

What is the difference between ANOVA with and without replication?

Authored by
stats writer

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ANOVA (Analysis of Variance) is a statistical method used to compare the means of two or more groups. The main difference between ANOVA with and without replication lies in the number of independent measurements or observations taken for each group. In ANOVA with replication, multiple measurements are taken for each group, while in ANOVA without replication, only one measurement is taken for each group. This difference affects the accuracy and precision of the results obtained from the analysis. ANOVA with replication provides more reliable and precise results, while ANOVA without replication may lead to less accurate conclusions. Overall, the decision to use ANOVA with or without replication depends on the research design and the level of accuracy required for the study.

ANOVA With or Without Replication: What's the Difference?

A two-way ANOVA is used to determine whether or not two predictor variables (or "factors") have a statistically significant effect on some response variable.

There are two different types of two-way ANOVA models:

1. Two-Way ANOVA Without Replication

For each combination of levels for the predictor variables, there is only one observation.

2. Two-Way ANOVA With Replication

For each combination of levels for the predictor variables, there are multiple observations.

For example, a botanist might want to know if sunlight exposure (None, Low, Medium, High) and watering frequency (Daily, Weekly) have a statistically significant effect on plant growth.

She could carry out one of the following two-way ANOVA models:

1. Two-Way ANOVA Without Replication

Using this approach, the botanist would only measure the growth of one plant for each combination of levels for sunlight and watering frequency.

For example, she would measure the growth of one plant that had no sunlight exposure and daily watering.

Then she would measure the growth of only one plant that had no sunlight exposure and weekly watering.

And so on.

The following table shows what a two-way ANOVA without replication could look like:

Two-Way ANOVA Without Replication

	Sunlight Exposure			
Watering Frequency	None	Low	Medium	High
Daily	4.8	5	6.4	6.3
Weekly	4.4	4.9	5.8	6

From the table we can see:

The plant that had no sunlight exposure and daily watering had a growth of 4.8 inches. The plant that had no sunlight exposure and weekly watering had a growth of 4.4 inches. The plant that had low sunlight exposure and daily watering had a growth of 5 inches. The plant that had low sunlight exposure and weekly watering had a growth of 4.9 inches.

2. Two-Way ANOVA With Replication

Using this approach, the botanist would measure the growth of multiple plants for each combination of levels for sunlight and watering frequency.

For example, she might measure the growth of five different plants that had no sunlight exposure and daily watering.

Then she would measure the growth of another five plants that had no sunlight exposure and weekly watering.

And so on.

The following table shows what a two-way ANOVA with replication could look like:

Two-Way ANOVA With Replication

	Sunlight Exposure			
Watering Frequency	None	Low	Medium	High
Daily	4.8	5	6.4	6.3
	4.4	5.2	6.2	6.4
	3.2	5.6	4.7	5.6
	3.9	4.3	5.5	4.8
	4.4	4.8	5.8	5.8
Weekly	4.4	4.9	5.8	6
	4.2	5.3	6.2	4.9
	3.8	5.7	6.3	4.6
	3.7	5.4	6.5	5.6
	3.9	4.8	5.5	5.5

From the table we can see:

One plant that had no sunlight exposure and daily watering had a growth of 4.8 inches. Another plant that had no sunlight exposure and daily watering had a

growth of 4.4 inches. Another plant that had no sunlight exposure and daily watering had a growth of 3.2 inches.

And so on.

The Difference Between ANOVA With & Without Replication

The biggest difference between an ANOVA model with replication and ANOVA model without replication is that it's only possible to measure the interaction effect between the two predictor variables in an ANOVA with replication.

An interaction effect means there is some type of interaction between the two predictor variables, which can impact the way we interpret the relationship between the predictor variables and the response variable.

For example, the botanist might want to know if sunlight exposure and watering frequency affect plant growth.

While it's possible that both of these predictor variables affect plant growth, it's also possible that the two predictor variables interact with each other.

For example, it's possible that sunlight exposure leads to plant growth at different rates depending on whether or not a plant is watered daily or weekly.

In this case, there is an interact effect between sunlight exposure and watering frequency.

However, the only way to measure an interaction effect is if we have multiple measurements for each combination of levels for the predictor variables.

ANOVA With & Without Replication in Excel

If we carry out a two-way ANOVA without replication in Excel, the output will look like the following:

ANOVA						
Source of Variation	SS	df	MS	F	P-value	F crit
Watering Frequency	0.245	1	0.245	11.30769	0.043646	10.12796
Sunlight Exposure	3.77	3	1.256667	58	0.003727	9.276628
Error	0.065	3	0.021667			
Total	4.08	7				

Since the p-values in the ANOVA table for both sunlight exposure and watering frequency are less than .05, we would conclude that both variables have a statistically significant effect on plant growth.

However, notice that there is no interaction term included in the ANOVA table so we don't know if there is any interaction effect between the two predictor variables.

On the other hand, if we carry out a two-way ANOVA with replication in Excel, the output will look like the following:

ANOVA						
Source of Variation	SS	df	MS	F	P-value	F crit
Watering Frequency	0.00025	1	0.00025	0.000921	0.975975	4.149097
Sunlight Exposure	18.76475	3	6.254917	23.04898	0.00008	2.90112
Interaction	1.01075	3	0.336917	1.241517	0.310898	2.90112
Within	8.684	32	0.271375			
Total	28.45975	39				

Notice that this ANOVA table contains p-values for sunlight exposure, watering frequency, *and* the interaction effect between these two predictor variables.

From the table we can see that watering frequency is not statistically significant, sunlight exposure *is* statistically significant, and there is no interaction effect between the two predictor variables is not statistically significant.

This means we can draw conclusions about the effects of sunlight exposure on plant growth, *regardless of watering frequency.*

The following tutorials provide additional information about two-way ANOVA models:

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