Tutorial on psychophysics

Tutorial 1: Estimation of Psychometric function

Dataset: psychophysics.xls, tab: psychometric function

Data are from one study of visual Ternus apparent motion. Ternus apparent motion (or Ternus illusion) was first discovered by Josef Ternus in 1926. Using two frames of multiple dots, when overlaid, share one or several common dots at the center. Depending on the spatial configuration and inter-stimulus-interval (ISI), two distinct motion percepts are usually observed: 'element motion' (outer dots flip) and 'group motion' (all dots shift together). Short ISIs usually give rise to the percept of 'element motion', while long ISIs give rise to the perception 'group motion'. A great interactive demo can be found in Michael Bach's visual illusion website: Pikler-Ternus Display demonstration.

The data contain two columns: inter-stimulus SOAs (ms) and responses. In the column of 'responses', 0 presents the percept of 'element motion' and 1 for the percept of 'group motion'.

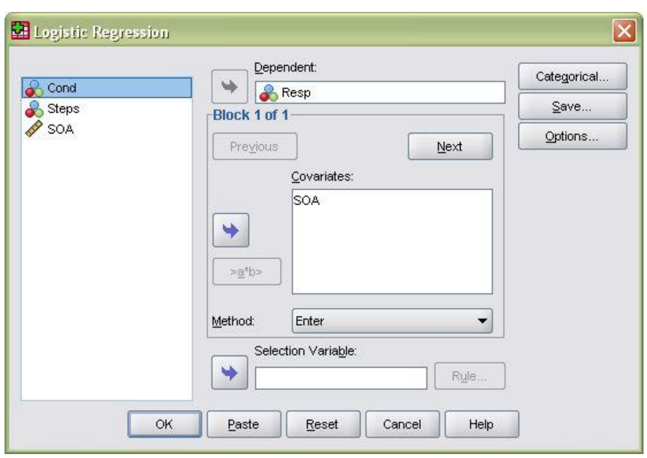
The **tasks** are: i) to estimate the psychometric curve (using logistic function) from the data, and then ii) to estimate the transition threshold from the 'element motion' to the 'group motion'.

There are several ways to estimate this. I would recommend using binary logistic regression via SPSS. Here are some details of estimations:

1. SPSS uses the following equation in the binary logistic regression:

$$\log \frac{p}{1-p} = a + bx$$

2. Input Response as dependent variable and SOA as independent (covariate) in the logistic regression (under the menu: Regression -> Binary logistic regression:



3. Then you will get estimations of 'constant' **a** and slope **b** from the table below ('B' column)

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	SOA	.042	.004	100.403	1	.000	1.043
	Constant	-5.344	.582	84.237	1	.000	.005

4. Replace the above estimated **a** and **b** in the aforementioned equation, you will have the estimated psychometric function.
5. The second step is to estimate the transition threshold between the 'element motion' and the 'group motion'. The transition threshold is defined at point of p=0.5 , thus the threshold will be calculated as

$$p = 0.5 \quad \mathrm{SOA} = -\frac{a}{b}$$

Tutorial 2: Signal detection (Estimation of accuracy Az and Response bias Ca)

Dataset: psychophysics.xls, tab: Signal detection

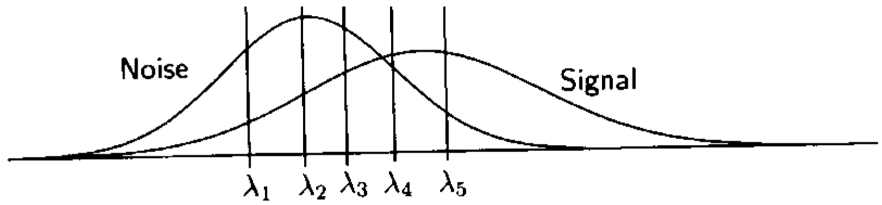
The dataset is from a study of visual masking experiment. There are two conditions: target present or absent, followed quickly by a backward mask. Participants were asked to rate how confidence they saw the target. They could give 5 rating scales: Sure of target absent, possible target absent, not sure, target possible present, and target present for sure (1-5). The data marked with blue (in the excel file) were average proportions from one participant.

Tasks:

1. Plot ROC curve for this dataset.
2. Estimate Dorfman accuracy index Az and Response bias Ca

Here are some steps to do this tutorial:

1. Plotting ROC curve is easy: simply plot Hit rates against FA rates. If they are transformed to z-scores and plotted again, they should roughly be linear. If signal and noise have the same variance, the slope of the transformed data should be close to 1.
2. Second step is to calculate the Az and Ca. Since these data were from multiple scale confidence ratings, we need to calculate Hit and FA rates multiple times. Regard each response as one level of criteria (see below figure as an illustration), accumulating those response proportions together we can get different level of Hit and FA rates (e.g. accumulating responses 'absent' and 'possible absent' together).



3. These multiple levels of Hit and FA rates indicate the shift of criteria (or confidences). Using these we can estimate the sensitivity and response bias in the next step. Note that normal d' and C are based on equal variance assumption (signal and noise have the same variance). In real data we don't know if the noise and signal have the same variance or not. So we have to use adjusted d-prime or Dorfman accuracy index Az to measure the sensitity, and to use Ca to measure response bias.
4. Az and Ca are calculated using the following equations:

$$A_z = \Phi\left[\frac{a}{\sqrt{1+b^2}}\right]$$

$$C_a = -\frac{\sqrt{2}\cdot b}{\sqrt{(1+b^2)}\cdot(1+b)}\cdot\left[z(H)+z(F)\right]$$

where **a** and **b** are the estimations of intercept and slope from the linear regression of z-transformed data. Note that b would be 1 if the signal and noise have the same variance. In this situation, Ca will become normal C, i.e. (z(H)+z(F))/2.

5. Estimation of **a** and **b** can be done by linear regression in SPSS. You should get similar results as follows:

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.595	.079		7.489	.005
	zfa	.820	.051	.994	15.967	.001

a. Dependent Variable: zhit

a = 0.595; b = 0.820

6. Using above estimated a and b, Az can be easily calculated. Note for Ca, you need to know the specific level of Hit and FA rates, since Ca depends on the level of confidence.