check their own work.

Course Specific Policies

Late work

Late work will be penalized by a 10% reduction in the assignment grade every 24 hours late unless due to an emergency excused by the instructor. Please email the instructor as soon as possible to discuss alternate arrangements due to an emergency.

Technology in the classroom

Phones

Your phone should be turned off or in silent mode (not on vibrate), and should not be used in the classroom.

Tablets and Laptops

During lecture time in the classroom, students can use tablets and laptops only for purposes of viewing course materials and taking notes. During the in-class exercises, students should use their laptops to complete the assignments.

Attendance

Students are expected to attend all Thursday class sessions on time. If they miss a session, they should complete the class exercises and turn in their work within the timeframe specified in [Description and Assessment of Assignments](#).

Classroom Norms

The following applies to both in-person and online communications (e.g., Slack discussions and email communications)

- Respect each other's views.
- In written communication messages, make sure they are something you could say to someone to their face.
- Recognize and/or remember that we have different backgrounds.
- Criticize ideas, not individuals or groups.
- Either support statements with evidence, or speak from personal experience.

Academic Integrity

The University of Southern California is foremost a learning community committed to fostering successful scholars and researchers dedicated to the pursuit of knowledge and the transmission of ideas. Academic misconduct is in contrast to the university's mission to educate students through a broad array of first-rank academic, professional, and extracurricular programs and includes any act of dishonesty in the submission of academic work (either in draft or final form).

In this course, you are allowed to use artificial intelligence (AI)-powered programs to help you with coding in R, but you should also be aware that AI text and code generation tools may present incorrect information, biased responses, and incomplete analyses; thus they may not produce text and analysis that meet the standards of this course. If you use AI tools beyond generating R code, to adhere to our university values and the guidelines from professional organizations, you must cite any AI-generated material (e.g., text, images, etc.) included or referenced in your work and provide the prompts used to generate the content. Please refer to the [Citing Generative AI Research Guide](#) by the USC Libraries. Using an AI tool to generate content without proper attribution will be treated as plagiarism and reported to the Office of Academic Integrity.

Course Content Distribution and Synchronous Session Recordings Policies

USC has policies that prohibit recording and distribution of any synchronous and asynchronous course content outside of the learning environment.

Recording a university class without the express permission of the instructor and announcement to the class, or unless conducted pursuant to an Office of Student Accessibility Services (OSAS) accommodation. Recording can inhibit free discussion in the future, and thus infringe on the academic freedom of other students as well as the instructor. ([Living our Unifying Values: The USC Student Handbook](#), page 13).

Distribution or use of notes, recordings, exams, or other intellectual property, based on university classes or lectures without the express permission of the instructor for purposes other than individual or group study. This includes but is not limited to providing materials for distribution by services publishing course materials. This restriction on unauthorized use also applies to all information, which had been distributed to students or in any way had been displayed for use in relation to the class, whether obtained in class, via email, on the internet, or via any other media. Distributing course material without the instructor's permission will be presumed to be an intentional act to facilitate or enable academic dishonesty and is strictly prohibited. ([Living our Unifying Values: The USC Student Handbook](#), page 13).

Course Evaluation

Student feedback is essential to the instructor and the Department to keep improving this course and faculty pedagogy. Students are encouraged to share their feedback and suggestions in a mid-semester feedback survey around week 5, and respond to the standard USC course evaluation survey at the end of the semester.

(Tentative) Course Schedule

Table 3: Course schedule

	Topics	Readings	Assignment Dates
Week 1 Aug 27 & 29	<ul style="list-style-type: none">• Overview of Bayesian Statistics	<ul style="list-style-type: none">• McElreath ch. 1• Supplemental: Gigerenzer (2004)• Quarto Tutorial	<ul style="list-style-type: none">• Exercise 1• HW 1
Week 2 Sep 3 & 5	<ul style="list-style-type: none">• Quarto• Probability• Bayes theorem	<ul style="list-style-type: none">• Markdown Basics• McElreath ch. 2, 3• Supplemental: James ch. 1	<ul style="list-style-type: none">• Exercise 2• HW 2

	Topics	Readings	Assignment Dates
Week 3 Sep 10 & 12	<ul style="list-style-type: none"> • One-parameter Model for binary variables • Bayesian workflow 	<ul style="list-style-type: none"> • Gigerenzer (2004) • Johnson ch. 3 • Getting started with CmdStanR 	<ul style="list-style-type: none"> • Exercise 3
Week 4 Sep 17 & 19	<ul style="list-style-type: none"> • STAN • Hierarchical models 	<ul style="list-style-type: none"> • McElreath ch. 13.1, 13.2 • Gabry et al. (2019) • Gelman et al. (2010) • McElreath ch. 4, 5, 7, 8 	<ul style="list-style-type: none"> • Exercise 4 • HW 3
Week 5 Sep 24 & 26	<ul style="list-style-type: none"> • Linear models • Interactions • Model comparison 	<ul style="list-style-type: none"> • McElreath ch. 6 	<ul style="list-style-type: none"> • Exercise 5
Week 6 Oct 1 & 3	<ul style="list-style-type: none"> • Causal Inference 	<ul style="list-style-type: none"> • McElreath ch. 9 	<ul style="list-style-type: none"> • Exercise 6 • HW 4
Week 7 Oct 8 & 10	<ul style="list-style-type: none"> • Markov Chain Monte Carlo 	<ul style="list-style-type: none"> • McElreath ch. 10 	<ul style="list-style-type: none"> • Exercise 7
Week 8 Oct 15 & 17	<ul style="list-style-type: none"> • Generalized Linear model (GLM) I 	<ul style="list-style-type: none"> • McElreath ch. 11 	<ul style="list-style-type: none"> • Exercise 8 • HW 5
Week 9 Oct 22 & 24	<ul style="list-style-type: none"> • GLM II 	<ul style="list-style-type: none"> • McElreath ch. 13, 14.1, 14.2 	<ul style="list-style-type: none"> • Exercise 9 • Project prospectus
Week 10 Oct 29 & 31	<ul style="list-style-type: none"> • Multilevel Models 	<ul style="list-style-type: none"> • McElreath ch. 15 	<ul style="list-style-type: none"> • Exercise 10 • HW 6
Week 11 Nov 5 & 7	<ul style="list-style-type: none"> • Missing data • Measurement error 	<ul style="list-style-type: none"> • Gelman et al. (2020) • ch 17.3-17.6 	<ul style="list-style-type: none"> • HW 7
Week 12 Nov 12 & 14	<ul style="list-style-type: none"> • Latent variable models 	<ul style="list-style-type: none"> • Supplemental reading • McElreath ch. 5, 6 	<ul style="list-style-type: none"> • Exercise 11
Week 13 Nov 19 & 21	<ul style="list-style-type: none"> • Social networks 	<ul style="list-style-type: none"> • McElreath ch. 14.4 • Broda et al. (2023) 	<ul style="list-style-type: none"> • Exercise 12 • HW 8
Week 14 Nov 26 & 28	<ul style="list-style-type: none"> • Advanced topic 	<ul style="list-style-type: none"> • TBD 	<ul style="list-style-type: none"> • Project update
Week 15 Dec 3 & 5	Presentation		
Week 15 Dec 12 1:00 pm PST	Final report		

Statement on University Academic and Support Systems

Students and Disability Accommodations:

USC welcomes students with disabilities into all of the University's educational programs. [The Office of Student Accessibility Services](#) (OSAS) is responsible for the determination of appropriate accommodations for students who encounter disability-related barriers. Once a student has completed the OSAS process (registration, initial appointment, and submitted documentation) and accommodations are determined to be reasonable and appropriate, a Letter of Accommodation (LOA) will be available to generate for each course. The LOA must be given to each course instructor by the student and followed up with a discussion. This should be done as early in the semester as possible as accommodations are not retroactive. More information can be found at osas.usc.edu. You may contact OSAS at (213) 740-0776 or via email at osasfrontdesk@usc.edu.

Student Financial Aid and Satisfactory Academic Progress:

To be eligible for certain kinds of financial aid, students are required to maintain Satisfactory Academic Progress (SAP) toward their degree objectives. Visit the [Financial Aid Office webpage](#) for [undergraduate](#)- and [graduate-level](#) SAP eligibility requirements and the appeals process.

Support Systems:

[Counseling and Mental Health](#) - (213) 740-9355 – 24/7 on call

Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

[988 Suicide and Crisis Lifeline](#) - 988 for both calls and text messages – 24/7 on call

The 988 Suicide and Crisis Lifeline (formerly known as the National Suicide Prevention Lifeline) provides free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week, across the United States. The Lifeline consists of a national network of over 200 local crisis centers, combining custom local care and resources with national standards and best practices. The new, shorter phone number makes it easier for people to remember and access mental health crisis services (though the previous 1 (800) 273-8255 number will continue to function indefinitely) and represents a continued commitment to those in crisis.

[Relationship and Sexual Violence Prevention Services \(RSVP\)](#) - (213) 740-9355(WELL) – 24/7 on call

Free and confidential therapy services, workshops, and training for situations related to gender- and power-based harm (including sexual assault, intimate partner violence, and stalking).

[Office for Equity, Equal Opportunity, and Title IX \(EEO-TIX\)](#) - (213) 740-5086

Information about how to get help or help someone affected by harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants.

[Reporting Incidents of Bias or Harassment](#) - (213) 740-2500

Avenue to report incidents of bias, hate crimes, and microaggressions to the Office for Equity, Equal Opportunity, and Title for appropriate investigation, supportive measures, and response.

[The Office of Student Accessibility Services \(OSAS\)](#) - (213) 740-0776

OSAS ensures equal access for students with disabilities through providing academic accommodations and auxiliary aids in accordance with federal laws and university policy.

[USC Campus Support and Intervention](#) - (213) 740-0411

Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.

[Diversity, Equity and Inclusion](#) - (213) 740-2101

Information on events, programs and training, the Provost's Diversity and Inclusion Council, Diversity Liaisons for each academic school, chronology, participation, and various resources for students.

[USC Emergency](#) - UPC: (213) 740-4321, HSC: (323) 442-1000 - 24/7 on call

Emergency assistance and avenue to report a crime. Latest updates regarding safety, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible.

[USC Department of Public Safety](#) - UPC: (213) 740-6000, HSC: (323) 442-1200 - 24/7 on call

Non-emergency assistance or information.

[Office of the Ombuds](#) - (213) 821-9556 (UPC) / (323-442-0382 (HSC)

A safe and confidential place to share your USC-related issues with a University Ombuds who will work with you to explore options or paths to manage your concern.

[Occupational Therapy Faculty Practice](#) - (323) 442-2850 or otfp@med.usc.edu

Confidential Lifestyle Redesign services for USC students to support health promoting habits and routines that enhance quality of life and academic performance.