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# THEORY AND ANALYSIS OF EXPERIMENTS

POLI 263 — Winter 2021

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**Lecture Time** Thu 3.00 - 5.50 PM (PST) **Office Hours** Tue 12.00 - 2.00 PM (PST)

## Useful Links

Latest version of syllabus:  Zoom link:   
Course Canvas page:  Download R and Rstudio:   
Perusall page:  Course calendar feed: 

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# 1 Overview

This course teaches the core principles that underlie experimental reasoning and research design. We start with a definition of causality and build from the ground up a set of simple but powerful intuitions about causal and statistical inference.

With these principles in hand, you will have everything you need to design high-quality survey, field, and lab experiments. They will also help you to reason through complex design choices in non-experimental research.

We spend the first half of the course setting up the basics. In the second half, we look at how experiments “break”—noncompliance, attrition, spillovers—and what to do about it. We look at causal moderation and mediation. We finish with a discussion of the ethics and practicalities of implementing experiments in the world.

## 1.1 Objectives

If I do my job, you should finish the course knowing at least ten things really well:

1. what a causal effect is
2. when experiments provide good answers about causal effects and when their answers are biased
3. what standard errors and p-values are, how they are useful, and when they can mislead
4. what blocks and clusters are, the problems they pose, and the problems they solve
5. how knowledge of assignment to treatment should guide estimation
6. when and why attrition matters, and what to do when it happens
7. when and why failure-to-treat matters, and what to do when it happens
8. when and why spillovers matter, and what to do when they happen
9. what post-treatment bias is
10. why mediation is hard

## 1.2 Textbook

The best way I know to learn experiments is to work through this book (FEDAI): Alan S. Gerber and Donald P. Green. *Field Experiments: Design, Analysis, and Interpretation*. W.W. Norton, New York, 2012. You can access a copy using the Perusall page for this course (see Section 2.2). It’s an absolutely essential methods book to have in your library, so if you can afford to I’d recommend buying it as well.

## 1.3 Prerequisites

Students of all methodological backgrounds are encouraged to take the course. An introduction to linear regression will help a lot, but advanced understanding of calculus, statistics, or coding is not required. Fundamental concepts are taught through simple algebraic proofs, numerical examples, and simulation. Another thing that will help a lot is proficiency with R, but if you don’t have any proficiency, that’s not a problem. You will by the end of the course!

## 1.4 Assessment

- **Reading the textbook — 25%:**

This course is straightforward if you come to class having read the textbook and confusing if you don’t. So, as a commitment device, the reading is graded in a simple way: you must provide three good annotations on the assigned reading for that week, **before** class. Exactly which pages to read, when to read them by, and where to find them is all laid out on the assignments page of Canvas. To be clear: you may

read the textbook in paper format if you prefer, but please remember to log on to Canvas and add your annotations there before class (there is no grading for amount of time spent looking at pages or any of that stuff, just points per annotation).

What's a good annotation? A good annotation should demonstrate engagement with the meaning of the content in the book. It doesn't need to be a novel. A good annotation could be of the form, "This makes the distinction between estimates and estimands clearer for me," or "I don't understand why this assumption is necessary, can we address this in class?" An unsatisfactory annotation is one that could be copied and pasted to any sentence in the reading, e.g., "Interesting," or "I don't get it."

Annotations are scored 1 if they are good and 0 otherwise. To count for one point, the annotation cannot be a reply to another person (though you are also welcome to do this). Annotations should also be evenly disbursed throughout the text. There are nine weeks of readings and each week of reading has three points to gain. Thus, there are over 25 opportunities to score the 25 points for reading.

- **Five problem sets — 50%:**

Each problem set will be worth 10 points. There are no trick questions: if you've read the FEDAI chapter and followed the lecture online, the problem set should not be too difficult. No one question should take all night or require pages of proofs—if it does, you may be overthinking things. Reach out to me via the [course canvas page](#) if you're encountering difficulties. I won't post solution sets or use class time for solutions. Please come to office hours if you want to go into more detail.

- **Homemade experiment — 25%:**

Design an experiment using household objects! No human subjects can be involved (except yourself!). Your experiment should address at least one of the following complex design challenges: noncompliance; differential attrition; spillovers; post-treatment censoring; heterogeneous assignment probabilities; compound treatments. The assignment is split into two components:

**Pre-analysis plan (10/25 points) due: March 8 at midnight.**

Prior to implementing your experiment, try to anticipate how it will be implemented, what kinds of datasets it might give rise to, and how you'll analyze the data. I will provide examples in class. Make sure to discuss different ideas with me. This one is peer-graded (random assignment, at least single-blind), with some oversight from me. See Canvas for detailed grading rubric and instructions. We will discuss in class.

**Final paper (15/25 points) due: March 15 at midnight.**

Conduct and write up your experiment using household objects. The write-up should be short: 5-10 pages long, no citations or literature required. The idea is to focus on one or two of the experimental design challenges listed above. Detailed instructions and grading rubric on Canvas.

## 2 Policies and Logistics

### 2.1 Online Class Format

We have a pretty long, two-hour-and-fifty-minute time slot for this course. To make things a bit more digestible, I have broken each class into three chunks, separated by two ten-minute breaks. The first two last an hour each and the last is one half-hour. Please make sure to ask clarifying questions as we go. If you want to discuss other points, please save them for the 10 minute breaks, during which I will hold an unrecorded Q&A. Here are a few other points to know:

- **Class will be synchronous.** I will teach live classes and be available for questions. A lot of it will be interactive, so please try to make it if you can.
- **Class will be recorded.** If you can't make it, the recordings will post to the course Canvas page under the Zoom section.
- **Cameras preferred.** I'd love to not teach into the void, so I greatly appreciate being able to see those there. But I'm more than happy to make any necessary allowances for pets and children and bad internet.
- **On-topic interruptions preferred.** Please ask questions in whatever way you find convenient. I'm liable to miss blue hands and comments in the chat, and am happy to be interrupted with questions about the course.

### 2.2 Reading the Textbook via Perusall

To access the assigned readings, go to the [course canvas page](#) and you can find them under the Assignments tab. If you want to peruse the book as a whole, click on the Perusall tab on the lefthand side. This should take you to the Perusall page for the course. In principle, there should be no need to sign up for anything. In practice, I expect some bumps as it's my first time using it, so your patience is appreciated.

### 2.3 Office Hours

I will hold virtual office hours on Tuesdays from 12:00 PM to 2:00 PM (PST) on Zoom. Office hours are organized into 20 minute slots. **Please make sure to sign up for office hours in advance.** If there is no one signed up, I will assume no one is coming. Please be respectful of other students' time and do not reserve more office hours slots than you need.

### 2.4 Software

We will be using the open-source statistical software R. While other statistical software packages such as SPSS, Stata, or even Excel can of course be used for experimental analysis, R has many advantages.

First, it is the programming language of choice of many (most?) data scientists and statisticians. Second, it makes writing loops and functions easy (tasks that are nearly impossible in Excel). Third, there is a large community of developers who have contributed a huge number of add-ons for R that you will find invaluable. Finally, it's free, and always will be, which is not true of other software. In addition to R, please also download and install RStudio, the top-of-the-line script editor. See the link at the top of the syllabus.

### 2.5 Problem Sets Policy

All students must write up their problem sets individually. However, you may work in groups of up to three (though you are not required to work in groups at all). Please indicate at the top of your homework the names

of the other students you worked with that week. Don't "share" members across groups. Do not copy and paste the answers across group members. Ultimately, the problem sets are pretty easy compared to most graduate methods courses, and they'll really help you to retain the core lessons.

## 2.6 Problem Set Submission

Please submit all problem sets through the [course canvas page](#). I recommend using `Rmarkdown` to prepare your problem sets, though you can use whatever you like (Word,  $\text{\LaTeX}$ , even `.txt` files!). Here's a great guide to getting started with `Rmarkdown`: [https://rmarkdown.rstudio.com/articles\\_intro.html](https://rmarkdown.rstudio.com/articles_intro.html).

## 2.7 Communication

**For questions about problem-sets, readings, and lecture content:** Please post all technical questions on the [course Canvas page](#), so that everyone can benefit from the answers. And please also feel free to weigh in on others' questions!

**Email:** I try to respond to all emails as soon as I get them, and at least within 24 hours. Don't be afraid to send me a little reminder if I haven't responded within that window. Before writing to me with a question, check the syllabus to see if it's addressed there first. Please don't leave questions until the last minute. **I don't respond to emails in the evening.**

## 2.8 Late submission

I am willing to make reasonable accommodations and understand that difficult situations can arise. However, I will not make exceptions for one person that are not available to every other person in the course. Hand all assignments in on time and reach out to me if you are encountering troubles.

## 2.9 Auditing

The aim of this course is to etch into your memory a set of core intuitions that you will be able to apply long after the course is over. The only way I know of to learn these well is to do the problem sets. So, in general, I discourage auditing—I'd like everyone in the group to be engaging with the material as much as possible. However, if you want to audit, then you must register for an [S/U \(Satisfactory / Unsatisfactory\)](#) grade. If you do the problem sets and the readings, you will get an S. You don't have to get all of them right, but you do have to make a good-faith effort and turn in responses. If you are auditing, you will not receive a grade on the problem sets.

## 2.10 Academic Integrity

Students agree that by taking this course all required papers will be subject to submission for textual similarity review to Turnitin.com for the detection of plagiarism. All submitted papers will be included as source documents in the Turnitin.com reference database solely for the purpose of detecting plagiarism of such papers. Use of the Turnitin.com service is subject to the terms of use agreement posted on the Turnitin.com site.

## 2.11 OSD Accommodations

Students requesting accommodations for this course due to a disability must provide a current Authorization for Accommodation (AFA) letter issued by the Office for Students with Disabilities (<https://osd.ucsd.edu/>). Students are required to discuss accommodation arrangements with instructors and OSD liaisons in the department well in advance of any exams or assignments. The OSD Liaison for the Department of Political Science is Joanna Peralta; please connect with her via in-person advising (SSB 301) or the Virtual Advising Center.

### 3 Weekly Outline

#### 3.1 Week 1 (January 7): Potential Outcomes and Estimands

- Read before class:
  - FEDAI Chapter 2 pp. 22-30
- Assignment due:
  - Install R, Rstudio, and swirl, following instructions here: <https://swirlstats.com/students.html>
  - Complete the swirl module: 1: R Programming: The basics of programming in R.
  - If you want to go further with R, check out the “Explore” chapter of Hadley Wickham’s great book: <https://r4ds.had.co.nz/introduction.html>.
- Assignment distributed:
  - Problem set 1.
- Class plan
  - 3:00-4:00 PM (1 hr): Introductions. Capacity and needs assessment. The case for experiments. Overview of the course.
  - 4:00-4:10 PM (10 min): Optional break or questions.
  - 4:10-5:10 PM (1 hr): Overview continued. Realized versus potential outcomes. Notation. Causal effects.
  - 5:10-5:20 PM (10 min): Optional break or questions.
  - 5:20-5:50 PM (30 min): Potential outcomes continued. How to peer into the causal fabric of the universe. Questions on R and other logistics issues.

#### 3.2 Week 2 (January 14): Randomization and Estimation

- Read before class:
  - FEDAI Chapter 2 pp. 30-45
- Assignment due:
  - Problem set 1
- Assignment distributed:
  - Problem set 2
- Class plan
  - 3:00-4:00 PM (1 hr): Let’s make a sampling distribution.
  - 4:00-4:10 PM (10 min): Optional break or questions.
  - 4:10-5:10 PM (1 hr): The deep connection between random sampling and random assignment. Why difference-in-means is an unbiased estimator in simple experiments.
  - 5:10-5:20 PM (10 min): Optional break or questions.
  - 5:20-5:50 PM (30 min): Important assumptions. Estimates vs. estimands.

## Martin Luther King, Jr. Holiday Monday, January 18

### 3.3 Week 3 (January 21): Statistical Inference

- Read before class:
  - FEDAI Chapter 3 pp. 51-71
- Assignment due:
  - None.
- Assignment distributed:
  - None.
- Class plan
  - 3:00-4:00 PM (1 hr): Real vs. estimated sampling distributions. The variance of the sampling distribution of the difference-in-means.
  - 4:00-4:10 PM (10 min): Optional break or questions.
  - 4:10-5:10 PM (1 hr): Estimating the variance of the sampling distribution using the standard error. Randomization inference for  $p$ -values. Sharp null hypothesis testing.
  - 5:10-5:20 PM (10 min): Optional break or questions.
  - 5:20-5:50 PM (30 min): Randomization inference continued.

### 3.4 Week 4 (January 28): Blocks and Clusters

- Read before class:
  - FEDAI Chapter 3 pp. 71-86
  - FEDAI Chapter 4 pp. 109-116
- Assignment due:
  - Problem set 2.
- Assignment distributed:
  - Problem set 3.
- Class plan
  - 3:00-4:00 PM (1 hr): What blocks and clusters are. How blocking affects variance and bias.
  - 4:00-4:10 PM (10 min): Optional break or questions.
  - 4:10-5:10 PM (1 hr): Blocking continued. How clustering affects variance and bias.
  - 5:10-5:20 PM (10 min): Optional break or questions.
  - 5:20-5:50 PM (30 min): Clustering continued. Statistical inference with blocks and clusters.

### 3.5 Week 5 (February 4): Covariates and Weights

- Read before class:
  - FEDAI Chapter 4 pp. 95-109
  - FEDAI Chapter 4 pp. 116-121
- Assignment due:
  - None.
- Assignment distributed:
  - None.
- Class plan
  - 3:00-4:00 PM (1 hr): What “controlling for covariates” means. How covariate adjustment affects variance.
  - 4:00-4:10 PM (10 min): Optional break or questions.
  - 4:10-5:10 PM (1 hr): How covariate adjustment affects bias. One benefit and three risks.
  - 5:10-5:20 PM (10 min): Optional break or questions.
  - 5:20-5:50 PM (30 min): Analyze as ye randomize.

### 3.6 Week 6 (February 11): Non-Compliance

- Assignment due:
  - Problem set 3.
- Assignment distributed:
  - Problem set 4.
- Read before class:
  - FEDAI Chapter 5
  - FEDAI Chapter 6
- Class plan
  - 3:00-4:00 PM (1 hr): Principal strata. New notation, assumptions, and estimands. One-sided noncompliance.
  - 4:00-4:10 PM (10 min): Optional break or questions.
  - 4:10-5:10 PM (1 hr): One-sided noncompliance continued. Two-sided noncompliance.
  - 5:10-5:20 PM (10 min): Optional break or questions.
  - 5:20-5:50 PM (30 min): Caveats and considerations. Placebo designs.



## Presidents' Day Holiday Monday, February 15

### 3.7 Week 7 (February 18): Attrition

- Read before class:
  - FEDAI Chapter 7
- Assignment due:
  - Problem set 4
- Assignment distributed:
  - Problem set 5
- Class plan
  - 3:00-4:00 PM (1 hr): New definitions, assumptions, notation, and estimands. Types of attrition.
  - 4:00-4:10 PM (10 min): Optional break or questions.
  - 4:10-5:10 PM (1 hr): Diagnosing attrition. Three approaches to differential attrition: IPW, extreme bounds, trimming bounds.
  - 5:10-5:20 PM (10 min): Optional break or questions.
  - 5:20-5:50 PM (30 min): Housekeeping. Homemade experiment discussion.

### 3.8 Week 8 (February 25): Spillovers

- Read before class:
  - FEDAI Chapter 8
- Assignment due:
  - None. But make progress on pre-analysis plan!
- Assignment distributed:
  - None.
- Class plan
  - 3:00-4:00 PM (1 hr): A deep point about fish. Definitions, notation, assumptions (SUTVA). Two problems: unmodeled potential outcomes and heterogeneous assignment probabilities.
  - 4:00-4:10 PM (10 min): Optional break or questions.
  - 4:10-5:10 PM (1 hr): Model-based solutions to spillovers. Design-based solutions to spillovers.
  - 5:10-5:20 PM (10 min): Optional break or questions.
  - 5:20-5:50 PM (30 min): Inter-temporal spillovers. Within-subjects designs. Stepped-wedge designs.

### 3.9 Week 9 (March 4): Moderation and Mediation

- Read before class:
  - FEDAI Chapter 9
  - FEDAI Chapter 10
- Assignment due:
  - Problem set 5
- Class plan
  - 3:00-4:00 PM (1 hr): Heterogeneous effects estimands. Treatment-by-covariate interactions. Treatment-by-treatment interactions. Post-treatment bias.
  - 4:00-4:10 PM (10 min): Optional break or questions.
  - 4:10-5:10 PM (1 hr): Mediation estimands vs. moderation estimands. Statistical challenges with mediation. Conceptual challenges. Implicit mediation analysis.
  - 5:10-5:20 PM (10 min): Optional break or questions.
  - 5:20-5:50 PM (30 min): Mediation continued. Housekeeping.

### Pre-analysis plan due Monday, March 8

### 3.10 Week 10 (March 11): Designing Experiments Online and in the Field

- Read before class:
  - Nothing. Come prepared to talk about your pre-analysis plan.
- Assignments due:
  - Peer-grading of other student's pre-analysis plan.
- Class plan
  - 3:00-4:00 PM (1 hr): Research design diagnosis. Ethics. Power. Bias.
  - 4:00-4:10 PM (10 min): Optional break or questions.
  - 4:10-5:10 PM (1 hr): Discussion of PAPs.
  - 5:10-5:20 PM (10 min): Optional break or questions.
  - 5:20-5:50 PM (30 min): Experiments on small budgets in the field and online.

**Instruction ends Friday, March 12**

**Final paper due Monday, March 15**

**Winter Quarter ends Saturday, March 20**

## 4 Resources

|                                  |   |
|----------------------------------|---|
| Library help and research tools: | <a href="https://library.ucsd.edu/ask-us/triton-ed.html">https://library.ucsd.edu/ask-us/triton-ed.html</a>   |
| Writing Hub:                     | <a href="https://commons.ucsd.edu/students/writing/index.html">https://commons.ucsd.edu/students/writing/index.html</a>   |
| Supplemental Instruction:        | <a href="https://commons.ucsd.edu/academic-support/supplemental-instruction/si-students.html">https://commons.ucsd.edu/academic-support/supplemental-instruction/si-students.html</a>   |
| Tutoring:                        | <a href="https://commons.ucsd.edu/academic-support/content-tutoring/index.html">https://commons.ucsd.edu/academic-support/content-tutoring/index.html</a>   |
| Mental Health Services:          | <a href="https://caps.ucsd.edu">https://caps.ucsd.edu</a>   |
| Community Centers:               | Learn about the different ways UC San Diego explores, supports, and celebrates the many cultures that make up our diverse community. <a href="https://students.ucsd.edu/student-life/diversity/index.html">https://students.ucsd.edu/student-life/diversity/index.html</a>  |
| Accessibility:                   | <a href="https://disabilities.ucsd.edu/">https://disabilities.ucsd.edu/</a>   |
| Basic Needs:                     | Any student who has difficulty accessing sufficient food to eat every day, or who lacks a safe and stable place to live, and believes this may affect their performance in this course, is encouraged to contact: <a href="mailto:foodpantry@ucsd.edu">foodpantry@ucsd.edu</a> and <a href="mailto:basicneeds@ucsd.edu">basicneeds@ucsd.edu</a> |