Introduction to Neural Data Science (IntroNDS)
NEURL-UA 302

This syllabus is subject to change. Changes will be announced in class and by email.

Description
This course will provide an introduction to data, data visualization, summary statistics, model fitting, hypothesis testing, and neuroscience-specific methods for data analysis. We will pay special attention to the assumptions behind and relations between different techniques. You will also learn the basics of the programming language Python. This course is strongly recommended if you are interested in doing research in neuroscience.

Prerequisites: Introduction to Neural Science and Calculus 1

Weekly schedule (exceptions will be announced)
Will include lectures, recitations, and office hours.

Questions
The instructor and TA will not answer content-related questions by email. Please ask your questions at an office hour or by appointment. Skype/Google Hangout meetings can be arranged.

Materials
- Lecture notes will be provided, but no lecture recordings.
- Materials to be used for in-class exercises will be provided in advance of the class.
- We will use Wallisch and Nylen, *Neural data science* (Elsevier, 2017) as a reference.
- We will use Python as a programming language.

Grading
The total grade will be calculated as follows:

Best 9 of 12 homework sets	50%
Midterm	20%
Final	20%
Participation	10%

Letter grade
Your numerical grade will be turned into a letter grade according to the following scale: 90-100 A; 87-89 A-; 84-86 B+; 80-83 B; 77-79 B-; 74-76 C+; 70-73 C; 67-69 C-; 64-66 D+; 60-63 D; 57-59 D-; 0-56 F.

Homework

- There will be twelve homework sets. The lowest three homework grades will not be counted. You can drop homework for any reason, but no more than three drops will be allowed.
- Homework will be issued at the start of each lecture starting Week 1. Homework is due at 2 PM every Tuesday starting Week 2, through NYU Classes → Assignments. After one day, late homework will not be accepted by the system and will count as 0. Late homework will be docked 20%.
- Submit all homework as a Jupyter notebook, both as the original (.ipynb) and as PDF. The notebook should contain everything: text answers, equations (as LaTeX), and plots. Make sure that all code runs without errors. Name both files with the homework number and your last name, e.g. "HW1_lastname.ipnyb" and "HW1_lastname.pdf".
- If you think your homework has been graded incorrectly, please first talk to your TA. If no resolution is reached, talk to the instructor.
- We will not provide answer keys. However, we will discuss any homework problem in recitation upon request.

Policies on collaboration and cheating

- You are expected to work on these homework assignments independently. If you are stuck on a problem: Try your best first – this could mean struggling for hours, but that is often the best way to learn. If you are still stuck, the preferred method is to contact the instructors for help.
- If you ask a classmate for help **after trying hard yourself**, then you must indicate on your homework whom you worked with on what. You will not be penalized for learning with your peers. We ask that you say who you worked with for two reasons: 1) Honesty. 2) We want to know what material is difficult so we can spend more time helping you learn. If you relied on a peer for a challenging question then we want to make sure that you understand the material before test time.
- Under no circumstances should you copy or allow someone to copy, your answers or code, even slightly. **Copying work is cheating, is easy to detect, and will result in a grade of 0 and potentially further disciplinary measures.**
- If someone asks you for help on the homework: do not give them your answer or code – this is cheating and will yield a grade of 0. First, make sure that the person you are helping has tried their best on the homework. You will only hurt them come exam time if you just handed them the answers all semester. Second, explain how you got started and how you thought about the problem. If you can help someone learn that way, that is impressive.

Participation

- Attendance is mandatory. Your participation grade will be based on attendance, as well as on participation during lecture and recitation.
- To declare an absence, please email the instructors in advance.

Midterm and final

- Both exams will be take-home. You may use any written and electronic materials (including your own code from before), but of course not consult anyone or communicate with anyone about the exam.
- No early or late exams.

Schedule

Week	What	Due	Topic
Week One	Lecture 1		Introductions. Programming in Python
	Recitation 1		Basics of Python. Plotting practices. Programming
Part 1: Summarizing data			
Week Two	Lecture 2	HW 1	Data in neuroscience research. Types of variables: dependent, independent, categorical, discrete, continuous. Univariate, bivariate, multivariate data.
	Recitation 2		Basics of Python. Plotting practices. Programming -
Week Three	Lecture 3	HW 2	Summarizing univariate data: histograms, mode, median, interquartile range, mean, variance, standard deviation, higher moments.
	Recitation 3		
Part 2: Estimators and models			
Week Four	Lecture 4	HW 3	Summarizing bivariate data: binning, covariance, correlation, spurious correlations, cross-correlogram.
	Recitation 4		
Week Five	Lecture 5	HW 4	Populations. Univariate population parameters: proportion, mean, and variance. Bias in estimation. Standard error of the mean.
	Recitation 5		
Week Six	Lecture 6	HW 5	Modeling univariate data: Models. Probability distributions. The Poisson distribution. The Gaussian distribution. Maximum-likelihood estimation.
	Recitation 6		
Week Seven	Lecture 7	HW 6	Modeling bivariate data: Linear regression and logistic regression.
	Recitation 7		
Part 3: Hypothesis testing after Lecture 8			
Week Eight	Lecture 8		Modeling bivariate data: Process models and how to fit them. Psychometric curve in perception. Softmax decision model. Tuning curves.
	Recitation 8		Go through HW 6.
Week Nine	Lecture 9	HW 7	Univariate data. One-sample t-test. Significance.
	Recitation 9		
Week Ten	Lecture 10	HW 8	Two-sample tests. Two-sample t-test, two-sample paired t-test, rank-sum test, signed-rank test, and permutation tests. Non-parametric tests. Sign test, randomization test. Statistical power.
	Recitation 10		
Week Eleven	Lecture 11	HW 9	More than two samples: Analysis of variance, Kruskal-Wallis test, permutation F-test.

	Recitation 11		
Week Twelve	Lecture 12	HW 10	Repeated-measures data, multivariate data, two-way ANOVA, significance of a correlation.
	Recitation 12		
Week Thirteen	Lecture 13	HW 11	Cautionary tales: multiple comparisons, false discovery rate, p-hacking, replication crisis.
	Recitation 13		
Part 4: Wrapping up			
Week Fourteen	Lecture 14	HW 12	Kaleidoscope of advanced methods: time series analysis, power spectrum, clustering, dimensionality reduction.
	Recitation 14		Final review and general discussion
Week Fifteen		**Final**	