Key Note

# Chapter 2: Research methods in perception

## Key note 2A: Operation of a staircase procedure

The aim of this note is to show you how an adaptive psychophysical procedure can home in on a sensory threshold. The procedure is a simple staircase, but the method captures many of the benefits of more complex procedures.

A staircase procedure can be a very effective way to find a threshold. Figure 1 shows successive stimulus values in a hypothetical experiment, in which the experimenter is measuring how bright a visual stimulus (a small homogeneous patch) has to be to be detected on a bright background. The values on the *y*-axis are the luminance values of the small patch which the computer sends to the monitor displaying the stimuli. The luminance of the background is held constant at say 120units, and the threshold to be measured is say 125 units (5 units greater than the background luminance, as shown by the horizontal orange line in Figure 1).

**Figure 1** Data from a hypothetical experiment measuring a luminance increment threshold with a staircase procedure.

The rules governing the procedure are as follows:

Initial stimulus value = 250

Initial step size = 50

Change stimulus level using 2 down, 1 up rule (see Chapter 2 in the book for a description of this rule)

After 4 reversals, reduce step size to 10

Stop the procedure after 11 reversals

Calculate threshold as the mean of the stimulus values at which the last 6 reversals occurred.

On Trials 1 and 2, the participant reports that she can detect the luminance increment, so stimulus level is reduced by the step size 50 to 200. Similarly, stimulus level is reduced to 150, following detection on Trials 3 and 4, and to 100 after Trials 5 and 6. This value is below increment threshold, but the participant reports in error on Trial 7 that she can detect it, so the same stimulus value is presented on Trial 8 when she says that she cannot detect it. On Trial 9 stimulus level is raised by the step size to 150. Because the previous change of stimulus level was a decrement (after Trial 6), and this is an increment, the change constitutes a reversal. On Trials 9 and 10, detection is reported, so after Trial 10, stimulus level is reduced to 100, so this is a second reversal, since the previous change (after Trial 9) was an increment. Further reversals occur after Trials 11 and 13. The reversal after Trial 13 is the fourth, and so the rule which reduces step size to 10 units is triggered.

After Trials 14 and 15, and again after Trials 16 and 17, stimulus level is reduced by the new step size of 10 units, so that it is now below threshold at 120 units. On Trial 18, the participant reports that she cannot see the patch so, for Trial 19, it is incremented by 10 units, leading to detection on Trials 19 and 20, and a decrement for Trial 21. The oscillation about threshold continues until Trial 28, which does not take place because the change between Trials 27 and 28 is the 11th reversal, and so the end of the procedure.

The computer then calculates the mean value at which the last 6 reversals occurred as follows:

|  |  |
| --- | --- |
| Reversal after | Stimulus level |
| Trial 20 | 130 |
| Trial 21 | 120 |
| Trial 23 | 130 |
| Trial 24 | 120 |
| Trial 26 | 130 |
| Trial 27 | 120 |
| **Mean** | **125** |

This is not a sophisticated procedure: step size is changed only once, and no attempt is made to calculate a psychometric function. Nevertheless, it illustrates several benefits of adaptive procedures. The experimenter can start with a high stimulus level, which it is almost certain that the participant will detect, and which shows the participant what a detectable stimulus should look like. The large initial step size rapidly brings stimulus level close to threshold, as indicated by the first few reversals, whereupon step size is greatly reduced, so that the size of the oscillations of stimulus level about threshold is small, and so the accuracy of the mean calculated from stimulus levels over the last few reversals is likely to be high.

Two variations on this simple procedure (as found for example in PEST – Taylor and Creelman, 1967) are to reduce step size progressively as reversals occur (rather than in one large step as here), and to vary the stopping rule. In PEST, one criterion for stopping is when step size falls to some previously determined small value.

Taylor MM, Creelman CD (1967) PEST: efficient estimates on probability functions. *Journal of the Acoustical Society of America* 41(4): 782–787