Tests of Significance

One and two-tailed tests

The calculation of the t distribution is based on the null hypothesis. The use of the t test, however, also depends on the alternative hypothesis.

If the alternative hypothesis is of the form
H_A: A   B
the mean of B could be either higher or lower than the mean of A and a two-tailed test is needed. For a test of significance at 5%, there is a 2.5% chance that B is less than A plus a 2.5% chance that B is greater than A due to random variation. The probabilities given in t tables are for this two-tailed test.

If the alternative hypothesis is of the form
H_A: A < B
the mean of B can only be greater than the mean of A and a one-tailed test is needed. For a test of significance at 5%, there is a 5% chance that B is greater than A due to random variation. The possibility of B being less than A is not considered. For a one tailed test, the probabilities in the t table are doubled. Similar considerations apply for
H_A: A > B

Test Requirements

Conditions that must be met in tests of significance for deciding whether or not to reject the null hypothesis:

1. Hypotheses that are true shall be rejected only very occasionally, and the probability of rejection can be chosen by the experimenter.

2. Hypotheses that are false shall be rejected as often as possible.

The failures of a test to fulfill these conditions are known as Type I and Type II errors:

Type I error is a false positive, or the rejection of the null hypothesis when it is in fact true. The probability of a type I error is indicated by   , the confidence limit.

Type II error is a false negative, or the acceptance of the null hypothesis when it is false. The probability of a type II error is indicated by   . The probability of avoiding a type II error is called the power P of an experiment, and depends on the number of replicates.   = 2(1 - P)

Formula for Calculating Number of Replicates

$$r \geq 2\frac{CV^2}{D^2}(t_\alpha + t_\beta)^2$$

$$r \geq 2\frac{s^2}{d^2}(t_\alpha + t_\beta)^2$$

r   = number of reps
CV   = coefficient of variation
D   = true difference it is desired to detect as a % of mean
t   = tabular t value for a specified level of significance and df for error
t   = tabular t value for df for error and a probability of 2(1-P), where P is the
            probability of detecting a significant result in a particular experiment
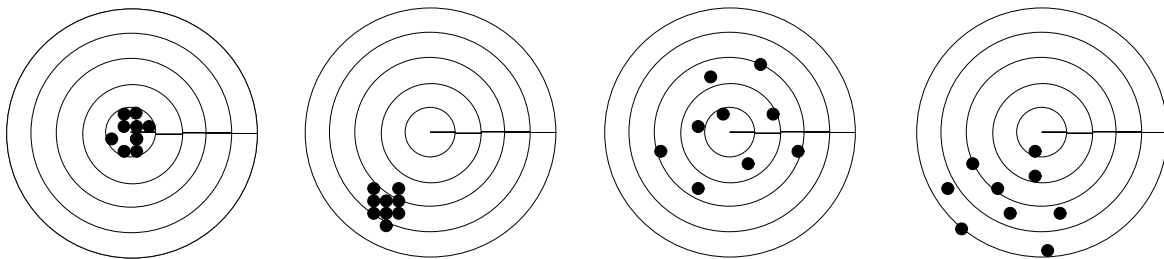s   = standard deviation
d   = true difference it is desired to detect

Precision and Accuracy

Precision: magnitude of the difference between two treatments that an experiment is capable of detecting at a given level of significance

Accuracy: closeness to true value with which a measurement can be made or a mean calculated

A Comparison of Precision and Accuracy

Rutherfurd and Moughan, 2000