

PGS 380S (60380) – NEU 385L

Basic Principles in Experimental Design and Statistics

Description

This course reviews “basic principles in experimental design and statistics” that are useful during graduate studies and beyond. Lectures are geared towards real-life experiences that students are likely to encounter while performing scientific research. This course also increases professionalism and communication skills.

Course coordinator and instructor

Micky Marinelli micky.marinelli@austin.utexas.edu Office: BME 6.114A (office hours: by appointment)

Suggested (but not required) textbooks:

Intuitive Statistics (Motulsky); ISBN 9780199730063

PDQ statistics (Norman and Streiner); ISBN 9781550092073

Bad Science (Goldacre); ISBN 9780007284870

Required

Access to “Statistica” software package <http://www.statsoft.com/Products/STATISTICA/Base>

(note: can be purchased for \$25 for 6 months - academic version)

Access to canvas (please log onto canvas regularly to see class updates)

Grading: A-F

27% !!!	[15%	Brief quizzes at the start of most lectures (1-3 points/lecture) – <i>tests previous class</i>
		10%	Brief quizzes at the end of most lectures (0.5-2 points/lecture) – <i>tests current class</i>
		2%	Brief “goodbye” quiz at the end of the last lecture – <i>tests all previous classes</i>
		20%	Quiz – <i>tests all previous classes</i>
		3%	Student filling-in of a worksheet showing experimental design and statistics
		15%	Student analysis and presentation of a research paper (experimental design and statistics)
		15%	Student presentation of their own research, and the manner in which they analyzed it
20%	Take-home exam – <i>tests all previous classes</i>		

Learning objectives

Principles in experimental design

Upon completion of the course the student should be able to:

- Recognize how cognitive illusions can impact research studies
- Avoid potential pitfalls in research studies
- Recognize the importance of control groups and data replication for the correct interpretation of results
- Design experiments with the appropriate control groups
- Design a set of experiments to test a given hypothesis
- Appraise research studies for their ability to test a hypothesis, design an experiment, and avoid pitfalls

Statistics

Upon completion of the course the student should be able to:

- Recognize the importance of statistics in research
- Discuss basic statistical concepts
- Use the appropriate statistics to analyze their data
- Report statistical results appropriately
- Present results in an effective way (in written and graph form)
- Appraise research studies for their ability to use the appropriate statistics, report statistical results, and present results

Overview of class schedule (see next pages for detailed description)

Spring semester (15 classes, from January to May 2015)

Mondays 8:15-11:45 AM (with one 10 min break around 9.45AM), PHR 3.114B

Date		Class (#)	Class topic	Homework (due today)	Points (Quiz/Exam/Homework)
15-Jan	Fri.	1	Introduction and cognitive illusions	2 Discussions on Dan Ariely's TED talk	1 Brief quiz at end of class
18-Jan	Mon.	2	Experimental design theory	Read 1 editorial, overview 1 paper	3.5 Brief quiz at start and end of class
25-Jan	Mon.	-	No class (winter conference on brain research micky)		
1-Feb	Mon.	-	No class (board of scientific counselors micky)		
8-Feb	Mon.	3	Experimental design theory & practice	Read 1 book chapter	2.5 Brief quiz at start and end of class
15-Feb	Mon.	4	Why we need statistics	Worksheet to plan an experiment	3 Brief quiz at start and end of class
22-Feb	Mon.	5	Describing & presenting data (written, graph, oral)	Reading of 2 papers and 1 handout	2 Brief quiz at start and end of class
29-Feb	Mon.	6	Intro to stats; focus on ANOVA	Reading of 2 papers; overview of 2 papers	2.5 Brief quiz at start and end of class
7-Mar	Mon.	7	Normalizing data: theory and practice		3.5 Brief quiz at start and end of class
14-Mar	Mon.	-	No class (spring break)		
21-Mar	Mon.	8	More basic statistics (ChiSq, CI, Correl, Power)		2 Brief quiz at start and end of class
28-Mar	Mon.	9	Practice choosing appropriate statistics to analyze data	Reading of 2 papers	5 Brief quiz at start and end of class
4-Apr	Mon.	10	Practice with statistical software; Review session	Worksheet to plan an experiment (revised)	3 Worksheet to plan an experiment
11-Apr	Mon.	11	Quiz & review of quiz; Evaluating presentations (rubrics)		20 Quiz
18-Apr	Mon.	12	Analysis/presentation of research papers	Presentation of published research paper	15 Student presentation 1 (paper)
25-Apr	Mon.	13	Presentation of student data	Presentation of own's research data	15 Student presentation 2 (research data)
2-May	Mon.	14	Presentation of student data	Take-home exam	20 Exam
9-May	Mon.	15	Exam overview + Brief notions on Multivariate analysis		2 Brief quiz at end of class

100 Total points

Description of each class**Class 1 – Introduction and cognitive illusions**Topics

Overview of the course and grading system

Ungraded quiz (time permitting)

Goals of scientific experiments

A few notions on cognitive illusions: how we (mis)perceive data

Introduction to how solid experimental design helps us interpret data

1pt brief quiz at the end of class (tests what was learnt in the current class)

Mandatory Resources (must read and know well by the end of the course)

Handout (outline of class lecture) & PowerPoint presentation & In-class exercises

Additional Resources

Gilovich_The hot hand in basketball_Cog Psychol_1985

Gonon_Misrepresentation of Neuroscience Data_PLoSone_2011

<http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0014618><http://www.nature.com/news/2011/110223/full/470437a.html><http://www.youtube.com/watch?v=9xrWqsLHd2M><http://www.youtube.com/watch?v=8uPmeWiFTIw&feature=related>Mandatory Homework (to be prepared before next class)

Read and understand (must be able to describe and discuss in detail in class)

McNutt_Reproducibility_Science_2014

Briefly go over (must be able to describe and discuss the main concepts in class)

Button_Power failure why small sample size undermines reliability_Nat Rev Neurosci_2013

Class 2 – Experimental Design: theory

Topics

2pt brief quiz at the start of class (tests what was learnt in the previous class)

Using knowledge on “cognitive illusions” to avoid scientific bias

- The scientific method
- Control groups (negative, positive, interpretive)
- Threats to internal validity (confounds, selection bias, regression to mean, history, maturation, instrument change, repeated testing experimenter bias)

The placebo & nocebo effect

More principles of experimental design

- Experimenter/subject bias
- Control groups (again)
- Representative sample
- Randomizing/matching/blocking (simple random, systematic, stratified, cluster, blocking matching)
- Replicating

Designing an experiment with appropriate control groups and well-randomized subjects

Setting up a worksheet to plan an experiment

1.5pt brief quiz at the end of class (tests what was learnt in the current class)

Mandatory Resources (must read and know well by the end of the course)

Handout (outline of class lecture) & PowerPoint presentation & In-class exercises

Worksheet to plan an experiment

Worksheet to randomize groups and subjects

Papers you had to read for today (see previous class “Mandatory Homework”)

Additional Resources

Larsen_Repeated testing improves retention_Med Educ_2009.pdf

Larsen_Test-enhanced learning_Med Educ_2008.pdf

Exner & Clark_Subtle variations in living conditions_Neuroreport_1993.pdf

Benedetti_How placebos change brain_Neuropsychopharm_2011.pdf

Mandatory Homework (to be prepared before next class)

Read and understand (must be able to describe and discuss in detail in class)

Day_The development of clinical trials_Textbook of clinical trials_2008

Class 3 – Experimental design: theory & practice

Topics

1.5pt brief quiz at the start of class (tests what was learnt in the previous class)

Experimental design 101 (for lack of a better title)

Approaches to testing a hypothesis (correlation vs. causation)

Correlation: factors that can account for correlation (cause, consequence, lurking, fake); ecological fallacy

Causation (part 1): manipulating the variable of interest (suppression/replacement; decreasing/increasing)

Causation (part 2): agonists/antagonists, dose-response curves

Brief notions on how to conveying the experimental approach (language and terminology)

Exercises in experimental design (correlation, causation, control groups, randomizing subjects)

1pt brief quiz at the end of class (tests what was learnt in the current class)

Mandatory Resources (must read and know well by the end of the course)

Handout (outline of class lecture) & PowerPoint presentation & In-class exercises

Mandatory Homework (to be prepared before next class)

Fill-in a brief version of worksheet to plan an experiment (Protocol_Homework_Name.docx)

Class 4 – Why we need statistics

Topics

2pts brief quiz at the start of class (tests what was learnt in the previous class)

Go over homework

What are statistics (very brief; descriptive, inferential); Hypothesis testing and p values (very brief)

Why do we need statistics?

Statistical significance vs. biological meaning

1pt brief quiz at the end of class (tests what was learnt in the current class)

Mandatory Resources (must read and know well by the end of the course)

Handout (outline of class lecture) & PowerPoint presentation & In-class exercises

Mandatory Homework (to be prepared before next class)

Read and understand (must be able to describe and discuss in detail class)

Wong_Design of data figures_Nature Methods_2010.pdf

Tufte handout http://www.edwardtufte.com/bboard/q-and-a-fetch-msg?msg_id=0001yB

Sand-Jensen_How to write consistently boring scientific literature_Oikos_2007

Class 5 – Describing and presenting data

Topics

1.5pts brief quiz at the start of class (tests what was learnt in the previous class)

Describing data (numbers): spreadsheets, stem and leaf

Describing data (graphs): means, medians, spreads, binning; visual effects

Describing data (written and oral): terminology, style

Information processing

0.5pt brief quiz at the end of class (tests what was learnt in the current class)

Mandatory Resources (must read and know well by the end of the course)

Handout (outline of class lecture) & PowerPoint presentation & In-class exercises

Papers you had to read for today (see previous class “Mandatory Homework”)

Mandatory Homework (to be prepared before next class)

Read and understand (must be able to describe and discuss in detail in class)

Sarter&Fritschy_ReportingStatistics_EJN_2008.pdf

Kranz_The null hypothesis_JASA_1999.pdf

Briefly go over (must be able to describe and discuss the main concepts in class)

Editorial_Animal research-reporting results ARRIVE guide_J Physiol_2010.pdf

Curran-Everett & Benos_Guidelines for reporting stats APS_Advan Physiol Edu_2007.pdf

Additional Resources

Excel worksheets on presenting data and bin counting

Class 6 – Intro to statistics; focus on ANOVA

Topics

1.5pts brief quiz at the start of class (tests what was learnt in the previous class)

What are statistics? (descriptive, inferential)

Variables (qualitative, quantitative)

A few basic formulas and symbols

Hypothesis testing & statistical error (type I, type II)

A few basic stats: parametric vs. non-parametric

ANOVA (examples, graphing results, describing/reading results)

1pt brief quiz at the end of class (tests what was learnt in the current class)

Mandatory Resources (must read and know well by the end of the course)

Handout (outline of class lecture) & PowerPoint presentation & In-class exercises

Papers you had to read for today (see previous class “Mandatory Homework”)

Additional Resources

Class6_Exercises

Class 7 – Normalizing data (theory & practice)

Topics

2.5pts brief quiz at the start of class (tests what was learnt in the previous class)

The Simpson paradox

Normalizing data (with respect to baseline; with respect to a control group; across experiments; within experiments; to create a normal distribution)

Practice normalizing data using excel spreadsheets

1pt brief quiz at the end of class (tests what was learnt in the current class)

Mandatory Resources (must read and know well by the end of the course)

Handout (outline of class lecture) & PowerPoint presentation & In-class exercises

Additional Resources

Connellan_Sex differences in human perception_Infant Behav Devel_2000

Marinelli (PNAS 1998)

Class 8 – More basic statistics

Topics

1pts brief quiz at the start of class (tests what was learnt in the previous class)

Confidence intervals, Power analysis, Chi Square, Correlations

1pt brief quiz at the end of class (tests what was learnt in the current class)

Mandatory Resources (must read and know well by the end of the course)

Handout (outline of class lecture) & PowerPoint presentation & In-class exercises

Mandatory Homework (to be prepared before next class)

Read and understand (must be able to describe and discuss in detail in class)

Lew_Good statistical practice in pharmacology_Br J Pharmacol_2007

Gelman & Stern_The difference between significant & not significant_JASA_2006

Class 9 – Practice choosing appropriate statistics to analyze data

Topics

3pts brief quiz at the start of class (tests what was learnt in the previous class)

Practice finding the appropriate approach to analyzing data

2pt brief quiz at the end of class (tests what was learnt in the current class)

Mandatory Resources (must read and know well by the end of the course)

PowerPoint presentation & In-class exercises

Sample calculations (averages, percentages, etc...) on excel

Papers you had to read for today (see previous class “Mandatory Homework”)

Mandatory Homework (to be prepared before next class)

Revise worksheet to plan an experiment (Protocol_Homework_Name_Revised.docx); add missing sections

3pts Worksheet

Class 10 – Practice using statistical software; Review session

Topics

Practice using software to analyze raw and normalized data (excel, Statistica)

Review of main points

Mandatory Resources (must read and know well by the end of the course)

PowerPoint presentation & In-class exercises

Sample calculations (averages, percentages, etc...) on excel

Class 11 – Quiz and review of quiz

Topics

20pts Quiz

Quiz review

Practice evaluating presentations based on rubrics

Mandatory Resources (must read and know well by the end of the course)

Quiz

Rubrics to prepare and evaluate presentations

Mandatory Homework (to be prepared before next class)

Read one paper and prepare brief presentation on hypothesis, approach, experimental design, and statistics (follow posted guidelines)

Class 12 – Analysis & presentation of research papers (student presentation 1)

Topics

15pts Student presentation of research paper (analysis of hypothesis, approach, experimental design, and statistics)

Student analysis of research papers (for hypothesis, approach, experimental design, and statistics)

Resources

Research papers

Rubrics to prepare and evaluate presentations

Mandatory Homework (to be prepared before next class)

Prepare a presentation on your own research, to be presented next week (follow posted guidelines)

Class 13 & 14 – Presentation of student data (student presentation 2)

Topics

15pts Student presentations of their own data

Resources

Handout (outline of class lecture) & PowerPoint presentation prepared by each student

Rubrics to prepare and evaluate presentations

Class 15 – Review of exam & Multivariate analysis

Topics

Review of exam

Not part of the exam: brief overview of multivariate statistics (MANOVA, discriminant function analysis, factor analysis), Cluster analysis

2pt brief “goodbye quiz” at the end of class (tests what was learnt throughout the course)

20pts Take-home exam due on 05/02/2015 by 8:30AM