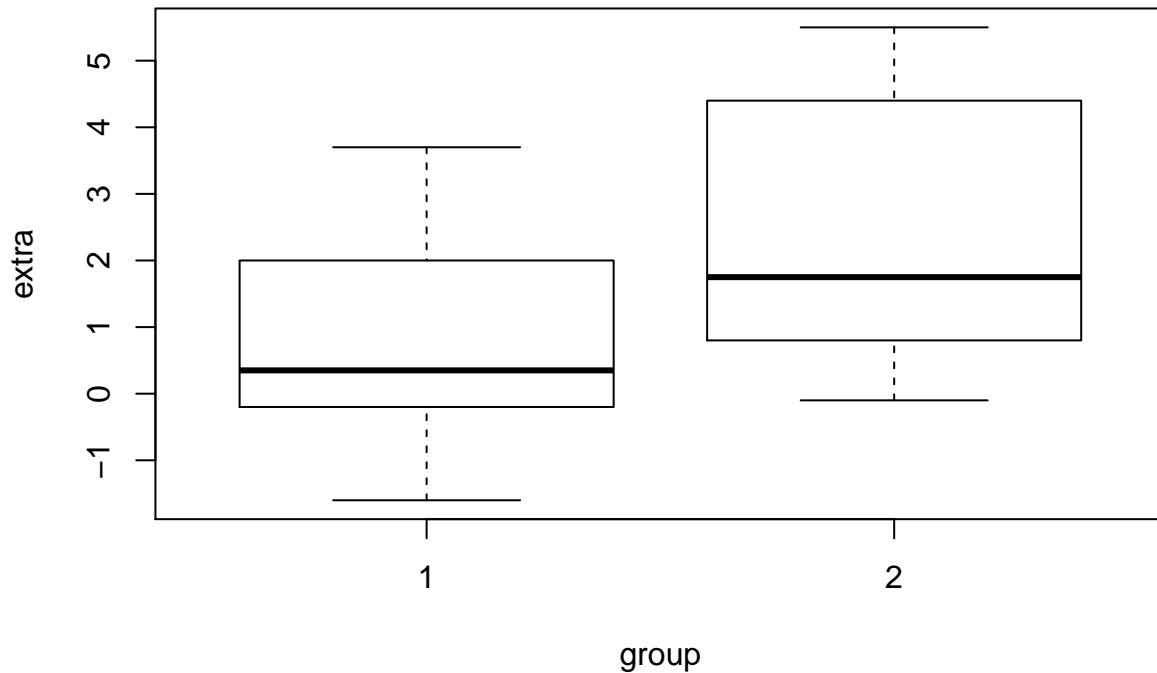


T-Test interpretation

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```
plot(extra ~ group, data = sleep)
```



Student's t-test or t-test (the real name is W.S. Gossett who hid his name due to his position as a worker in a brewery company) is a simple yet very useful statistical test. The basic idea behind t-test is the inference problem from a small sample size data set to test whether its sample mean may have large deviation from the true population mean.

A very common problem you will encounter is having two data sets and you want to test whether the two sets are coming from the same (assuming) normal distributions.

In t-test, the null hypothesis is that the mean of the two samples is equal. This means that the alternative hypothesis for the test is that the difference of the mean is not equal to zero. In a hypothesis test, we want to reject or accept the null hypothesis with some confidence interval. Since we test the difference between the two means, the confidence interval in this case specifies the range of values within which the difference may lie.

The t-test will also produce the p-value, which is the probability of wrongly rejecting the null hypothesis. The p-value is always compared with the significance level of the test. For instances, at 95% level of confidence, the significant level is 5% and the p-value is reported as $p < 0.05$. Small p-values suggest that the null hypothesis is unlikely to be true. The smaller it is, the more confident we can reject the null hypothesis.

In R, the test is performed by the built-in `t.test()` function. Let's use the sleep data from R where there are 20 samples in two groups (group 1 and 2, each with 10 samples) that show the effect of two soporific drug to increase the hours in sleep. Okay, we are not interested in the details of the data, but if we plot the data like this:

A quick grasp to the plot we see that there is naturally an overlap but the mean (half of the rectangle height) is different. Can we confidently say that the two groups have different means?

A quick t-test reveals the result:

```
t.test(extra~group,data=sleep)

##
##  Welch Two Sample t-test
##
## data:  extra by group
## t = -1.8608, df = 17.776, p-value = 0.07939
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -3.3654832  0.2054832
## sample estimates:
## mean in group 1 mean in group 2
##           0.75           2.33
```

Welch Two Sample t-test

Based on the result, you can say: at 95% confidence level, there is no significant difference ($p\text{-value} = 0.0794$) of the two means. Here you should accept the null hypothesis that the two means are equal because the $p\text{-value}$ is larger than 0.05. The maximum difference of the mean can be as low as -3.37 and as high as 0.21. The output also produces estimates of the sample means, the mean and the degree of freedom of the $t\text{-distribution}$. Note that Welch's $t\text{-test}$ is a $t\text{-test}$ with unequal variances.

The above example uses unpaired data sets with unequal variances. You may have different types of data sets. For instances,

You may have paired or unpaired data sets. Paired data sets means that if X_1, X_2, \dots, X_n are the first data set and Y_1, Y_2, \dots, Y_n are the second one, then X_i corresponds to Y_i . Hence, the two data set size must be the same. In unpaired data sets, the sample size between two sets may not be the same. In `t.test()`, you can set this with paired option.

You may have equal or unequal variances. Use `var.equal` option.

You may have a constant value, which means that the null hypothesis is in the form that the difference between the two population means is equal to some constant, instead of zero. Use `mu` option. `plot(extra~group,sleep)`