

How do I perform a Two-Way ANOVA in SAS?

Authored by
stats writer

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A Two-Way ANOVA (Analysis of Variance) is a statistical method used to analyze the differences between two or more groups while considering the effects of two categorical independent variables. In SAS, performing a Two-Way ANOVA requires the use of the PROC GLM (General Linear Model) procedure. This procedure allows for the examination of main effects and interaction effects between the two independent variables, as well as the overall significance of the model. The output of the analysis includes various statistical measures such as F-values, p-values, and means of each group. By following the appropriate syntax and inputting the necessary data, SAS can efficiently and accurately perform a Two-Way ANOVA, aiding in the interpretation of relationships between variables in a research study or experiment.

Perform a Two-Way ANOVA in SAS

A two-way ANOVA is used to determine whether or not there is a statistically significant difference between the means of three or more independent groups that have been split on two variables (sometimes called "factors").

This tutorial provides a step-by-step example of how to perform a two-way ANOVA in SAS.

Step 1: Create the Data

Suppose a botanist wants to know whether or not plant growth is influenced by sunlight exposure and watering frequency.

She plants 30 seeds and lets them grow for one month under different conditions for sunlight exposure and

watering frequency. After one month, she records the height of each plant. The results are shown below:

	Sunlight Exposure		
Watering Frequency	Low	Medium	High
Daily	6	5	6
	6	5	6
	6	6	7
	5	4	8
	6	5	7
Weekly	3	4	5
	4	4	6
	4	4	6
	4	4	7
	5	4	8

We can use the following code to create this dataset in SAS:

```
/*create dataset*/  
data my_data;  
input water $ sunlight $ height;  
datalines;  
daily low 6  
daily low 6  
daily low 6  
daily low 5  
daily low 6
```

daily med 5

daily med 5

daily med 6

daily med 4

daily med 5

daily high 6

daily high 6

daily high 7

daily high 8

daily high 7

weekly low 3

weekly low 4

weekly low 4

weekly low 4

weekly low 5

weekly med 4

weekly med 4

weekly med 4

weekly med 4

weekly med 4

weekly high 5

weekly high 6

weekly high 6

weekly high 7

weekly high 8

;run;

Step 2: Perform the Two-Way ANOVA

Next, we'll use `proc ANOVA` to perform the two-way ANOVA:

```
/*perform two-way ANOVA*/  
proc ANOVAdata=my_data;  
class water sunlight;  
model height = water sunlight water*sunlight;  
means water sunlight / tukeycliff;  
run;
```

Step 3: Interpret the Results

The first table we want to analyze in the results is the ANOVA table:

The ANOVA Procedure

Dependent Variable: height

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	35.86666667	7.17333333	13.45	<.0001
Error	24	12.80000000	0.53333333		
Corrected Total	29	48.66666667			

R-Square	Coeff Var	Root MSE	height Mean
0.736986	13.69306	0.730297	5.333333

Source	DF	Anova SS	Mean Square	F Value	Pr > F
water	1	8.53333333	8.53333333	16.00	0.0005
sunlight	2	24.86666667	12.43333333	23.31	<.0001
water*sunlight	2	2.46666667	1.23333333	2.31	0.1207

From this table we can see:

The p-value for water: .0005
 The p-value for sunlight: <.0001
 The p-value for the interaction between water and sunlight: .1207

This tells us that both water and sunlight are statistically significant predictors of plant height and that there is no statistically significant interaction effect between water and sunlight.

First, we'll look at the Tukey post-hoc comparisons for water:

The ANOVA Procedure

Tukey's Studentized Range (HSD) Test for height

Note: This test controls the Type I experimentwise error rate.

Alpha	0.05
Error Degrees of Freedom	24
Error Mean Square	0.533333
Critical Value of Studentized Range	2.91879
Minimum Significant Difference	0.5504

Comparisons significant at the 0.05 level are indicated by ***.

water Comparison	Difference Between Means	Simultaneous 95% Confidence Limits		
daily - weekly	1.0667	0.5163	1.6170	***
weekly - daily	-1.0667	-1.6170	-0.5163	***

From the output we can see that the mean difference in height between plants that were watered daily vs. weekly was 1.0667 inches.

The 95% confidence interval for the difference in mean height is . This means we're 95% confident that the true difference in mean height between plants watered daily and plants watered weekly is between .5163 inches and 1.6170 inches.

First, we'll look at the Tukey post-hoc comparisons for sunlight:

The ANOVA Procedure

Tukey's Studentized Range (HSD) Test for height

Note: This test controls the Type I experimentwise error rate.

Alpha	0.05
Error Degrees of Freedom	24
Error Mean Square	0.533333
Critical Value of Studentized Range	3.53170
Minimum Significant Difference	0.8156

Comparisons significant at the 0.05 level are indicated by ***.

sunlight Comparison	Difference Between Means	Simultaneous 95% Confidence Limits		
high - low	1.7000	0.8844	2.5156	***
high - med	2.1000	1.2844	2.9156	***
low - high	-1.7000	-2.5156	-0.8844	***
low - med	0.4000	-0.4156	1.2156	
med - high	-2.1000	-2.9156	-1.2844	***
med - low	-0.4000	-1.2156	0.4156	

To tell which group means are different, we must look at which pairwise comparisons have stars (***) next to them.

From the table we can see that the following group means are statistically significantly different:

High sunlight vs. Low sunlight (95% C.I. =)
High sunlight vs. Medium sunlight (95% C.I. =)

Step 4: Report the Results

Lastly, we can of the two-way ANOVA:

A two-way ANOVA was performed to analyze the effect of watering frequency and sunlight exposure on plant growth.

A two-way ANOVA revealed that there was not a statistically significant interaction between the effects of watering frequency and sunlight exposure ($p = .1207$).

Simple main effects analysis showed that watering frequency had a statistically significant effect on plant growth ($p = .0005$).

Simple main effects analysis showed that sunlight exposure also had a statistically significant effect on plant growth ($p < .0001$).

Additional Resources

The following tutorials provide additional information about two-way ANOVAs: