Adaptive Psychophysical Methods

Outline

- **Simple Up-Down Method (also known as Staircase Method)**
- **Transformed Up-Down Methods**
  - **Overview**
  - **The 3-interval 1-up 3-down Method**
- **Interleaved Adaptive Methods**
  - **Double-Random Staircase (i.e., interleaved simple up-down method)**
  - **Interleaved 3I 1-up 3-down method**

What Do We Mean by “Adaptive”?

- **The stimulus intensity level on any one trial is determined by the preceding stimuli and responses**

- ***Do we already know any adaptive method?***

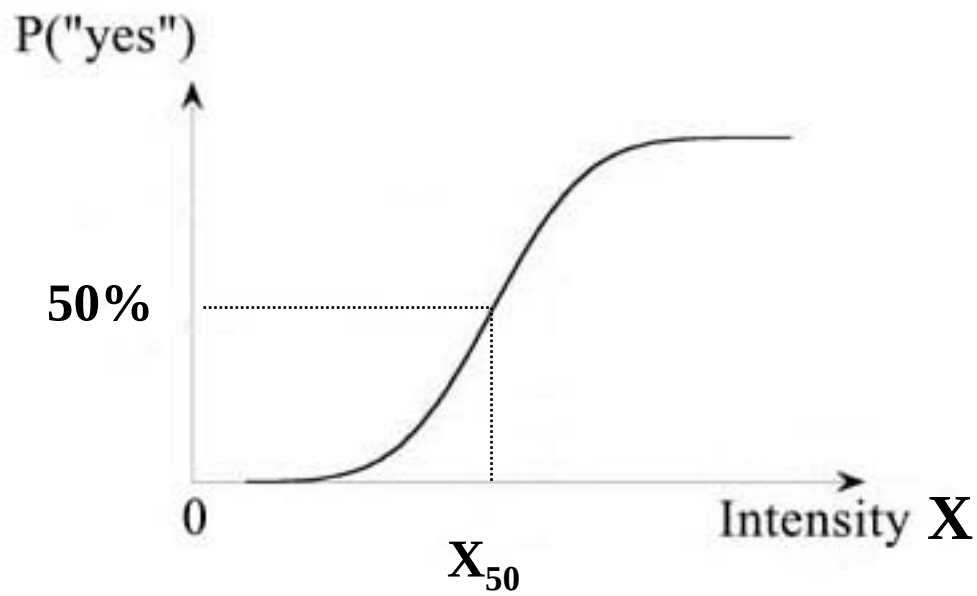
Why Adaptive Method?

- **Compared with other methods (e.g., constant stimuli, signal detection), adaptive method places most of the stimuli at intensity levels close to the threshold that is being measured**
- **Adaptive method allows for more *efficient* estimation of thresholds**

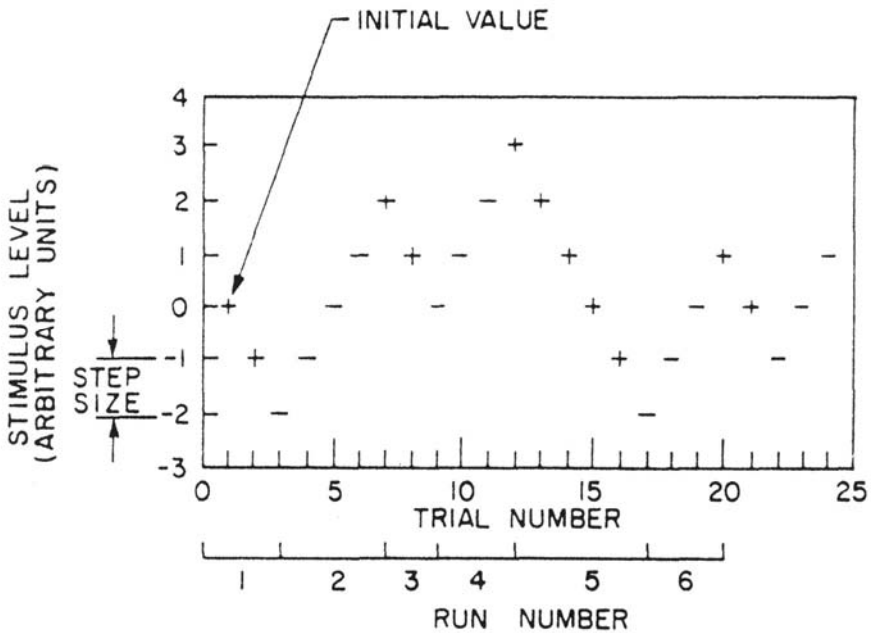
Simple Up-Down Method (Staircase Method)

- **Adaptive methods reduce the number of trials at the stimulus intensity levels at which the proportion of responses YES is close to zero or close to one.**
- **Staircase method is analogous to the method of limits, *except that***
  - **an ascending (descending) sequence does not terminate after the first reversal from NO to YES (YES to NO) response.**
  - **Instead, the experiment continues until many reversals are obtained around the value to be estimated.**

- **Staircase method estimates the 50% point of the psychometric function.**



Data Analysis (Staircase Method)



- The concept of *initial value*, *step size*, *run*
- Estimate of X_{50}: midpoint of every 2nd run; or equivalently, average of peak-valley pairs.

Discussion of the Simple Up-Down (Staircase) Method

- **Advantage**
  - **Most stimulus intensity levels are placed around X_{50}**
- **Disadvantage**
  - **Difficulty with steps that are too small (takes forever) or too large (low precision)**
  - **Can't estimate levels other than X_{50}**
    - **Solution: Transformed Up-Down Methods (see also 10/18/05)**
  - **Subject can anticipate the stimuli and adjust responses accordingly**
    - **Solution: Double-Random Staircase Method (see 10/18/05)**

Adaptive Step Size

- At the start of an experiment, a large step size is used
- The step size is gradually decreased during the course of the experiment
  - Robbins and Monroe (1951): c/n (c: constant, n: trial number)
  - Half the step size after a fixed number of trials
- When in doubt, aim at a larger initial step size
  - Efficiency is reduced by 25% if initial step is twice the optimum value
  - Efficiency is reduced by 100% if initial step is half the optimum value.

Transformed Up-Down Methods

- **Transformed methods are used to estimate percentile points other than 50%. The stimulus level is increased or decreased after specific sequences of stimuli and responses.**

Comparing the Simple and Two Transformed Up-Down Methods

	Simple	Transformed (70.7% percentile) 1-up 2-down	Transformed (84.1 percentile) 1-up 4-down
Increase Level after	–	+ – or –	+ + + – or + + – or + – or –
Decrease level after	+	+ +	+ + + +
P(UP)=P(DOWN)=.5	P(X)	$[P(X)]^2$	$[P(X)]^4$
P(X)	0.5	0.707	0.841

References

- Macmillan, N. A., & Creelman, C. D. (2004). *Detection Theory: A User's Guide* (2nd ed.). New York: Lawrence Erlbaum Associates.