In an experiment study, various treatments are applied to test subjects and the response data is gathered for analysis. A critical tool for carrying out the analysis is the **Analysis of Variance** (ANOVA). It enables a researcher to differentiate treatment results based on easily computed statistical quantities from the treatment outcome.

The statistical process is derived from estimates of the [population variances](http://www.r-tutor.com/node/42) via two separate approaches. The first approach is based on the variance of the [sample means](http://www.r-tutor.com/node/35), and the second one is based on the mean of the sample variances. Under the ANOVA assumptions as stated below, the ratio of the two statistical estimates follows the [F distribution](http://www.r-tutor.com/node/141). Hence we can test the null hypothesis on the equality of various response data from different treatments via estimates of critical regions.

* The treatment responses are independent of each other.
* The response data follow the [normal distribution](http://www.r-tutor.com/node/58).
* The variances of the response data are identical.

In the following tutorials, we demonstrate how to perform ANOVA on a few basic experimental designs.

**Completely Randomized Design**

In a completely randomized design, there is only one primary factor under consideration in the experiment. The test subjects are assigned to treatment levels of the primary factor at random.

Example

A fast food franchise is test marketing 3 new menu items. To find out if they the same popularity, 18 franchisee restaurants are randomly chosen for participation in the study. In accordance with the completely randomized design, 6 of the restaurants are randomly chosen to test market the first new menu item, another 6 for the second menu item, and the remaining 6 for the last menu item.

Problem

Suppose the following table represents the sales figures of the 3 new menu items in the 18 restaurants after a week of test marketing. At .05 level of significance, test whether the [mean](http://www.r-tutor.com/node/35) sales volume for the 3 new menu items are all equal.

 Item1 Item2 Item3   
    22    52    16   
    42    33    24   
    44     8    19   
    52    47    18   
    45    43    34   
    37    32    39

**Randomized Block Design**

In a randomized block design, there is only one primary factor under consideration in the experiment. Similar test subjects are grouped into blocks. Each block is tested against all treatment levels of the primary factor at random order. This is intended to eliminate possible influence by other extraneous factors.

Example

A fast food franchise is test marketing 3 new menu items. To find out if they have the same popularity, 6 franchisee restaurants are randomly chosen for participation in the study. In accordance with the randomized block design, each restaurant will be test marketing all 3 new menu items. Furthermore, a restaurant will test market only one menu item per week, and it takes 3 weeks to test market all menu items. The testing order of the menu items for each restaurant is randomly assigned as well.

Problem

Suppose each row in the following table represents the sales figures of the 3 new menu in a restaurant after a week of test marketing. At .05 level of significance, test whether the [mean](http://www.r-tutor.com/node/35) sales volume for the 3 new menu items are all equal.

 Item1 Item2 Item3   
    31    27    24   
    31    28    31   
    45    29    46   
    21    18    48   
    42    36    46   
    32    17    40