Syllabus for BIOL 485/PHYS 741R: Measuring and Modeling Animal Behavior (Fall 2017)

Course Information:

Meeting Time: MW 2:30pm - 3:45pm  
Room: 113 Dental School Building (1462 Clifton Road)  
Instructor: Dr. Gordon Berman, Assistant Professor of Biology  
Office: 2107 Rollins Research Center  
Email: gordon.berman@emory.edu (the best way to contact me). Please put [Behavior] in the subject line so that I can prioritize class-related emails.  
Office Hours: By appointment

Goals:

My aim is to provide a broad survey of the experimental, data analytical, and theoretical techniques in quantitative animal behavior. This will be done through engaging with the primary literature, completion of an end-of-semester project, and (for the graduate student enrollees) approximately bi-weekly computational/analytical assignments. It should be noted that this course is not aimed to be a survey of the specifics and mechanisms of how animals behave – as would be done in a standard introduction to ethology or behavioral neuroscience genetics course. That’s not to say that we won’t learn some interesting things about behavior along the way, but instead, our focus will be on understanding the methods that researchers use to quantitatively probe animal behavior, keeping in mind three basic, fundamentally intertwined, questions:

1. What are the best quantities to measure for assessing the underlying behavioral questions?  
2. How can these quantities be accurately measured?  
3. What type of models can best lead to theoretical understanding of the data?

Themes:

1. Defining Behavior  
2. Measuring Behavior  
3. Latent States and Patterns  
4. Collective and Social Behavior  
5. Locomotion and Control  
6. Behavioral Neuroscience  
7. Behavioral Genetics

Course meetings and Quizzes:

After the first three meetings (where I will give an introduction and the lead the first two paper discussions), subsequent classes will be lead by individual students, who will present and discuss papers related to the themes enumerated below. The schedule of papers is listed at the end of this document and students should sign-up for presentation slots online before the second course meeting of the semester via a survey on Canvas. All papers will be posted on the course Canvas site. At least 36 hours prior to every class (excepting the first), I will post a brief quiz/questionnaire onto Canvas about the next papers to be discussed, with questions about previous readings potentially alongside. Answers to these questions are due on Canvas before noon of the day of every class meeting. There will also be a box to post any questions and comments or topics about the reading that you would like to discuss, contributions to which will be considered part of your participation grade. Students presenting should send me any notes/slides they
used for their paper presentations, as these materials will be used in evaluating the presentations and will be distributed to the class as a resource.

**Homework**

For graduate enrollees, homework assignments will be due approximately bi-weekly (5 or 6 over the semester). Assignments will be related to the papers we have discussed in class and will consist of computational and analytical exercises. For computational problems, I am agnostic as to the choice of programming language, although I imagine that python, Matlab, Mathematica, and/or C/C++ will prove the most useful. Group work is encouraged, but I ask that all collaborators’ names be listed on the final document and that each individual writes their own solutions and code.

**Final Project**

A final project will also be required of all enrollees, due before 11:59pm on Friday, December 8th. This project can take one of three forms: (1) A detailed grant-proposal-like document that outlines a set of specific experiments or models to undertake, (2) A detailed review article describing and synthesizing progress and future directions within a particular field, or (3) A computational, theoretical, or data-analytical project related to the themes of the course. Graduate enrollees are particularly encouraged to choose option (3) and to incorporate their own research, if possible. Additional papers related to the discussed topics in this course will be posted in Canvas for inspiration.

Paragraph-long project proposals will be due by the beginning of class on October 11th and project outlines will be due on November 8th. All projects must be pre-approved by the instructor.

If choosing option (1), the proposal must include sections detailing the necessary scientific background, the overarching goals and significance of the proposed research, a set of proposed experiments/analyses/modeling projects, potential pitfalls and problems, necessary resources, and a projected timeline for the work.

For option (2), the review should encompass a relatively large swath of behavioral research (e.g. “Using perturbations to study sensorimotor learning” or “Methods for unsupervised learning of behavioral dynamics”). The general standard for an ‘A’ project is that a first year Ph.D. student should be able to read the review and be immediately up to the state of the art in the field you have decided to write about.

For option (3), my expectation for the project is that it will either be an application of an method/model/technique we have discussed to a previously unexamined system or a replication of an existing work, with some extension added-on. This could be adding another term to a model or analyzing a different parameter regime, applying another analysis to the same data set, or a variety of other options. Deeper extensions will be expected of graduate students’ projects than will be expected for undergraduates.

One last potential option is for the class to engage in a team project, with the goal of producing an original research output by the end of the semester. This can be discussed as the semester progresses, and all of the same due-dates would apply. All students are responsible for listing their independent contributions to the project.

All projects will be presented during the final two sessions. The presentation will be approximately 15% of the overall project grade. Further details will be provided closer to the first due date.

**Evaluation:**

Undergraduate Students: 25% paper presentations, 15% quizzes, 45% final project, and 15% course participation.

Graduate Students: 20% paper presentations, 10% quizzes, 30% homework assignments, 30% final project, and 10% course participation.

The participation grade will be assessed through a combination of attendance, participation in discussions, and submitted discussion questions/comments.

**Absences:**

Because course participation is a significant portion of the grade, attendance will be noted. Please discuss with me if you need to miss a class for whatever reason. Pre-excused absences can be made-up through handing in written notes of the papers to be discussed.
Honor code:

The Emory College Honor code applies to all work in this class.

Tentative Schedule

8/23: Introduction

8/28: Defining Behavior: Ethology

Discussion Papers:

8/30: Defining Behavior: Quantifying Behavior

Discussion Papers:

9/6: Defining Behavior: Behavior and Mechanisms

Discussion Papers:

9/11: Measuring Behavior: Image Analysis

Discussion Papers:

9/13: Measuring Behavior: Center of Mass Tracking

Discussion Papers:

9/18: Measuring Behavior: Limb Tracking

Discussion Papers:
9/20: Measuring Behavior: Supervised Analysis

Discussion Papers:

9/25: Measuring Behavior: Unsupervised Analysis

Discussion Papers:

9/27: Measuring Behavior: Unsupervised Analysis

Discussion Papers:

10/2: Latent States and Patterns: Patterns of behavior

Discussion Papers:

10/4: Latent States and Patterns: Hierarchical Structure

Discussion Papers:

10/11: Latent States and Patterns: Time Scales & Predictability

Discussion Papers:

10/16: Locomotion and Control: Legged Locomotion

Discussion Papers:
10/18: Locomotion and Control: Flight Maneuvers

**Discussion Papers:**
- Ristroph, L. et al. Discovering the flight autostabilizer of fruit flies by inducing aerial stumbles. PNAS. 107, 4820-4824 (2010).

10/23: Locomotion and Control: Robotic Models

**Discussion Papers:**

10/25: Collective and Social Behavior: Flocking

**Discussion Papers:**

10/30: Collective and Social Behavior: Social Interactions

**Discussion Papers:**

11/1: Collective and Social Behavior: Collective Decision Making

**Discussion Papers:**

11/6: Behavioral Neuroscience: Adaptation & Control

**Discussion Papers:**

11/8: Behavioral Neuroscience: Multi-sensory Integration

**Discussion Papers:**
11/13: Behavioral Neuroscience: Reinforcement Learning

Discussion Papers:
- Desrochers, T. M. et al. Optimal habits can develop spontaneously through sensitivity to local cost. PNASi. 107, 20512-20517 (2010).

11/15: Behavioral Neuroscience: Neurons + Behavior

Discussion Papers:

11/20: Behavioral Genetics: Phenotyping

Discussion Papers:

11/22: Project Workshop

11/27: Behavioral Genetics: Individuality

Discussion Papers:

11/29: Project Presentations

12/4: Project Presentations