19.2 EXPERIMENTS WITH REPEATED MEASUREMENTS

Many experiments in psychology and education require the repeated measurement of the same subjects under a number of different conditions or treatments. Such experiments may be single-factor experiments in which each subject is tested or measured under a number of different experimental conditions. The simplest experiment of this kind would be one in which the same subjects are tested under two experimental conditions. Sometimes, when the same subjects are tested under a number of different treatments, the order of the presentation of treatments to subjects is randomized independently for each subject or a systematic plan for the ordering of the presentation of treatments to subjects is adopted. The purpose of either randomization, or the use of a systematic plan for the ordering of treatments, is to eliminate effects which might result from the order of the treatments. In some situations randomization is not appropriate because the different levels of the treatment variable have a natural order. This is the case where performance is measured at different time intervals, as, for example, in the study of changes in dark adaptation with time, or for different numbers of trials in a simple learning experiment.

Experiments of the type described above are called *one-factor experiments with repeated measurements.* In such experiments N subjects are measured under k conditions or treatments. The matrix of data thus obtained is a table of numbers containing N rows and k columns.

Repeated measurements may, however, be used in two-way classification or higher-order factorial experiments. For example, in a 2×2 factorial experiment four treatment combinations exist, four groups of experimental subjects are used, and each combination is applied to a different group of subjects. Experiments may be designed in which each of the N subjects receives all four treatment combinations. The matrix of data is a block of numbers containing two rows, two columns, and N layers, each layer corresponding to a subject. In general, for an $R \times C$ factorial experiment with repeated measurements the matrix of data is an $R \times C \times N$ block of numbers. The idea involved here can be extended to higher-order factorial experiments.

Two-way classification experiments may also be conducted with repeated measurements over one factor but not over the other factor. Consider an experiment involving two factors with three levels of one factor and two levels of the other. If this were an independent-groups factorial experiment, six treatment combinations and six groups of subjects would be used. The investigator may, however, decide to use two groups of subjects, with each of the two groups receiving only one level of one factor but all three levels of the other. Thus the experiment has repeated measurements over the factor with three levels, but not over the factor with two levels.

Experiments with repeated measurements have advantages and disadvantages. One advantage is that the measurements obtained under the dif-