LPS/Phil 31: Introduction to Inductive Logic

Summer Session II | 2019

Instructor Information

Instructor	Email	Office Location & Hours
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General Information

Course Description

How should we reason about uncertainty? How does science find order in this complex world? This course addresses these questions by introducing philosophical and mathematical perspectives on probability and statistics. We start with simple probabilistic calculations of obviously-random events such as the flipping of a coin or the rolling of a die. We then move on to slightly harder mathematical problems such as calculating the probability of "rolling a die six times and getting three 1s". As we will see, the number you get with the assumption that the die is fair is the p-value for the null hypothesis "the die is fair", under the observation of three 1s. We discuss the scientific method of Null Hypothesis Significance Testing (NHST), which is essentially a more sophisticated version of the same reasoning. After that, we turn to a different conception of probability – Bayesianism – and introduce Bayes' Theorem as an alternative to NHST. We conclude with an overview of some contemporary debates in medical sciences concerning statistical methods.

Learning Outcome

This class fulfills the General Education (GE) requirement under the **II. Science and Technology** and **V. a Quantitative Literacy** categories. As such, the class is (roughly) evenly divided into **conceptual understanding of scientific inference** and **mathematical ability to solve probability problems**. Students will learn:

a) The difference between two major interpretations of probability: physical propensity and degree of belief.
b) The difference between the Null-Hypothesis Significance Testing (NHST) paradigm and Bayesian inductive reasoning
c) How to solve basic problems of probability
    a. Simple combinatorics using binomial distribution
    b. Bayesian updating using Bayes' Theorem

Reading

There is no required reading for the class. Instead, there will be short "recommended readings" associated with each lecture that may help you understand the concepts better. There will also be "advanced readings" posted every so often in case you find the topics interesting and want to know more. You should be able to understand the lectures without having done the readings (or vice versa). All the readings will be posted online.

Office hour: what is it for

The only requirement I have is that you have read the lecture slides and recommended readings (not necessarily advanced ones) prior to seeing me during office hours. If the set hours don't work for you, please email and make an appointment.

Here are some examples of what I can help you with during office hours: explain key concepts, explain lecture/reading (recommended OR advanced) material, work through examples, discuss more advanced concepts.

I'm also happy to talk to you about other school-related stuff.

Prerequisite

There is no prerequisite for this class. The mathematical calculations will not exceed simple addition and multiplication, and you are allowed calculators. Some familiarity with basic logic concepts such as conjunction and disjunction helps but is not mandatory. In particular, LPS 29 and 30 are *not* required.

Assessment

Grade Breakdown

20% attendance

25% x 2 midterm tests

30% final exam

(up to 4% extra credits)

Attendance

Attendance is **mandatory**. A short comprehension quiz will be given during each lecture (not necessarily at the end). The participation quizzes are graded for **completion only**.

If you must miss a lecture, you can make up the attendance grade by answering a few short questions provided by me. You are more than welcome to seek out my help and the help of your fellow students in completing these questions. The goal is to catch you up to speed, rather than to test your prior knowledge.

Weekly math practices (and extra credit)

Math is all about practice. The kind of math we will be engaging in is probably easier than what you learned in high school, just slightly different. Every week I will post a list of math problems for you to practice. These are completely **optional** and you are encouraged to work in groups with classmates and/or in consultation with me during Office Hours. Many problems are only slight variations of each other, aimed at helping you get used to doing it. You have the option of submitting your answers to be graded. **If you get 80% or higher, you will be granted an extra credit.** You can do this for all 4 weekly practices. You will have to submit your answer by **Monday 5 pm** to have it graded as extra credit. If you are not interested in having it graded, I am still happy to look over your answers anytime throughout the term for the purpose of feedback.

Exam Schedule

Date	Subject	Date
Midterm 1	Propensity interpretation, binomial distribution	Aug 15

Date	Subject	Date
Midterm 2	Degree of belief, Bayes' Theorem	Aug 27
Final	… is cumulative	Take home

Policies

Use of technology in class

Laptops are allowed in class. Please be mindful of what you do on your screen so as to not disturb others. Please also bring pen and paper for the math portion of the class. Trying to do math in Microsoft Word is just an awful idea.

Missing an exam

If you cannot make it to one of the exam dates, let me know as soon as possible so we can make alternative arrangement. If an accident happens on the day of the exam, keep a record of the relevant documentations and deal with the accident first. I will not be mad if you are a few days late at notifying me. If there are other things I might be able to help, please let me know.

Cheating

The penalty for any violation of cheating on the exams or assignments is a **fail grade**. Depending on the level of severity, a letter recording the violation may be sent to the Dean.

For the weekly math practices:

- Working with friends to figure out a problem or having a more knowledgeable person (friend or tutor or me) teach you how to solve a few problems **do not count as cheating**.
- Having someone else write up the answers and put your name on it or blindly copying someone else's answers without understanding the steps both **count as cheating**.
- If I suspect you might not understand your own answers, I will ask you to come in and solve a problem in front of me. Sometimes this may simply be that you've shown a surprising amount of progress. If you have worked very hard to get very far, you will not be penalized in any way for this exercise.

Course Schedule (subject to modification closer to date)

Week		Topic	Reading
Week 1	Tuesday (Aug 6)	- Going through the syllabus - Conjunction, disjunction, negation, equivalence - Venn diagrams - Probability calculation: single events, negations, equivalence	- Hacking p.23-29; p.40-42 - *Advanced reading: Hacking p.11-18*
	Thursday (Aug 8)	- Independent vs. dependent events - Probability as physical chance (propensity)	- https://plato.stanford.edu/entries/probability-interpret/#ProInt Section 3.5 Propensity Interpretations - *Advanced reading: Hacking p.30-33*

Week		Topic	Reading
		- Probability calculation: conjunction, special disjunction, general disjunction	
Week 2	Tuesday (Aug 13)	- De Morgan's laws - Probability calculation: probability mass function (pmf) for binomial distribution	
	Thursday (Aug 15)	- **Midterm 1**: negation, equivalence, conjunction, disjunction, pmf for binomial distribution - Limitations of propensity interpretation - Introduction to Bayesianism	
Week 3	Tuesday (Aug 20)	- NHST - Bayes' Theorem	- https://plato.stanford.edu/entries/logic-inductive/ Section 3. The Application of Inductive Probabilities to the Evaluation of Scientific Hypotheses - Hacking p.209-211 - *Advanced reading: https://plato.stanford.edu/entries/epistemology-bayesian/ Section 3. Dutch Book Arguments; Section 6. Potential Problems*
	Thursday (Aug 22)	- Probability as subjective degrees of belief - Using Bayes' Theorem to update your belief	- https://plato.stanford.edu/entries/probability-interpret/#SubPro 3.3 Subjective probability
Week 4	Tuesday (Aug 27)	- **Midterm 2**: Bayes' Theorem - Null hypothesis significance testing (NHST) vs. Bayesian method	- *Advanced reading: https://plato.stanford.edu/entries/statistics/ Section 1. Statistics and induction; Section 2. Foundations and interpretations*
	Thursday (Aug 29)	- Using binomial pmf to calculate the likelihood in Bayes' Theorem	
Week 5	Tuesday (Sept 3)	- Pros & cons of classical vs. Bayesian statistics - The complications of scientific inquiry	- *Advanced reading: https://www.iep.utm.edu/evidence/ Section 1. The Nature of Evidence: What Is It and What Does It Do?*
	Thursday (Sept 5)	- Review	

(updated Mar 21, 2019)