Statistics Kingdom

ANOVA Calculator

One-Way ANOVA Calculator and Tukey HSD

Significance level (α): 0,05

Outliers: Included

Effect: Medium

Effect type: f

Effect Size: 0.25

Rounding: 4

- (selected) Enter raw data directly
- Enter raw data from excel

Enter sample data directly

Groups:	Conventional	Assertiveness-based
Data:	123 166 97 134 113 117 140 114 111 277 102 188 153 112 193	40 157 88 101 64 103 135 57 103 172 95 174 107 109 166
Skewness:	1.733033	-0.0814874
Excess kurtosis:	4.287913	0.183377
Normality	0.000754	0.2211
Outliers	277	40
Mean	142.10345	114.41379
S	38.11575	32.21304

Calculate | Validate | Insert column | Delete column | Clear | Load last run

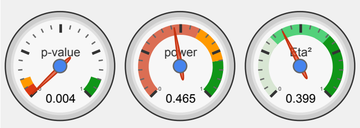
Header: You may change groups' names to the real names.
Data: When entering data, press Enter or , (comma) after each value.
You may paste full column from excel.
The calculator ignores empty cells or non-numeric cells.

Group1 contains 29 values
Group2 contains 29 values
validation:success

Hover over the cells for more information.

Source	DF	Sum of Square	Mean Square	F Statistic	P-value
Groups (between groups)	1	11117.3964	11117.3964	8.9279	0.004163
Error (within groups)	56	69733.7239	1245.2451		
Total	57	80851.1203	1418.4407		

R code.



One Way ANOVA test, using F distribution df(1,56) (right tailed)

1. H_0 hypothesis
Since p-value<α, H_0 is rejected.
Some of the groups' averages consider to be not equal.
In other words, the difference between the averages of some groups is big enough to be statistically significant.

2. P-value
p-value equals **0.00416348**, [p(x ≤ F) = 0.995837]. It means that the chance of type1 error (rejecting a correct H_0) is small: 0.004163 (0.42%)
The smaller the p-value the stronger it support H_1

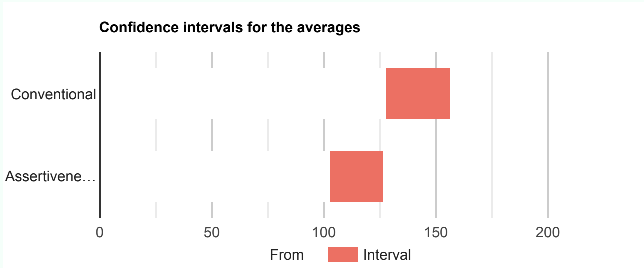
3. The statistics
The test statistic F equals **8.927878**, which is not in the 95% region of acceptance: [-∞ : 4.013]

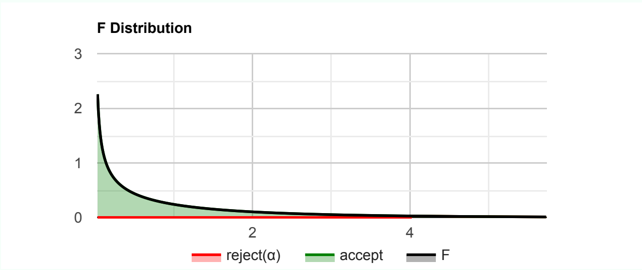
4. Effect size

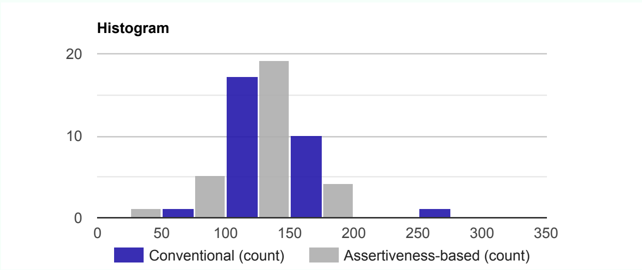
The observed effect size f is **large** (0.4). That indicates that the magnitude of the difference between the averages is large.
The η^2 equals 0.14. It means that the **group** explains 13.8% of the variance from the average (similar to R^2 in the linear regression)

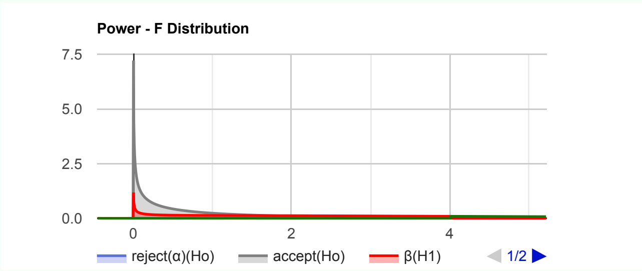
5. Tukey HSD / Tukey Kramer

The means of the following pair are significantly different: **x1-x2**.









Validation

- **Test power**

  Although the priori power is low (0.4647), the H_0 is rejected.

- **Equality of variances**

  The tool used the Levene's test to assess the equality of variances.
  The population's variances consider to be **equal**. (p-value = 0.497).
  Levene's test power consider to be weak (0.46).
  The groups' size consider similar. (The ratio between the bigger group and the smaller group is: 1)
  The ANOVA test consider to be robust to the homogeneity of variances assumtion when the groups' sizes are similar.

  It is suggested to consider the **Kruskal-Wallis ANOVA.** non-parametric test.

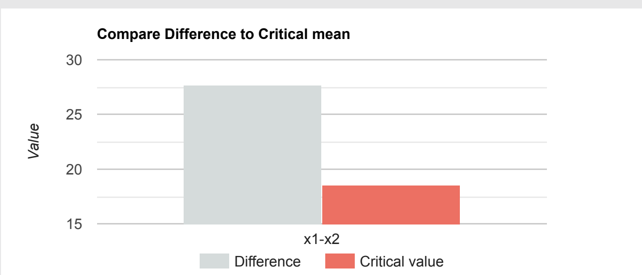
- **Normality assumption**

  The assumption was checked based on the Shapiro-Wilk Test. (α=0.05)
  The ANOVA test is considered robust for moderate violation of the normality assumption.
  From the groups with small sample size, less than 30, **1** group doesn't distribute normally (p-value is 0.000754).
  You should consider transform the data or use the Kruskal–Wallis non-parametric test.

Tukey HSD / Tukey Kramer

Pair	Difference	SE	Q	Lower CI	Upper CI	Critical Mean	p-value
x1-x2	27.6897	6.5528	4.2256	9.1254	46.2539	18.5642	0.004163

Group	x2
x1	27.69



ANOVA

What is the ANOVA?

The ANOVA test checks if the difference between the averages of two or more groups is significant, using sample data.
ANOVA is usually used when there are at least three groups since for two groups, the *two-tailed* pooled variance t-test and the *right-tailed* ANOVA test have the same result.
The basic ANOVA test contains only one categorical value, one-way ANOVA. For example, if you compare the performence of three schools, the categorical variable is school, and the possible values of the categorical variable are School-A, School-B, School-C. There are more complex ANOVA tests that contain two categorical variables (Two-way ANOVA calculator), or more. When performing a one-way ANOVA test, we try to determine if the difference between the averages reflects a real difference between the groups, or is due to the random noise inside each group.
The F statistic represents the ratio of the variance between the groups and the variance inside the groups. Unlike many other statistic tests, the smaller the F statistic the more likely the averages are equal.

Example: Compare four fertilizers used in four fields
H_0: The average weight of crops per square meter is equal in all fields.
H_1: At least one field yields a different average per square meter.

Right-tailed, for ANOVA test you can use only the right tail. Why?

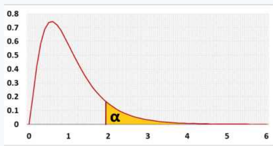
Hypotheses

H_0: $\mu_1 = \ldots = \mu_k$
H_1: not($\mu_1 = \ldots = \mu_k$)

ANOVA formula

$$F = \frac{MSG}{MSE}$$

F distribution



Assumptions

- Independent samples
- Normal distribution of the analyzed population
- Equal standard deviation, $\sigma_1=\sigma_2=\ldots=\sigma_k$
  The assumption is more important when the groups' sizes not similar

Required Sample Data

- Sample data from all compared groups

Parameters

- **k** - Number of groups.
- **n_i** - Sample side of group i
- **n** - Overall sample side, includes all the groups (Σn_i, i=1 to k)
- **$\bar{x}_i$** - Average of group i.
- **$\bar{x}$** - Overall average ($\Sigma x_{i,j}$ / n, i=1 to k, j=1 to n_i)
- **S_i** - Standard deviation of group i

Results calculations

Source	Degrees of Freedom	Sum of Squares	Mean Square	F statistic	p-value
Groups (between groups)	k - 1	$SSG=\sum_{i=1}^{k} n_i\,(\bar{x}_i-\bar{x})^2$	MSG = SSG / (k - 1)	F = MSG / MSE	P(x > F)
Error (within groups)	n - k	$SSE=\sum_{i=1}^{k}(n_i-1)\,S_i^2$	MSE = SSE / (n - k)		
Total	n - 1	SS(total) = SSG + SSE	Sample Variance = SS(total) / (n - 1)		

R Code

The following R code should produce the same results

```
value<-
c(97,102,107,111,112,113,114,115,117,118,121,121,122,123,134,136,136,140,151,153,156,164,166,169,172,188,193,193,277,40,57,64,87,88,95,101,102,103,103,106,107,108,108,109,109,109,111,114,126,135,136,141,143,147,15
group1 <- c(rep("Conventional", 29), rep("Assertiveness-based", 29))
my.dataframe<-data.frame(value, group1)
res.aov <- aov(value ~ group1, data = my.dataframe)
summary(res.aov)
TukeyHSD(res.aov)
```