Q: Why learn about experimental design?

A: Experimenting is at the root of the philosophy of science. Science has two stages: the planning stage, in which we deduce the underlying rules of the universe from previous ones and make further predictions from it, and the inference stage, in which we observe the world through our senses and attempt to reject our prior beliefs about those rules. Experiments are the glue that holds these two stages together, because they force us not only to consider our own understanding of the world and attempt to form models of it, but they also press us to consciously imagine and create unique situations in which we can test those beliefs.

Q: What makes a good experiment?

A: Experiments are consciously designed for a specific purpose: to test a theory, to refine a parameter, to test the function of equipment, or to describe a causal relationship. The best experiments do so in ways that stand up to scrutiny and criticism of fellow scientists.

Q: What makes a bad experiment?

A: Bad experiments fail the above criterion: they fail to produce conclusions that fulfill their purpose. This can happen for any number of a long list of reasons, at any stage in the experiment. For example, they can fail from the very beginning by not being related to the stated purpose or theory (that is, they have no internal validity). It could fail in the middle by using a method that introduces bias in the collected data, thereby leading to results that can mislead scientists attempting to make inferences from them. It could use methods with too low precision for the desired effect size, and thereby end in a null result. The results could be unreliable. Any of these mistakes can lead to a rejection of your conclusions by your peers. This course’s purpose is to make you aware of ways in which your experiment can fail, so that you may carefully design one that stands up to scrutiny and criticism. Along the way, I’ll provide some tools and guidelines to help you accomplish this task.

Lecture: Noise

* Precision as a concept
* Effect Size, Signal-to-Noise Ratio,
* General Overview of Descriptive and Inferential Statistics
* Tool: A-Priori Power Analysis in GPower software

Lecture: Reliability and Validity

Lecture: Confounds and Artifacts

* Independent and Dependent Variables (and Observational Variables)
* IV Problem: Confounds
* Solution to Confounds: Control Conditions and Control Variables
* DV Problem: Artifacts
* Precision vs Accuracy
* Sources of Artifacts
* Artifact Avoidance vs Artifact Rejection vs Artifact Correction
* Tool: Experiment Mapping

Lecture: Standard Experiment Designs

* Pitfalls of Historical Data
* Correlation and Causation
* Artifcacts brought about by Experiment Design and Sampling
  + Carry-Over Effect
  + Placebo Effect
* Special Topic: Within-Subject vs Between-Subject Designs
* Example Experiment Designs:
  + Treatment-Reversal Design
  + ABA Design
  + Latin Squares
  + Block Design
  + Etc