PSYCHOLOGY 801

Design of Experiments/Data Analysis

Fall 2025

Instructor: Mark Sabbagh, sabbagh@queensu.ca
Lab & Homework TA: Emma Ilyaz (emma.ilyaz@queensu.ca)
Office hours TBA and by appointment

Learning Objectives

- Articulate the purpose of basic experiments in Psychological Science
- Explain the relationship between psychological constructs and their quantitative estimation from measurement
- Articulate the logical basis of classical approaches to null hypothesis testing in the context of basic experimental and quasi-experimental designs in psychology.
- Use open-source software packages to create and run "Monte-Carlo" simulations to illustrate the effects of common research practices on statistical decision making.
- Use open-source software packages to conduct basic descriptive and inferential analyses for simple data sets.
- Critically evaluate existing debates in the field pertaining to replication, "researcher degrees of freedom," and the broader use of null-hypothesis testing as an epistemic foundation for the discipline.
- Apply understandings gained throughout the course to a critical reading of the literature in ones own subfield with the goal of understanding what constitutes strong versus weak evidence for some claim.

Course Outline

Until recently, it was common to think about data analysis as a set of prescriptive rules, which themselves are based on doing what people in your field tend to do. The idea is that if you do it "right" then you'll get published. While current practice necessitates understanding this process to some extent, it is likely the case that by solely relying on precedent we have drifted away from best practices. Worse, statistics primers that teach "cookbook" methods tend to perpetuate simplistic, mostly incorrect understandings of the sorts of inferences one can draw from statistics and statistical tests. These misunderstandings have led to various crises in our field, such as the "replicability crisis."

One goal of this course is to reintroduce relatively simple statistical techniques, like t-test, ANOVA, and regression, to better understand not just the computational bases of each technique, but also the logical foundations of each as they relate to hypothesis testing in study designs that are common in our discipline. I hope that we will also develop an understanding of why particular conventions are in use, why some conventional practices might be flawed, and when it might be a good idea to think outside of those conventions.

A secondary goal is to introduce the notion that statistics themselves can be the subject of exploration and intellectual inquiry. We are going to use the open-source software package R to both conduct and explore common statistics and statistical tests. In particular, you will be introduced to the "monte-carlo simulation" technique for illustrating key statistical concepts such as central limit theorem, Type I and Type II error, and non-parametric tests. I hope that by learning how to make these inquiries, students will gain the foundation for a deeper set of understandings about how our common practices work. Ultimately, I hope that this deeper critical understanding will shape how students ultimately conceptualize and communicate their own research contributions.

Required Materials

- **R and R-studio on an accessible computer**
  All homework assignments and labs will be require the use of R and R-Studio, two free, open-source computer software packages that are rapidly becoming the new standard for researchers in psychology. I know that some of you will not have used R before and there certainly is a learning curve for it. We will support you as much as we can in this and I strongly encourage anyone who is struggling to reach out for help early and often. You'll be happy you did!
- **Navarro, D.** ***Learning Statistics in R***

This is a long, chatty book about doing statistics with R, and is availabe for free via the Creative Commons licence. The author and I agree on almost everything that could be controversial, and we also agree on the sorts of things that are interesting to pay attention to in statistics. There are thoughtful discussions of the basic techniques that we will go over, as well as detailed instructions on methods for conduct the statistics using R. Download through our class onQ, where it is called LSR.pdf

- **Frank, M. C., et al., *Experimentology* (experimentology.io)**
  This is another open-access textbook that my colleague (the main author) uses in his first year graduate statistics and research methods class at Stanford University. The writing is clear, the conceptual work is terrific, and in many places, thought provoking. It doesn't get enough into actual statistics for to be a main text for us, but I've sprinkled in some chapters to help illustrate main concepts. Access it on the web via the above link.

- **ChatGPT or other Generative AI**
  You can use whatever resources you want to help negotiate the technical aspects of this course. A main challenge for this course is that you are you are going to have to become familiar with some of the basics of programming to conduct the analyses and simulations that we do in R. Everything I know about using R, I learned by going through tutorials or by using Google. Now, I frequently use ChatGPT. **Using ChatGPT as your "programming co-pilot" does not violate academic integrity**. Indeed, I suggest it. Access via openai.com (account required).

  However, using ChatGPT or any other Generative AI platform to compose answers for required assignments that are turned in to be graded will be considered a violation of academic integrity and runs counter to the learning goals of the course. Please do not hesitate to ask if you have any questions about appropriate use of generative AI tools in this course.

Grading Scheme

- Homeworks: 30%
- Participation in Labs: 10%
- Mid-term exam: 25%
- Final exam: 35%

Grading Method

All components of this course will receive numerical percentage marks. The final grade you receive for the course will be derived by converting your numerical course average to a letter grade according to Queen's Official Grade Conversion Scale:

Grade	Range
A+	90–100
A	85–89
A-	80–84
A+	77–89
B	73–76
B-	70–72
C+	67–69
C	63–66
C-	60–62
D+	57–59
D	53–56
D-	50–52
F	<50

Late Policy

Late work will be accepted but its mark will be discounted by 20% for each 24 hour period it is late. Exceptions to this policy are if serious extenuating circumstances prevented you from completing the work, or if we have a prearranged agreement. Please do not hesitate to communicate with me regarding any difficulties you may be having completing the course material to your standards on time.

Academic Integrity

Queen's University is dedicated to creating a scholarly community free to explore a range of ideas, to build and advance knowledge and to share the ideas and knowledge that emerge from a range of intellectual pursuits. Each core value of academic integrity, as defined in the Senate Academic Integrity Policy, gives rise to and supports the next.

Honesty appears in presenting one's own academic work, whether in the context of an examination, written assignment, laboratory or seminar presentation. It is in researching one's own work for course assignments, acknowledging

dependence on the ideas or words of another and in distinguishing one's own ideas and thoughts from other sources. It is also present in faithfully reporting laboratory results even when they do not conform to an original hypothesis. Further, honesty is present in truthfully communicating in written and/or oral exchanges with instructors, peers and other individuals (e.g. teaching assistants, proctors, university staff and/or university administrators).

Trust exists in an environment in which one's own ideas can be expressed without fear of ridicule or fear that someone else will take credit for them.

Fairness appears in the proper and full acknowledgement of the contributions of collaborators in group projects and in the full participation of partners in collaborative projects.

Respect, in a general sense, is part of an intellectual community that recognizes the participatory nature of the learning process and honours and respects a wide range of opinions and ideas. However, "respect" appears in a very particular sense when students attend class, pay attention, contribute to discussion and submit papers on time; instructors "show respect by taking students' ideas seriously, by recognizing them as individuals, helping them develop their ideas, providing full and honest feedback on their work, and valuing their perspectives and their goals" ("The Fundamental Values of Academic Integrity", 3rd Edition, p. 8).

Ultimately, *responsibility* is both personal and collective and engages students, administrators, faculty and staff in creating and maintaining a learning environment supported by and supporting academic integrity.

Courage differs from the preceding values by being more a quality or capacity of character – "the capacity to act in accordance with one's values despite fear" ("The Fundamental Values of Academic Integrity", 3rd edition, p. 10). Courage is displayed by students who make choices and integrous decisions that are followed by action, even in the face of peer pressure to cheat, copy another's material, provide their own work to others to facilitate cheating, or otherwise represent themselves dishonestly. Students also display courage by acknowledging prior wrongdoing and taking proactive measures to rectify any associated negative impact.

All of these values are not merely abstract but are expressed in and reinforced by the University's policies and practices.

Accessibility & Accommodation

Queen's University is committed to working with students with disabilities to remove barriers to their academic goals. Queen's Student Accessibility Services (QSAS), students with disabilities, instructors, and faculty staff work together to provide and implement academic accommodations designed to allow students with

disabilities equitable access to all course material (including in-class as well as exams). If you are a student currently experiencing barriers to your academics due to disability related reasons, and you would like to understand whether academic accommodations could support the removal of those barriers, please visit the QSAS website to learn more about academic accommodations or start the registration process with QSAS by clicking Access Ventus button at Ventus | Accessibility Services | Queen's (queensu.ca)

VENTUS is an online portal that connects students, instructors, Queen's Student Accessibility Services, the Exam's Office and other support services in the process to request, assess, and implement academic accommodations.

To learn more go to:
https://www.queensu.ca/ventus-support/students/visual-guide-ventus-students

Extenuating Circumstances

Academic Consideration is a process for the University community to provide a compassionate response to assist students experiencing unforeseen, short-term extenuating circumstances that may impact or impede a student's ability to complete their academics. This may include but is not limited to any extenuating circumstance (illness, bereavement, traumatic event, injury, family emergency, etc.) which is short-lived, begins within the term, and will not last longer than 12 weeks.

Please do not hesitate to contact me if you are experiencing extenuating circumstances that will affect your ability or capacity to complete the work for this course on time. I will be happy to arrange something that works with you.

For more information, please see the Senate Policy on Academic Consideration for Students in Extenuating Circumstances.

Course Schedule and Readings (may change)

Week	Date	Topic	Reading	HW
1	Wed 9/3	Lab 1: Brief intro to R & Programming	Navarro Ch 3, 4, 8 – 8.3	HW 1
	Fri 9/5	Experiments, theory, and measurement	Frank Ch 1 & Navarro Ch 2	
2	Mon 9/8	Measurement scales	Navarro Ch 2 & Frank Ch 8	
	Wed 9/10	Lab 2: Imagining & Simulating Data		
	Fri 9/12	Drawing a sample from a population	Navarro Ch 10–10.2, Frank 10–10.3	
3	Mon 9/15	Descriptive statistics	Navarro Ch 5	
	Wed 9/17	Lab 3: Sampling Distributions	Navarro Ch 10.3–10.5	HW 2
	Fri 9/19	Bias & Efficiency of statistics		
4	Mon 9/22	Central Limit Theorem		
	Wed 9/24	Lab 4: How to determine "normality"	Navarro Ch 9	
	Fri 9/26	Z-test of the population mean		
5	Mon 9/29	Hypothesis Testing, Type I & II errors	Navarro Ch 11	
	Wed 10/1	Lab 5: Conducting simulations to understand Type I and Type II errors		HW 3
	Fri 10/3	Power in the context of the Z-test		
6	Mon 10/6	What affects power		
	Wed 10/8	Lab 6: Review lab, bring Questions		
	Fri 10/10	**Midterm**		
		Happy Thanksgiving + Fall Break		
7	Mon 10/20	T-tests	Navarro Ch 13	
	Wed 10/22	Lab 7: How to t-test in R		HW4
	Fri 10/24	T-tests, power, and Type I error		
8	Mon 10/27	Non-parametric 2-group comparisons		
	Wed 10/29	Lab 8: How to non-parametric		
	Fri 10/31	Comparing power in t-test and non-par. alternatives		
9	Mon 11/3	Between-subjects 1-way ANOVA	Navarro Ch 14	
	Wed 11/5	Lab 9: How to...		HW5

	Fri, 11/7	Post-hoc comparisons		
10	Mon 11/10	Within-subjects 1-way ANOVA		
	Wed 11/12	Lab 10: How to...		
	Fri 11/14	Comparing power in between- vs. within-subs ANOVA		
11	Mon 11/17	Factorial ANOVA	Navarro Ch 16	
	Wed 11/19	Interactions and Simple effects		HW6
	Fri 11/21	Lab 11: How to do a factorial ANOVA		
12	Mon 11/24	Chi-Square	Navarro Ch 12	
	Wed 11/26	Lab 12: How to Chi-square		
	Fri 11/28	Correlation & Regression Intro	Navarro Ch 15	
13	Mon 12/2	How to Regression...		