a two-factor experiment with repeated measurements, row, column, and interaction effects are tested by using an F ratio with 1 degree of freedom associated with the numerator and $N - 1$ degrees of freedom associated with the denominator. In a two-factor experiment with repeated measurements on one factor only, no adjustment is made in the number of degrees of freedom used in the F ratio for testing row effects, because repeated measurements are not involved in the row factor. Thus the row effect is tested with $R - 1$ and $R(n - 1)$ degrees of freedom associated with the numerator and denominator, respectively, of the F ratio. Adjustments should, however, be made in the degrees of freedom used in the F ratios for column and $R \times C$ interaction effects. Here, using the Box procedure, the column effect is tested with 1 and $R(n - 1)$ degrees of freedom associated, respectively, with the numerator and denominator of the F ratio. The $R \times C$ interaction is tested by using $(R - 1)$ and $R(n - 1)$ degrees of freedom. Here again, because of the conservative nature of these tests, if a significant result is found by using the F test with adjusted degrees of freedom, the result is significant *a fortiori*, regardless of the homogeneity of variance-covariance assumption.

19.11 RANDOMIZED BLOCK DESIGNS

Consider a one-way classification experiment of the type described in Chapter 15, where N subjects are assigned at random to k treatment groups. Assume that the groups are of equal size with n subjects in each of the k groups. Between-groups and within-groups sums of squares are obtained with $k - 1$ and $N - k$ degrees of freedom, respectively. The precision of such experiments can be increased, sometimes substantially, by grouping the subjects into a number of blocks, using a variable that is known to be correlated with the dependent variable. For example, assume that four different methods of learning an artificial language are under investigation and 40 subjects are available. In the usual one-way classification experiment these 40 subjects would be allocated to the four methods at random resulting in 4 groups of 10 subjects each. Measures of scholastic achievement may, however, be available, and this variable may be thought to be correlated with the performance of subjects in learning the artificial language. Subjects may be divided into two groups, or blocks, of 20 subjects each. One group may be a high, the other a low, scholastic achievement group. The 20 subjects in each block may then be assigned at random to the four methods, resulting in eight groups of five subjects. Such an experiment is called a randomized block experiment. The essence of the idea of a randomized block experiment is that subjects can be grouped into blocks according to a known classification variable, which is correlated with the dependent variable. Subjects within blocks are then assigned at random to the k treatments. The analysis of data for such an experiment presents no problems. In the example above the analysis of