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Performance Evaluation

Rapid Introduction

The purpose of plotting scientific data is to show relationships between variables or visualize variation, but not all data sets require a plot. If there are only one or two points, it is easy to examine the numbers directly, and little or nothing is gained by putting them on a graph. Similarly, if there is no variation in the data, it is easy enough to see or state the fact without using a graph of any sort. This document provides several steps to plot graphs that might be used in understanding or presenting data.

To start with, we obtained the data by the following experiment.

1. Subjects performed a two-alternative forced-choice frequency discrimination task. They discriminated between the frequency of two vibrotactile stimuli (f_1 and f_2) applied sequentially to the left index finger.
2. Data Storage (Click!)
3. Column Headers
   (a) Block
   (b) Trial
   (c) f_1 (Hz)
   (d) A first interstimulus interval(often abbreviated as ISI) time (sec)
   (e) f_2 (Hz)
   (f) A second ISI time (sec)
   (g) **Subject's decision.** 'before' means that they chose (c), 'after' means (e), and 'NaN' means that they didn't make a decision.
   (h) A time taken to make a decision (sec)
   (i) A third ISI time (sec)

A set of steps to analyze data

Comments with each step are intended to help you understand. Fortunately, you can use any computer language to follow the procedure. (e.g. python, MATLAB, R, etc.)

1. A psychometric function is about relation between human performance (e.g., classification) on a psychophysical task and sensory inputs (e.g., stimulus intensity). In this case, it shows the probability of 'higher' response as a function of the comparison stimulus f.
   Plot the dots represent each comparative stimulus like **Figure 1**.

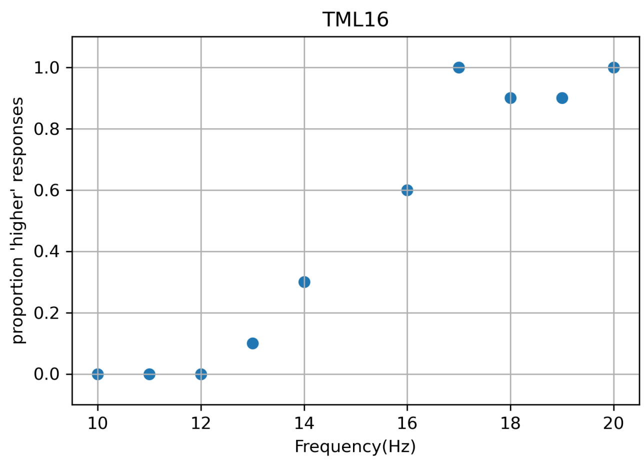


Figure 1: An example of estimation of a subject 'TML16'. Filled circles are data which are based on 10 trials at each stimulus level.

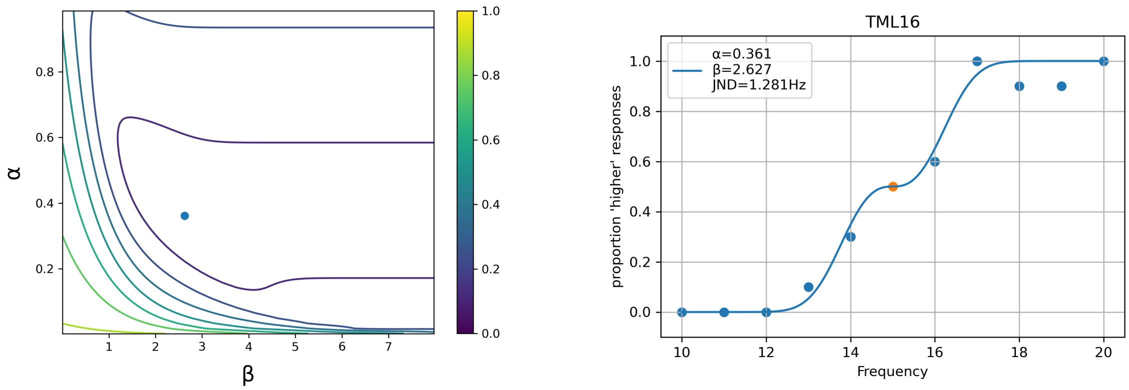
2. Given a set of data (x_i, y_i), a major task of the experimentalist is to fit them into a model, i.e. find parameters a, b, c, ... such that $f(x; a, b, c, ...)$ best describes the data. In this case, we can use the Weibull cumulative distribution function (CDF) to estimate the optimum fitting curve :

$$f(x;\alpha,\beta) = \begin{cases} g\exp\left(-\alpha(-x)^{\beta}\right) & \text{if } x < 0 \\ g & \text{if } x = 0 \\ 1-(1-g)\exp\left(-\alpha x^{\beta}\right) & \text{if } x > 0 \end{cases}$$

   where $\alpha > 0$, $\beta > 0$ are parameters of the CDF, x is the difference between two stimuli, i.e. $x = f - 15$, and $g = 0.5$ is a chance level of two-alternative forced choice (2AFC). Then we should find the best set of parameters which minimize the difference between the model and the data :

$$\chi^2 = \sum_{i=1}^{N} \{f(x_i;\alpha,\beta) - y_i\}^2$$

   The function χ^2 is the sum of the square of residual; choosing wisely α, β means finding the point (α^*, β^*) which minimizes χ^2.
   Plot a contour line of χ^2 on the parameter space (α, β) like **Figure 2-(a)**.



(a) **(b)**

Figure 2: An example of estimation of the optimum fitting curve. **(a)** A contour plot of $\log \chi^2$. The blue point (α^*, β^*) is an optimal parameter pair which minimize the χ^2. **(b)** The solid line is the expected $f(x; \alpha^*, \beta^*)$, blue circles are data, and a red circle is the point of subjective equality (PSE). We can easily obtained just noticeable difference (JND) whereas PSE is 15Hz. Notice, the JND is defined by the difference between thresholds $P = 0.5$ and $P = 0.75$, so JND $= (\frac{1}{\alpha} \log 2)^{1/\beta}$. that is, when the slope α becomes steeper, the JND becomes smaller.

3. Finally, we found computer-generated best-fit line to demonstrate agreement with the model. The next step is to see if the distribution of data follows the expected function $f(x; \alpha, \beta)$; see **Figure 2-(b)**.

   Show the validity of the results in the same plane and calculate a just noticeable difference (JND) :

$$\mathrm{JND} = (\frac{1}{\alpha} \log 2)^{1/\beta}$$