Course Syllabus

Applied Psychophysics using Python and R
7.5 credits, fall semester 2017
Applied Psychophysics using Python and R

Psychophysical methods are used for determining the relationship between physical stimuli and their subjective or behavioral correlates. The methods can be applied to sensory systems (e.g., hearing, vision) as well as to higher cognitive functions (e.g., attention, memory). Psychophysics is a subdivision of psychology. However, knowledge and know-how in psychophysical methods is a sought after competence in many research fields, including neuroscience, medicine (e.g., audiology, ophtamology), and physics (e.g., acoustics, optics). The course has a strong focus on the practical side of psychophysics: How to get your experiment up and running by writing programs in Python, and how to analyze the data in R. This means that the course is suitable for any student that wants to acquire practical skills for measuring human perception and performance.

Course coordinator
Mats E. Nilsson, Department of Psychology, Stockholm University
E-mail: mats.nilsson@psychology.su.se

Learning outcomes

Upon successfully completing the course, you will have improved your ability to

1. … understand and contribute to theoretical and practical discussions on threshold estimation;
2. … understand and contribute to theoretical and practical discussions on signal detection theory;
3. … conduct psychophysical experiments, including selection of method, experimental design, computerized data collection, data analyzes and presentation of results in text, tables and figures;
4. … write programs in Python and R, and do some basic shell scripting.

Content

The course will focus on:

(a) Key concepts and distinctions (e.g., forced choice, detection vs. discrimination, appearance vs. performance, etc.) needed for understanding how different psychophysical methods relate to each other and when to use one method rather than another.

(b) Properties of the psychometric function, parametric methods for estimating the parameters of the function, and non-parametric methods for estimating a specific point along the function.

(c) Signal detection theory.

Course activities

The main activity is to set up two psychophysical experiments using the programming language Python (version 2) and its library Psychopy, developed for programming psychological experiments. In Psychopy, it is possible to create experiments either in Builder mode, a graphical interface similar to E-prime, or in Script mode, by writing plain code as for any other Python application. This course will use Psychopy in Script mode. You will write code for two experiments as part of the course requirements, one obligatory task common to all course participants (problem provided at the first seminar) and one of your own choice.

You will run your experiments on (at least) one participant and then analyze the data using R (or Python). Python is a general-purpose programming language; any experiment you can think of can be developed in this language. R is a domain-specific language that has become the lingua franca of statistical science, and is used increasingly in behavioral science. Several libraries exist that are helpful for analyzing psychophysical data, e.g., estimating parameters of psychometric functions using maximum likelihood estimation. Examples are provided in Knoblauch & Maloney, (2012; Chs. 3-5); other examples can easily be found on the web. Some course
participants may prefer to do the data analysis in Python, to keep the whole experiment in one environment. For example, printing the results directly after the participants have completed the experiment. This is of course perfectly fine; students fluent in R but new to Python, may want to do everything in Python to improve their Python skills.

Note that Kingdom & Prins (2016) presents code written in Matlab, whereas this course will use Python (for running experiments) and R (for data analysis). A learning activity of the course is therefore to implement in Python or R methods that Kingdom & Prins implemented in Matlab.

Signal detection theory is a corner stone of psychophysics, and it is important to obtain a solid understanding of its main assumptions and implications. For this purpose, simulations of signal detection theory will be conducted using Python or R. Chapter 3 of Knoblauch & Maloney provides inspiration for these simulations.

Seminars

The first seminar gives a general introduction to psychophysics; its history and current state of affairs. It will also exemplify one approach to running experiments using Python and Shell scripting (cf. Shaw, 2011), and give some examples of how to analyze psychophysical data using R.

The following seminars are divided in three parts. The first part covers fundamentals of psychophysics, e.g., key concepts and classification of methods. The second part is devoted to python coding on the common research problem. It is highly recommended that you bring your own laptop to the seminars and try out code as it is discussed. The third part is open to discussions of the student's own experiments, e.g., selection of method, python coding, approaches to data analysis, etc.

Examination

The examination comprises three parts: Two lab-reports and one R-function, to be submitted to the course leader no later than 1 month after the last seminar.

1-2. One lab-report on the experiment addressing a specific research problem (common to all participants), the other on the experiment that addresses a problem of your own choice. The reports should look like a short report (or letter) to a journal, with the addition that you have to append all code for running the experiment and all code for the data analysis. (An example of a lab-report will be provided at the start of the course.)

3. One R-function. The function should illustrate the basic principles of signal detection theory. Arguments: proportion hits and false alarms, and form of the underlying distributions. Output: iso-sensitivity curve in ROC diagram, and values of sensitivity index \(d'\) and response criterion \(c\).

Grade and grade criteria

Grades: Pass or Fail.

Pass: All three examination parts have been submitted and they have been assessed as being of sufficient quality by the course leader. Sufficient quality means that (a) the two lab-reports are complete and read like a manuscript that might be accepted as a letter to a journal, and (b) the R-function works properly.

Fail: If not Pass. There will be room for revisions of the lab-reports and the R-script to reach sufficient quality for passing the course, up to two months after the final seminar.
Literature


Psychopy website: [www.psychopy.org](http://www.psychopy.org)

Kingdom & Prins (2016) covers key concepts and distinctions (Chs. 1 – 3), the psychometric function (Ch. 4) and adaptive methods for estimating thresholds (Ch. 5). Statistical methods for estimating parameters of the psychometric function in R are presented in Knoblauch & Maloney, 2012 (Chs. 4 and 5). Signal detection theory is described in Chapter 6 of Kingdom & Prins. It is a short chapter, but we will discuss it thoroughly to make sure that everyone fully understands its main assumptions and implications. The general strategy of running Python using the Shell is described in the Appendix of Shaw (2011); the main part of this book is for self studies. Psychopy’s website is a valuable resource with plenty of code examples and a reference manual for all Psychopy functions.