Behavioral Research: Statistical Methods

INTRODUCTION

WHY DO STATISTICS?

Agenda

Syllabus and related questions

Syllabus

CS9.422 Behavioral Research: Statistical Methods

Course Information

Instructor Information

Instructors: Dr Vinoo Alluri and Dr Vishnu Sreekumar
with guest lectures by Dr Bhaktee Dongaonkar
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vishnu.sreekumar@iiit.ac.in; bhaktee.dongaonkar@gmail.com

Course Information

Course Description: Students will be introduced to the different statistical methods employed in the analysis of behavioral data. The material will be delivered as a combination of lectures and practical sessions. In the practical sessions, students will be provided with data and code snippets to help them practice the concepts taught in the lectures. They will also receive regular problem sets/assignments which will comprise the majority of the course evaluation. We will primarily rely on R for statistical analysis but may also use other tools as deemed appropriate for the material being covered.
Credits: 4
L-T-P: 3-0-1 (L = lecture hours, T = tutorial hours, P = practical hours)
Prerequisite: None

Textbook & Course Materials

Recommended Texts & Other Readings: Learning Statistics with R by Danielle Navarro: https://learningstatisticswithr.com/lsr-0.6.pdf
Lecture slides and supplementary reading materials (journal articles, books/book chapters, online resources) will be uploaded on the course page on Moodle.

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Course Technology Requirements

- You will need access to the following tools to participate in this course.
    - Laptop computer to bring to class for practical sessions
    - Webcam (if attending online)
    - Microphone (if attending online)
    - a stable internet connection (don't rely on cellular)

Course Structure

This course will be delivered as in-person lectures and practical sessions.

Student Expectations

In this course you will be expected to complete the following types of tasks.

- Read the syllabus!
- Meet deadlines
- Attend in-person classes or online classes (if sick)
- Participate in practical sessions every week
- Submit your practical class-work every week
- Communicate via email
- Complete basic internet searches
- Download and upload documents to the course site on Moodle
- participate in class discussions
- complete quizzes/tests
- upload documents to a Dropbox/Moodle

Expected Instructor/TA Response Times

- We will attempt to respond to student emails within 24 hours. If you have not received a reply from us within 24 hours, please resend your email. Please email both of us to maximize the probability of a quick response.
    - ***If you have a general course question (not confidential or personal in nature), please post it to the Course Q&A Discussion Forum found on the course homepage on Moodle. We will post answers to all general questions there

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so that all students can view them. Students are encouraged to answer each other's questions too.
- We will attempt to reply to and assess student discussion posts within 48 hours.

Course Outcomes (COs)

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

- CO-1: develop an understanding of various experimental designs
- CO-2: recognize and employ appropriate statistical packages to analyze data
- CO-3: apply appropriate parametric and non-parametric analyses techniques
- CO-4: perform exploratory data analysis and examine intrinsic relationships between variables
- CO-5: reflect and draw appropriate inferences post analyses
- CO-6: create custom code by adapting exploratory and confirmatory analyses techniques

You will meet the outcomes listed above through a combination of the following activities in this course:

- Attend lectures and participate in class discussions (CO-1, CO-2, CO-3, CO-4, CO-5)
- Quiz 1 and Quiz 2 (CO-1, CO-2, CO-5)
- Complete problem sets and assignments (CO-2, CO-3, CO4, CO-5, CO-6)
- Complete a course project and present the results (CO-3, CO-4, CO-5, CO-6)

Tentative Schedule

Week 1: Introduction: why do statistics, and basics of research design
Week 2: Installing R and basics of R
Week 3: Descriptive statistics and visualizing data
Week 4: Organizing, sorting, merging, and reading data in R
Week 5: Probability and sampling distributions
Week 6: Null hypothesis testing
Week 7: Categorical data analysis, comparing two means, data reduction

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Week 8: Linear regression, regression diagnostics, and related hypothesis tests
Week 9: One-way ANOVA
Week 10: Factorial ANOVA
Week 11: Bayesian statistics and inference
Week 12: Project presentations and report submission

Grading Policies

Graded Course Activities

Description	Percentage
In-class problem sets	10
4 assignments (10% each)	40
2 Quizzes (10% each)	20
Final Project	30
Total	100

In-class problem sets

We will provide sample datasets and problems to work on in class, and code snippets to facilitate them. You are highly encouraged to use Google Search during the practical sessions when analyzing data using R. Students are expected to attend all the practical sessions and submit their answers at the end of the class (10% weightage).

Assignments

Students will have to submit code (R, Python, or MATLAB) and solutions to 4 assignments. Plagiarism will result in 0 marks and the students will also be reported to the administration. If you have queries about what constitutes plagiarism, please read: https://mrwachs.wordpress.com/2019/11/25/what-is-plagiarism-in-computer-science/, https://clas.iusb.edu/computer-science-informatics/prospective-students/plagiarism.html, and also contact the instructors by email with your questions.

If you are stuck on a problem, brain-storming with a friend or group of friends is encouraged but not looking at their code and copying their code

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and logic. The latter will result in 0 marks awarded for the assignment, and a letter grade penalty for each further infraction.

Final Project (60 marks, 30% weightage)

You can start working on the project at any point during the course, the earlier, the better. You can pick any paper from the behavioral sciences and either conduct a replication study by collecting your own data, or use data shared by the authors of the paper to replicate their analysis using your own custom analysis code demonstrating any technique taught in the course and/or other statistical techniques of your choice depending on the problem statement. There will be three main components of the final project: 1. A project proposal 2. A final project presentation in class and 3. A final project write-up. They will be graded as follows:

2-3 page (single-spaced, font size 12) project proposal **to be submitted by midnight Feb 18, 2023** (initial topic selection, with brief description of what you intend to study, how you plan to collect data, how the analysis will be performed, and what the data analysis is expected to teach us about that topic) – 10 marks

Final Presentation – 15 marks (clarity of presentation: setting up the problem, describing the experiment/data = 10 marks; visualization of the results and conclusions = 5 marks)

Final Project Write-up (~10 pages, single-spaced, font size 12) **to be submitted by midnight April 30, 2023**

1. Introduction and clarity of problem statement, including an appropriate literature review – 5 marks
2. Methods (the analysis you did must be clear from the methods section) – 10 marks
3. Results (make good figures, use statistics to make your points about what you present in the figures) – 10 marks
4. Conclusion and Discussion – 5 marks
5. Formatting, citations, references – 5 marks

Participation

Students are expected to participate in all class activities as listed on the course calendar. *Failure to participate will result in students being unable to complete the in-class problem sets, assignments, and project satisfactorily and any such resulting effect on the final grade is entirely the student's responsibility.*

Complete Assignments

All assignments for this course will be submitted electronically

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through the course page on Moodle unless otherwise instructed. Assignments must be submitted by the given deadline or special permission must be requested from instructor *before the due date*. Extensions will not be given beyond the next assignment except under extreme circumstances.

Late or missing assignments will affect the student's grade.

Late Work Policy

Be sure to pay close attention to deadlines—there will be no make-up assignments or quizzes, or late work accepted without a serious and compelling reason and instructor approval.

Viewing Grades on Moodle

Points you receive for graded activities will be posted to the course page on Moodle. Click on the Grades link to view your points.

Grading

Absolute grading will be followed if the size of the class is <60 and relative grading otherwise. Final scores will be rounded up and graded accordingly.

Course Policies

Netiquette Guidelines

Netiquette is a set of rules for behaving properly online. Your instructor and fellow students wish to foster a safe online learning environment. All opinions and experiences, no matter how different or controversial they may be perceived, must be respected in the tolerant spirit of academic discourse. You are encouraged to comment, question, or critique an idea but you are not to attack an individual. Working as a community of learners, we can build a polite and respectful course community.

The following netiquette tips will enhance the learning experience for everyone in the course:

- Do not dominate any discussion.
- Give other students the opportunity to join in the discussion.
- Do not use offensive language. Present ideas appropriately.
- Be cautious in using Internet language. For example, do not capitalize all letters since this suggests shouting.
- Avoid using vernacular and/or slang language. This could possibly lead to misinterpretation.
- Never make fun of someone's ability to read or write.
- Share tips with other students.
- Keep an "open-mind" and be willing to express even your minority opinion. Minority opinions have to be respected.
- Think and edit before you push the "Send" button.
- Do not hesitate to ask for feedback.

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- Always assume good intentions and ask for clarification. Communication online is difficult without facial and gestural cues.

Adapted from:

Mintu-Wimsatt, A., Kernek, C., & Lozada, H. R. (2010). *Netiquette: Make it part of your syllabus*. Journal of Online Learning and Teaching, 6(1). Retrieved from http://jolt.merlot.org/vol6no1/mintu-wimsatt_0310.htm

Shea, V. (1994). Netiquette. Albion.com. Retrieved from: http://www.albion.com/netiquette/book/.

Build Rapport

If you find that you have any trouble keeping up with assignments or other aspects of the course, make sure you let your instructor know as early as possible. As you will find, building rapport and effective relationships are key to becoming an effective professional. Make sure that you are proactive in informing your instructor when difficulties arise during the semester so that we can help you find a solution.

Inform Your Instructor of Any Accommodations Needed

If you have a documented disability and wish to discuss academic accommodations, please contact your instructors as soon as possible.

Statement of Policy

The instructors of this course will modify requirements as necessary to ensure that they do not discriminate against qualified students with disabilities. The modifications should not affect the substance of educational programs or compromise academic standards; nor should they intrude upon academic freedom. Examinations or other procedures used for evaluating students' academic achievements may be adapted. The results of such evaluation must demonstrate the student's achievement in the academic activity, rather than describe his/her disability.

If modifications are required due to a disability, please inform the instructor

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Commit to Integrity

As a student in this course (and at IIIT Hyderabad) you are expected to maintain high degrees of professionalism, commitment to active learning and participation in this class and also integrity in your behavior in and out of the classroom.

IIIT Hyderabad Academic Honesty Policy & Procedures

Student Academic Disciplinary Procedures

(1) Academic misconduct is an act in which a student:

(a) Seeks to claim credit for the work or efforts of another without authorization or citation;

(b) Uses unauthorized materials or fabricated data in any academic exercise;

(c) Forges or falsifies academic documents or records;

(d) Intentionally impedes or damages the academic work of others;

(e) Engages in conduct aimed at making false representation of a student's academic performance; or

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(f) Assists other students in any of these acts.

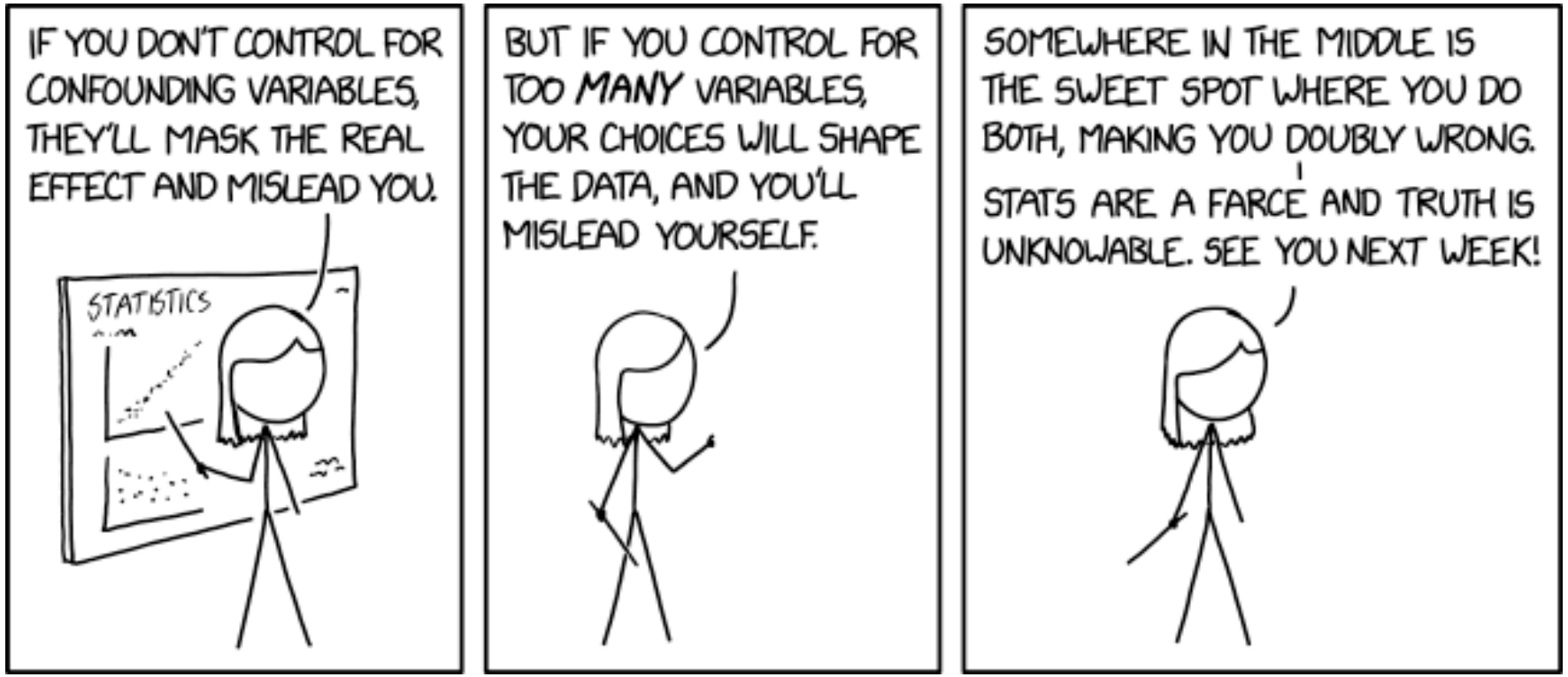
(2) Examples of academic misconduct include, but are not limited to: cheating on an examination; collaborating with others in work to be presented, contrary to the stated rules of the course; submitting a paper or assignment as one's own work when a part or all of the paper or assignment is the work of another; submitting a paper or assignment that contains ideas or research of others without appropriately identifying the sources of those ideas; stealing examinations or course materials; submitting, if contrary to the rules of a course, work previously presented in another course; tampering with the laboratory experiment or computer program of another student; knowingly and intentionally assisting another student in any of the above, including assistance in an arrangement whereby any work, classroom performance, examination or other activity is submitted or performed by a person other than the student under whose name the work is submitted or performed.

We will be using plagiarism detection software. Please do not copy-paste from other papers. If you use direct quotes, you have to use the quotation marks "xyz" and cite your source: e.g. (Johnson & Johnson, 1988, p. 5). Please use APA format. If plagiarism is detected, you will lose the 10 marks assigned to formatting and you will be advised regarding plagiarism. If plagiarism is detected a second time in another assignment/project write-up, then one letter grade will be deducted from the final grade (e.g.[1] if you get a B, that will be changed to C) and you will be reported to the appropriate authorities for further disciplinary action.

Question about coding language

The reference textbook for the course uses R. Many of our problem and practice sets will include R code snippets. So you will need a laptop with R and RStudio installed.

You can however use any language of your choice (MATLAB, Python, etc) to complete your assignments and projects.



Why do statistics?

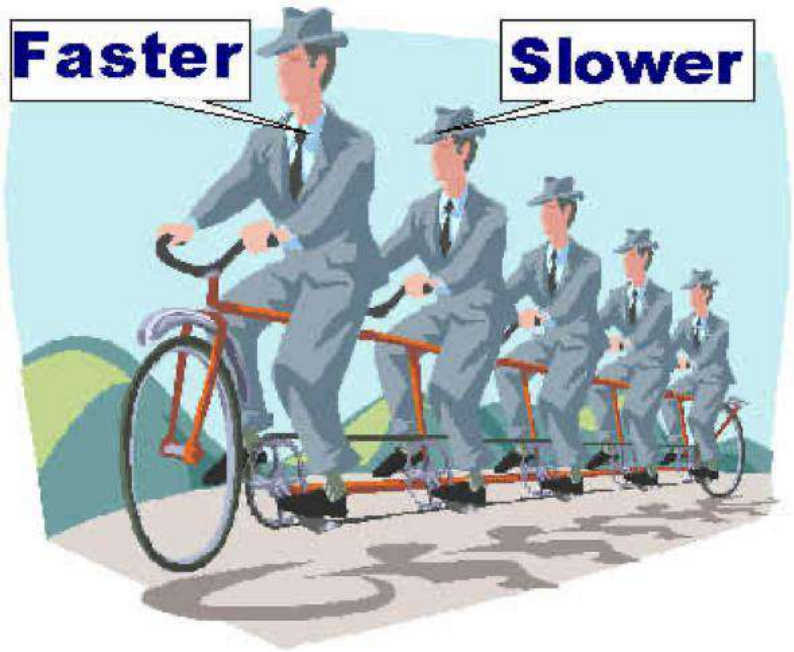
Why do statistics, why not use common sense?

My mom: drink milk with turmeric, it will cure you of sore throat. I have experienced this, 3 days of drinking it and my sore throat is gone. My friends have also experienced it.

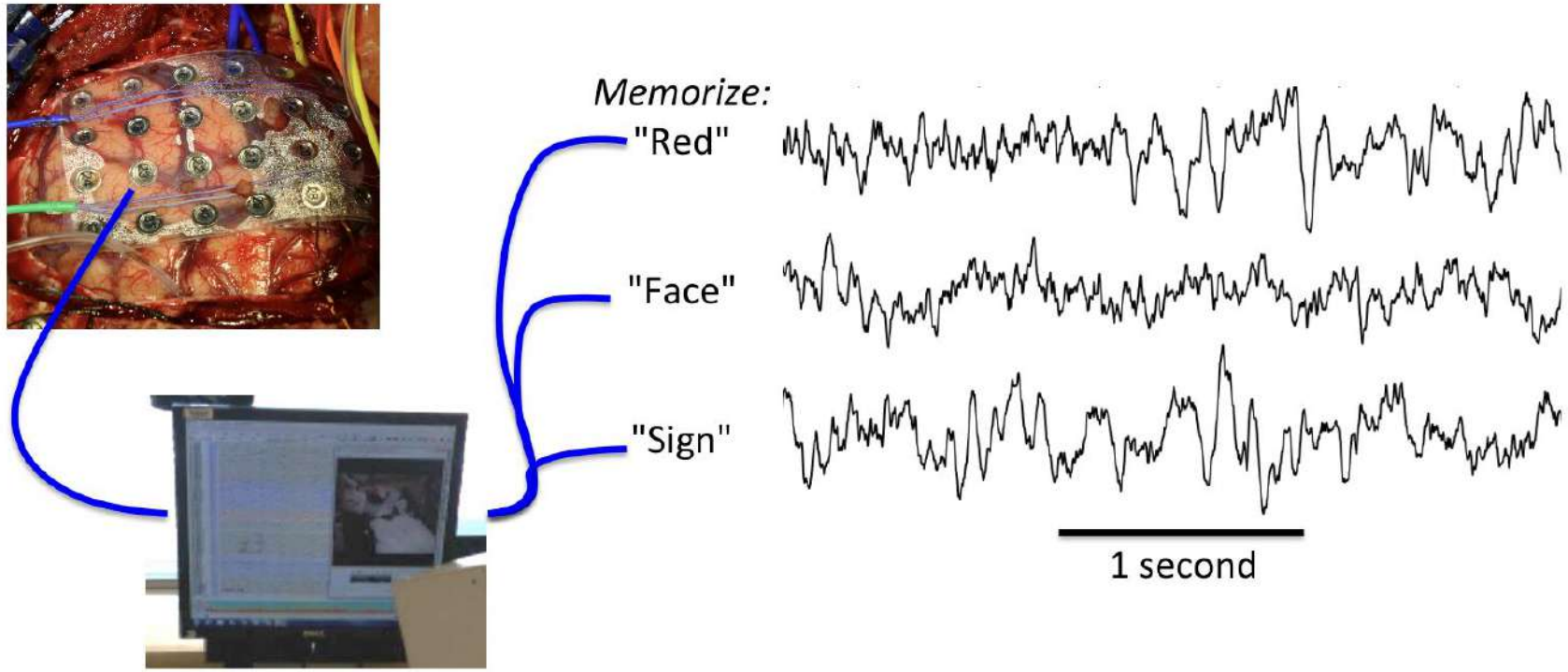
You might have encountered many such claims, especially during the early days of COVID. There is also currently a proliferation of pseudoscientific thinking in India. An education in basic statistics and research design will hopefully help you see through some of the issues with such claims.

Human-beings

- Complexity
- Variability
- Reactivity



Brains



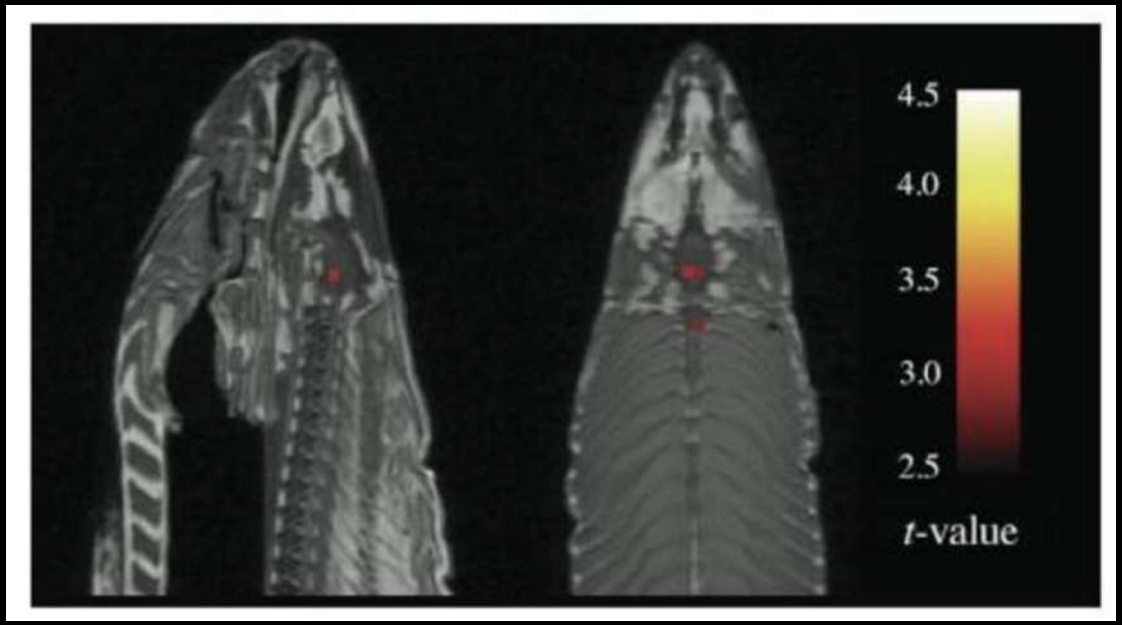
Related statistical pitfalls

Replication Crisis

Reproducibility Crisis

Reviewed by Psychology Today Staff

The replication crisis in psychology refers to concerns about the credibility of findings in psychological science. The term, which originated in the early 2010s, denotes that findings in behavioral science often cannot be replicated: Researchers do not obtain results comparable to the original, peer-reviewed study when repeating that study using similar procedures. For this reason, many scientists question the accuracy of published findings and now call for increased scrutiny of research practices in psychology.



IgNobel Prize in Neuroscience: The dead salmon study

Human biases

Belief bias

We tend to be swayed by the "believability" of the conclusion even when we are trying to deduce the conclusion from certain premises in a logical fashion (I.e., assuming the premises are true, is the conclusion valid?).

Believable conclusion and valid argument

- No cigarettes are inexpensive (Premise 1)
- Some addictive things are inexpensive (Premise 2)
- Therefore, some addictive things are not cigarettes (Conclusion)

Unbelievable conclusion but valid argument

- No addictive things are inexpensive (Premise 1)
- Some cigarettes are inexpensive (Premise 2)
- Therefore, some cigarettes are not addictive (Conclusion)

Believable conclusion but invalid argument

- No addictive things are inexpensive (Premise 1)
- Some cigarettes are inexpensive (Premise 2)
- Therefore, some addictive things are not cigarettes (Conclusion)

Unbelievable conclusion and invalid argument

- No cigarettes are inexpensive (Premise 1)
- Some addictive things are inexpensive (Premise 2)
- Therefore, some cigarettes are not addictive (Conclusion)

	conlusion feels true	conclusion feels false
argument is valid	92% say “valid”	–
argument is invalid	–	8% say “valid”

Evans, Barston, & Pollard (1983)

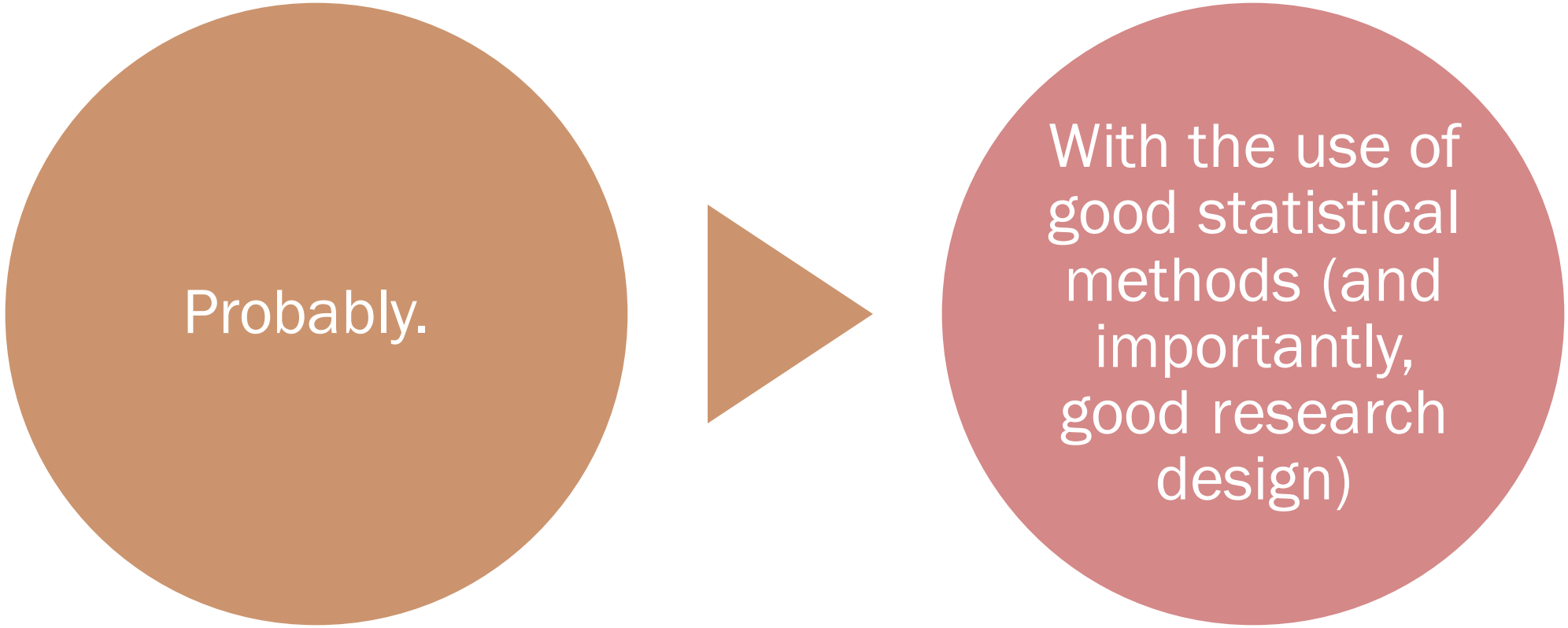
when the structure of the argument was in line with pre-existing beliefs and biases

	conlusion feels true	conclusion feels false
argument is valid	92% say “valid”	**46% say “valid”**
argument is invalid	**92% say “valid”**	8% say “valid”

Evans, Barston, & Pollard (1983)

when the structure of the argument contradicted pre-existing beliefs and biases

Can we improve our chances of being correct from 60% to 90+%?



Simpson's paradox

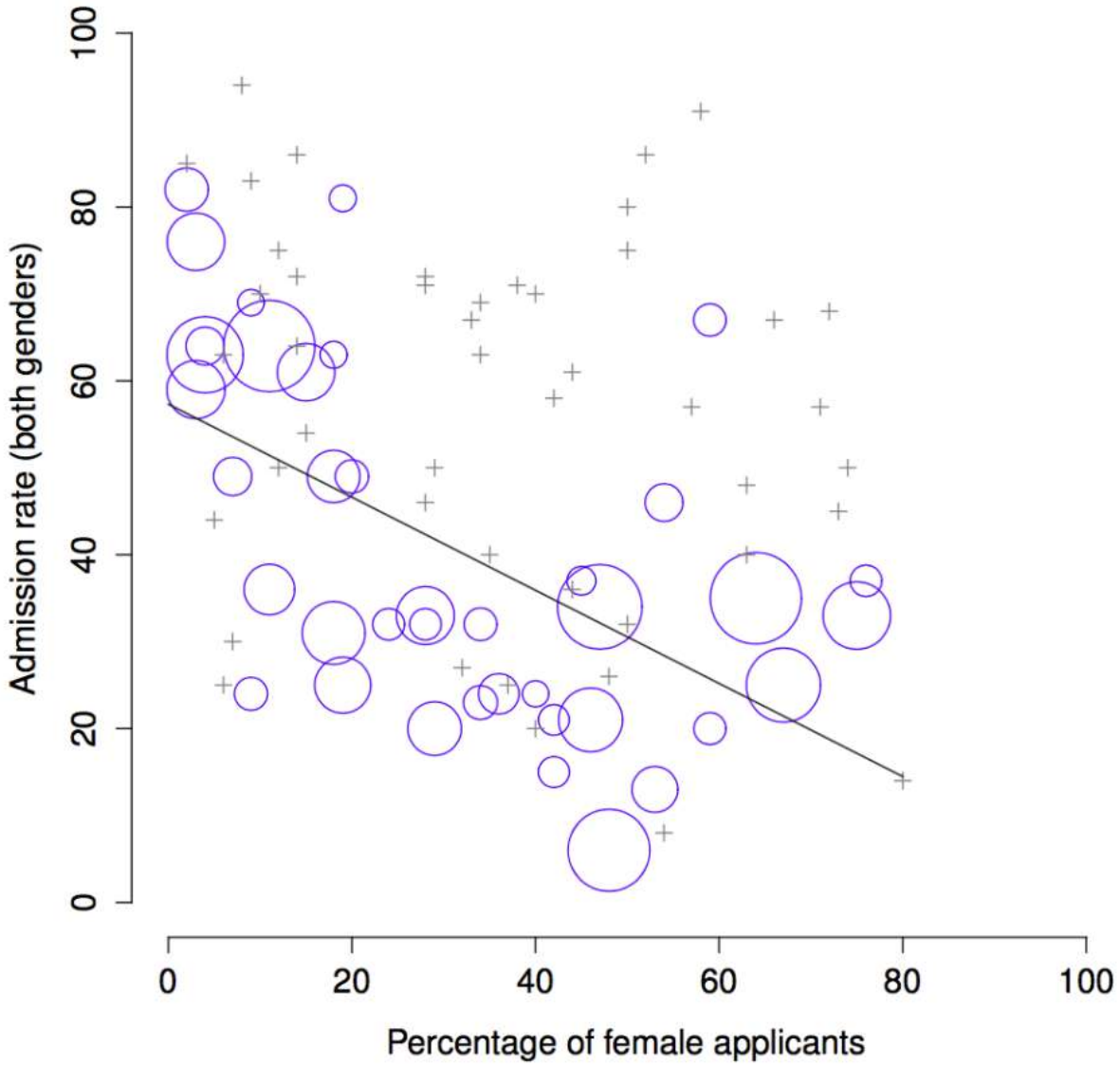
	Number of applicants	Percent admitted
Males	8442	44%
Females	4321	35%

Department	Applicants	Percent admitted	Applicants	Percent admitted
A	825	62%	108	82%
B	560	63%	25	68%
C	325	37%	593	34%
D	417	33%	375	35%
E	191	28%	393	24%
F	272	6%	341	7%

Counter-intuitive but of practical relevance

The overall rate of admission was lower for females than males but in individual departments, it was the opposite!!

The textbook says this is a rare example, but this is actually quite applicable in many scenarios where instead of departments in this example, you have data from different human subjects. These subjects do slightly different things but you try to make a conclusion about the whole population with some average measure. What the average tells you in some cases may be misleading. We need to have strong foundations in statistics to be aware of such cases.



Data visualization

Data interpretation

Once you do the statistics, it is time to interpret the results of your analysis

Is there gender bias in admissions?

Based on the departmental data?

Based on what criteria? This now is where you bring your theories to bear upon the data. For example, does the theory care about systemic issues that make females apply less frequently to say the engineering departments (explaining why the total number of applicants are distributed differently across the departments for males and females)?

Statistics in everyday life

WE SEE CLAIMS EVERY DAY IN THE MEDIA USING STATISTICS

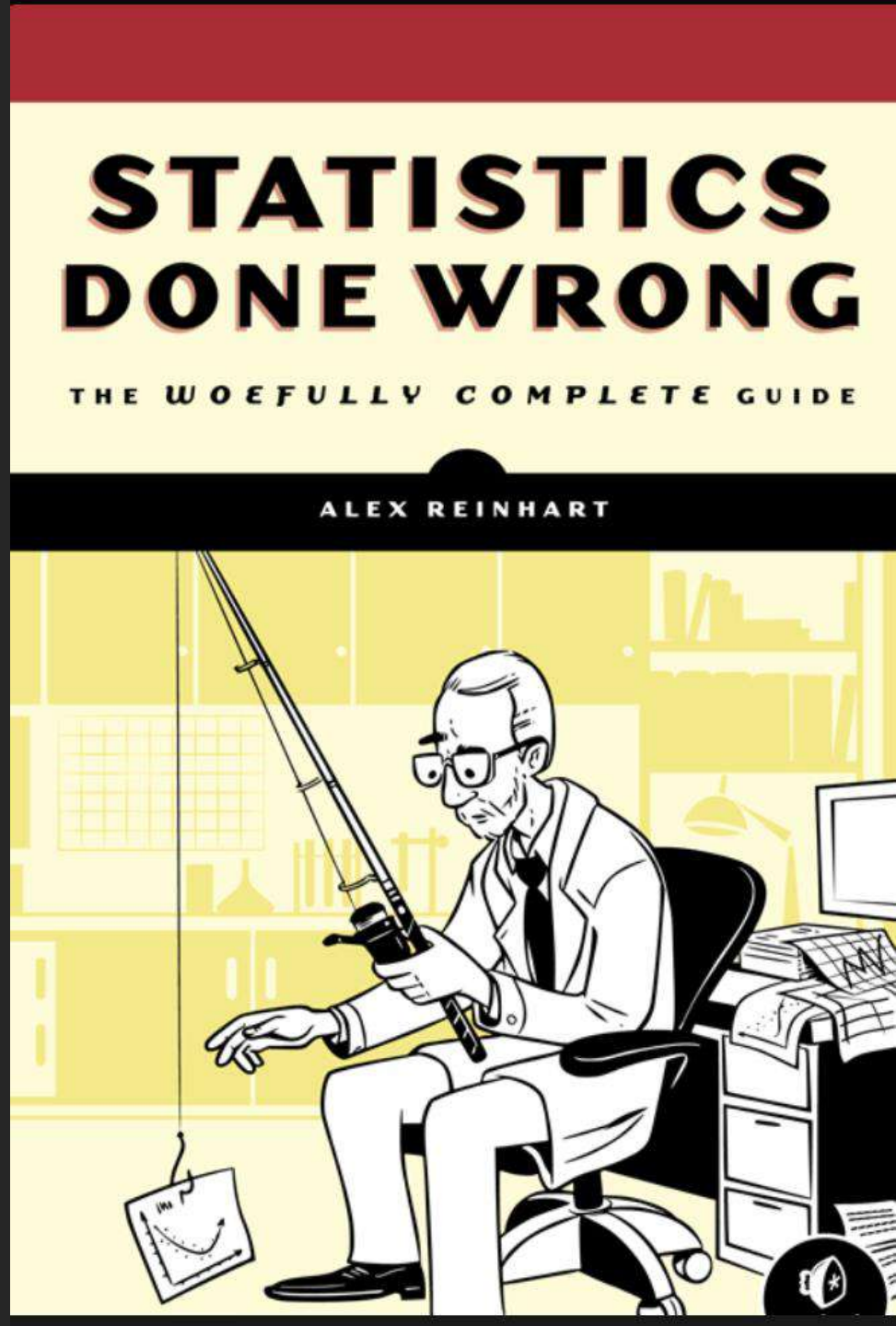
OFTEN, REPORTERS MAKE FUNDAMENTAL ERRORS WHEN THEY REPORT NUMBERS (E.G. NOT TAKING INTO ACCOUNT BASE RATES)

Some pitfalls

Misinterpreting p values

Misinterpreting confidence intervals (I estimate the mean height of boys in this class to be 5'7" with a 95% CI of [5'3", 5'11"])

Base rate fallacy (a lack of understanding of Bayesian probability)



The base rate fallacy

Let's say you or your relative/friend gets a positive mammogram result.

How likely is it that they have cancer?

Some relevant info (premises)

- 0.8% of all women who get mammograms have breast cancer
- In 90% of these women with breast cancer, a mammogram will correctly detect it (defined as the **statistical power**)
- However 7% of women without cancer will get a false positive mammogram
- How likely is it that a positive test indicates cancer?

Imagine 1000 tests

8 of them have cancer

7/8 of them will get a positive mammogram (due to the 90% power of this test)

992 with no breast cancer

7% false positive = ~70 women incorrectly told they have breast cancer

Now, how many total positive mammograms do we have?? 70 + 7 = 77

Only 7 of them actually have breast cancer.

(7/77)x100 = 9%.

So the probability that given a positive mammogram, someone actually has breast cancer = 0.09 or 9%

Bayes' rule

Bayes' Theorem

We can turn the process above into an equation, which is Bayes' Theorem. It lets you take the test results and correct for the "skew" introduced by false positives. You get the real chance of having the event. Here's the equation:

$$\Pr(\mathrm{H}|\mathrm{E}) = \frac{\Pr(\mathrm{E}|\mathrm{H})\,\Pr(\mathrm{H})}{\Pr(\mathrm{E}|\mathrm{H})\,\Pr(\mathrm{H}) + \Pr(\mathrm{E}|\text{not H})\,\Pr(\text{not H})}$$

The chance evidence is real (supports a hypothesis)
is the chance of a true positive among
all positives (true or false)

Bayes' rule

P(cancer|positive test) = P(positive test|cancer) * P(cancer)/P(positive test)

What we know:

1. P(positive test|not cancer) = 0.07 (false positive probability)
2. P(cancer) = 0.8% = 0.008
3. P(positive test|cancer) = 0.9

P(positive test) = 77/1000 = 0.077 (from the last slide)

The other way to calculate P(positive test) = P(positive test|cancer)*P(cancer) + P(positive test|not cancer) * P(not cancer) = 0.9*0.008 + 0.07*0.992 = 0.07664 ~= 0.077

P(cancer|positive test) = 0.9 *0.008/0.077 = 0.09

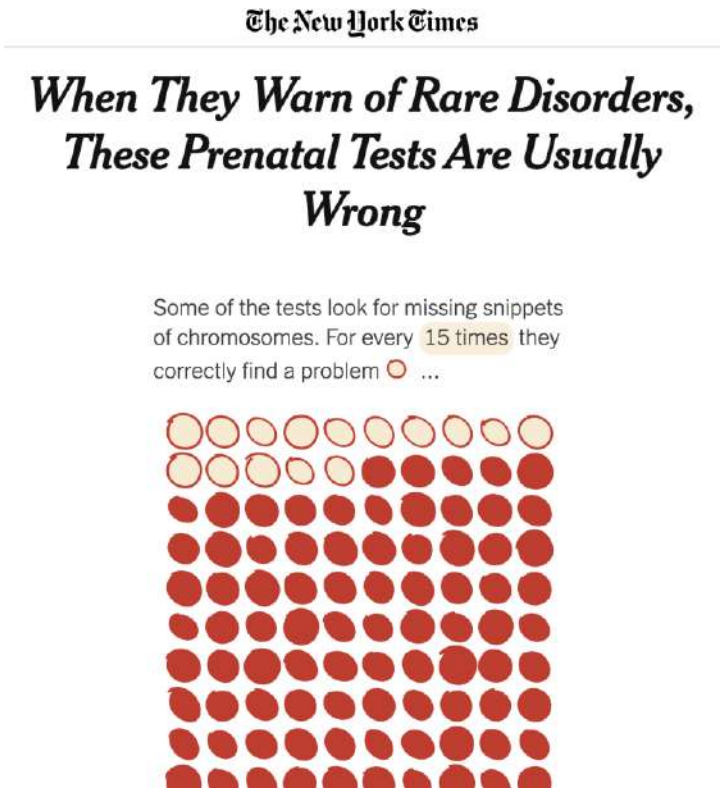
P(cancer) = base rate P(positive test|not cancer = false positive probability

Many fail to give the right answer

2/3rds of doctors fail this test

1/3rds of statistics and methodology instructors like myself and statistics students.

Just from recent news:



The New York Times

When They Warn of Rare Disorders, These Prenatal Tests Are Usually Wrong

Some of the tests look for missing snippets of chromosomes. For every 15 times they correctly find a problem ○ ...

Genetic counselors who have dealt with false positives say some doctors may not understand how poorly the tests work. And even when caregivers do correctly interpret the information, patients may still be inclined to believe the confident-sounding results sheets.

When Cloey Canida, 25, got a positive result from Roche's Harmony test in September, the result sheet seemed clear: It said her daughter had a "greater than 99/100" probability of being born with Patau syndrome, a condition that babies often do not survive beyond a week.

“I wish that we would have been informed of the false positive rate before I agreed to the test,” she said. “I was given zero information about that.”

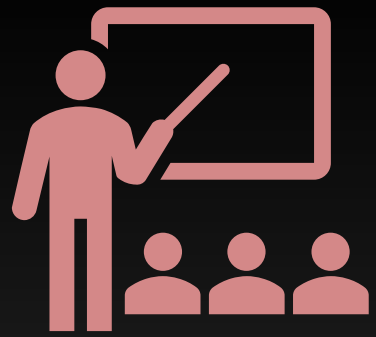
Basic knowledge of statistics and probability can help you in everyday life as well

You read a story in the newspaper about a certain group of people (with certain attributes: religion, caste, etc) and how prone they are to violence based on some numbers. Knowledge of basic statistical and probabilistic pitfalls can help you evaluate these claims better.

You read a story about COVID-19 and Omicron, and the probability of getting seriously sick based on hospital admission numbers. You know about confounding variables, you know about base rates, etc – evaluate the claims calmly and logically.

False positives, false negatives, etc in statistics for psychology

We as researchers too conduct tests. Every test has some chance of a false positive, false negative, etc. To make inferences from the data, we need to compute numbers. There are many statistical tools available to do this.



This will be a major topic of this course.

15 min homework

PLEASE READ CHAPTER 1: HTTPS://LEARNINGSTATISTICSWITHR.COM/BOOK/WHY-DO-WE-LEARN-STATISTICS.HTML