

What is a Factorial ANOVA? (Definition & Example)

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A factorial ANOVA (Analysis of Variance) is a statistical test used to analyze the effects of two or more independent variables (also known as factors) on a dependent variable. It is often used in research studies to determine if there is a significant difference between the means of different groups. This test allows researchers to examine the main effects of each individual factor, as well as any interactions between the factors. For example, a researcher may use a factorial ANOVA to analyze the effects of both gender and age on job satisfaction. This test is commonly used in various fields such as psychology, sociology, and marketing research.

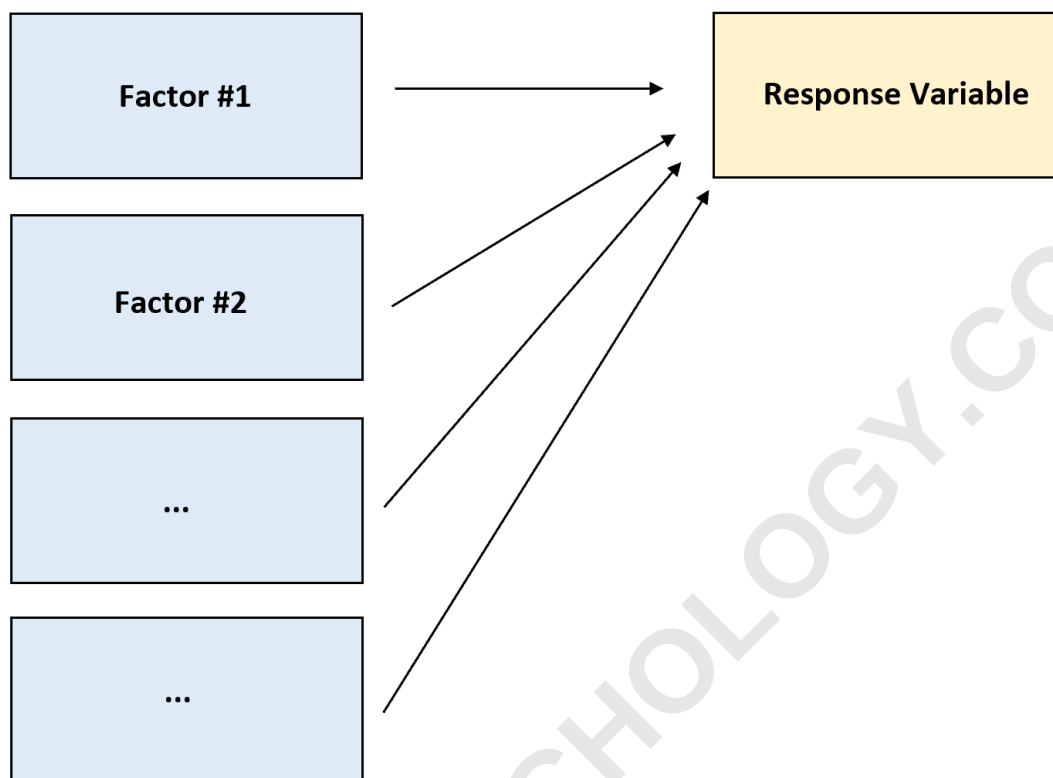
What is a Factorial ANOVA? (Definition & Example)

A factorial ANOVA is any ANOVA ("analysis of variance") that uses two or more independent factors and a single response variable.

This type of ANOVA should be used whenever you'd like to understand how two or more factors affect a and whether or not there is an interaction effect between the factors on the response variable.

Factorial ANOVA

How do two or more independent factors affect a response variable?



This tutorial provides several examples of situations where a factorial ANOVA may be used along with a step-by-step example of how to perform a factorial ANOVA.

Note: A is a type of factorial ANOVA.

Examples of Using a Factorial ANOVA

A factorial ANOVA could be used in each of the following situations.

Example 1: Plant Growth

A botanist wants to understand how sunlight exposure and watering frequency affect plant growth. She plants 100 seeds and lets them grow for three months under different conditions for sunlight exposure and watering frequency. After three months, she records the height of each plant.

In this case, she has the following variables:

Response variable: plant growth
Factors: sunlight exposure, watering frequency

And she would like to answer the following questions:

Does sunlight exposure affect plant growth?
Does watering frequency affect plant growth?
Is there an interaction effect between sunlight exposure and watering frequency?

She could use a factorial ANOVA for this analysis because she wants to understand how two factors affect a single response variable.

Example 2: Exam Scores

A professor wants to understand how class time and teaching method affect exam scores. He uses two different teaching methods and two different teaching times (early morning and early afternoon) and records the average exam scores of each student at the end of the semester.

In this case, he has the following variables:

Response variable: exam score
Factors: teaching method, teaching time

And he would like to answer the following questions:

Does teaching method affect exam scores?
Does teaching time affect exam scores?
Is there an interaction effect between teaching method and teach time?

He could use a factorial ANOVA for this analysis because he wants to understand how two factors affect a single response variable.

Example 3: Annual Income

An economist collects data to understand how education level (high school diploma, college degree,

graduate degree), marital status (single, divorced, married), and region (North, East, South, West) affect annual income.

In this case, he has the following variables:

Response variable: annual income
Factors: education level, marital status, region

And he would like to answer the following questions:

Does education level affect income? Does marital status affect income? Does region affect income? Is there an interaction effect between these three independent factors?

He could use a factorial ANOVA for this analysis because he wants to understand how three factors affect a single response variable.

Step-by-Step Example of a Factorial ANOVA

A botanist wants to know if sunlight exposure and watering frequency affect plant growth. She plants 40 seeds and lets them grow for two months under different conditions for sunlight exposure and watering

frequency. After two months, she records the height of each plant.

The results are shown below:

	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

We can see that five plants were grown under each combination of conditions.

For example, there were five plants grown with daily watering and no sunlight and their heights after two months were 4.8 inches, 4.4 inches, 3.2 inches, 3.9 inches, and 4.4 inches:

	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

The botanist uses this data to perform a and ends up with the following output:

G	H	I	J	K	L	M
SUMMARY	None	Low	Medium	High	Total	
<i>Daily</i>						
Count	5	5	5	5	20	
Sum	20.7	24.9	28.6	28.9	103.1	
Average	4.14	4.98	5.72	5.78	5.155	
Variance	0.378	0.232	0.447	0.412	0.775237	
<i>Weekly</i>						
Count	5	5	5	5	20	
Sum	20	26.1	30.3	26.6	103	
Average	4	5.22	6.06	5.32	5.15	
Variance	0.085	0.137	0.163	0.317	0.722632	
<i>Total</i>						
Count	10	10	10	10		
Sum	40.7	51	58.9	55.5		
Average	4.07	5.1	5.89	5.55		
Variance	0.211222	0.18	0.303222	0.382778		
ANOVA						
<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Sample (Watering)	0.00025	1	0.00025	0.000921	0.975975	4.149097
Columns (Sunlight)	18.76475	3	6.254917	23.04898	3.9E-08	2.90112
Interaction	1.01075	3	0.336917	1.241517	0.310898	2.90112
Within	8.684	32	0.271375			
Total	28.45975	39				

The last table shows the result of the factorial ANOVA:

The p-value for the interaction between watering frequency and sunlight exposure was 0.310898. This is not statistically significant at alpha level 0.05. The p-value for watering frequency was 0.975975. This is not statistically significant at alpha level 0.05. The p-value

for sunlight exposure was $3.9E-8$ (0.000000039). This is statistically significant at alpha level 0.05.

We can conclude that sunlight exposure is the only factor that has a statistically significant effect on plant growth.

We can also conclude that there is no interaction effect between sunlight exposure and watering frequency and that watering frequency does not have a statistically significant effect on plant growth.

The following tutorials provide additional information about ANOVA models: