**Introduction to Neural data analysis (NEURL-UA 302-005)**
**Spring 2016**

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

**Description**

This course will provide a rigorous introduction to basic statistics as relevant to neuroscience. We will pay special attention to the assumptions behind and relations between different techniques. The course will emphasize the ability to work with data on your own. This course will be a good preparation for doing research in neuroscience. It will be different from *Statistics for the behavioral sciences* and from most other statistics courses in several ways:

- We will use real data sets from many NYU labs, not only to make our material directly applicable but also to give an overview of the types of research in neuroscience.
- We will go in depth on the math behind the statistics. For example, did you know that the "t" in "t-test" refers to "t distribution"? What is that distribution and why does it appear?
- We will examine what happens when assumptions behind statistical tests are violated. For example, how can a t-test go wrong when the underlying distributions are not Gaussian? What alternatives exist?
- We will use Matlab, which is more powerful for data analysis than SPSS.

**Prerequisites**

- Introduction to Neural Science (or permission from the lecturer)
- Calculus 1 or equivalent


| **Lecturer** | **Teaching assistant** |
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| Prof. Wei Ji Ma | Michael Rabadi |
| weijima@nyu.edu | michael.rabadi@nyu.edu |
| Meyer Hall, Room 750C | Meyer Hall, Room 1023 |
| 212 992 6530 | |


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| **Lecture** | Tuesdays, 10-12 | Meyer Hall, Room 808 |
| **Recitation** | Thursdays, 10-11:30 | Meyer Hall, Room 808 |

**Questions**

There will be no set office hours, but you can make an appointment anytime. Please schedule appointments with Michael and me at least 24 hours in advance.

**Materials**

There will be no textbook.

You will need Matlab. If you have a laptop, please install Matlab before the course starts (instructions: http://www.cns.nyu.edu/~eero/math-tools/Handouts/matlab-installation.txt).

**Grading**

The total grade will be calculated as follows:

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

*Letter grade*
Numerical grades will be mapped to letter grades as follows:

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| A | 95-100 | C+ | 77-80 | F | 0-60 |
| A- | 90-95 | C | 73-77 | | |
| B+ | 87-90 | C- | 70-73 | | |
| B | 83-87 | D+ | 65-70 | | |
| B- | 80-83 | D | 60-65 | | |

*Homework*

- The best 10 out of 12 homework sets will be counted. If you submitted fewer than 10 sets, the missing ones will count as having a grade of 0. If you have medical reasons for submitting fewer than 10 sets, a doctor's note is required; the instructors will judge each case individually.
- Homework is due at the start of class to Michael. Late homework will not be accepted and will be graded as 0. Homework must be typed. Handwritten homework will not be accepted.
- Collaboration on homework is permitted, but joint submissions or copying each other's work are not and will result in a grade of 0. Collaboration means that you discuss the ideas and approach together, but each write up your own solutions. It is easy for an instructor to tell the difference between collaboration and plagiarism.

*Participation*

- Attendance is mandatory. Your participation grade will be based on attendance, as well as on participation during lecture and recitation.
- To request an excused absence, please email Michael and Wei Ji in advance.

**Schedule**

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| Week 1 | | **Types of data** in neuroscience. Experimental design. What is noise? Sources of noise; hidden variables. How to plot data. The dangers of data reduction (pooling, binning, smoothing, …).**Matlab primer Part 1.** |
| Week 2 | HW 1 due | **Univariate probability distributions.** Mean, median, mode, variance, standard deviation, quantiles. The normal distribution. The Poisson distribution. Other distributions. **Matlab primer Part 2.** |
| Week 3 | HW 2 due | **Estimation with simple distributions.** Maximum-likelihood estimation. Estimating the mean of a normal distribution. Standard error of the mean. Estimating the rate of a Poisson distribution. V1 neuron (Movshon) |
| Week 4 | HW 3 due | **Covariance and correlation.** Estimating a correlation. Meaningless correlations. Sources of correlations. Correlation and causation. |
| Week 5 | HW 4 due | **Linear regression.** Ordinary least squares. Goodness of fit. Confidence on coefficients. Relation with correlation. Extensions of linear regression. |
| Week 6 | HW 5 due | **Hypothesis and significance testing.** Type I and Type II errors. Derivation of the one-sample t-test.<br>**The t-test.** Calculating significance. Two-sample t-test. Applications. Significance in linear regression. Implications of violating the assumptions. Error bars and significance. Effect size, power, multiple comparisons. Memory persistence versus PKMζ (Fenton). |
| Week 7 | HW 6 due | **The z-test for proportions.** Freezing in different conditioning conditions (LeDoux).<br>**Inferential statistics for non-normal variables.** Non-parametric tests. Wilcoxon signed-rank test. Fano factor of a V1 neuron (Movshon). Kolmogorov-Smirnov test. |
| Week 8 | Midterm | |
| Week 9 | HW 7 due | **ANOVA.** Random versus fixed effects. Implications of violating the assumptions. Gene expression (LeDoux). Response to reward of hippocampal neurons (Suzuki). Choice probability in V1 neurons (Movshon).<br>What to do when your variable is binary? **Logistic regression.** Spatial resolution versus eccentricity (Carrasco). |
| Week 10 | HW 8 due | **Resampling methods.** Bootstrap. Permutation test.<br>**Problems with hypothesis testing.** |
| Week 11 | HW 9 due | **Model fitting.** Fitting a psychometric curve. Line length discrimination (Ma). Fitting a V1 tuning curve (Shapley). |
| Week 12 | HW 10 due | **Model comparison.** The problem of overfitting. Occam's razor. AIC. Cross-validation. Spatial tuning in OFC (Glimcher). Lapse rate in psychophysics (Ma). |

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| Week 13 | HW 11 due | **Fourier analysis.** EEG in response to an alternating stimulus (Kiorpes). Spectrogram. LFP in premotor cortex (Pesaran). Birdsong (Long). |
| Week 14 | HW 12 due | **Clustering and spike sorting.** K-means. PCA. |
| Exam week | Final | |

Labs will be asked for permission to use their data sets.