How can I perform a Two-Way ANOVA in SPSS?

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Executing a Two-Way ANOVA in SPSS is a straightforward process requiring several key menu selections. The user navigates through the main menu by selecting the **Analyze** option, then proceeding to the **General Linear Model** submenu, and finally choosing **Univariate**. This powerful statistical procedure allows researchers to simultaneously assess the effects of two independent variables (or factors) on a single dependent variable. Once the variables are defined and the necessary options, such as Post Hoc tests and plots, are configured, clicking **OK** initiates the complex analysis, providing comprehensive results that detail main effects and interaction effects.

Introduction to Two-Way ANOVA

A Two-Way ANOVA (Analysis of Variance) is a critical statistical technique employed to determine whether there is a statistically significant difference between the means of groups defined by two distinct factors. Unlike a one-way ANOVA, which assesses the impact of a single independent variable, the two-way approach allows for a richer analysis by considering the combined influence of two categorical variables on a continuous outcome measure.

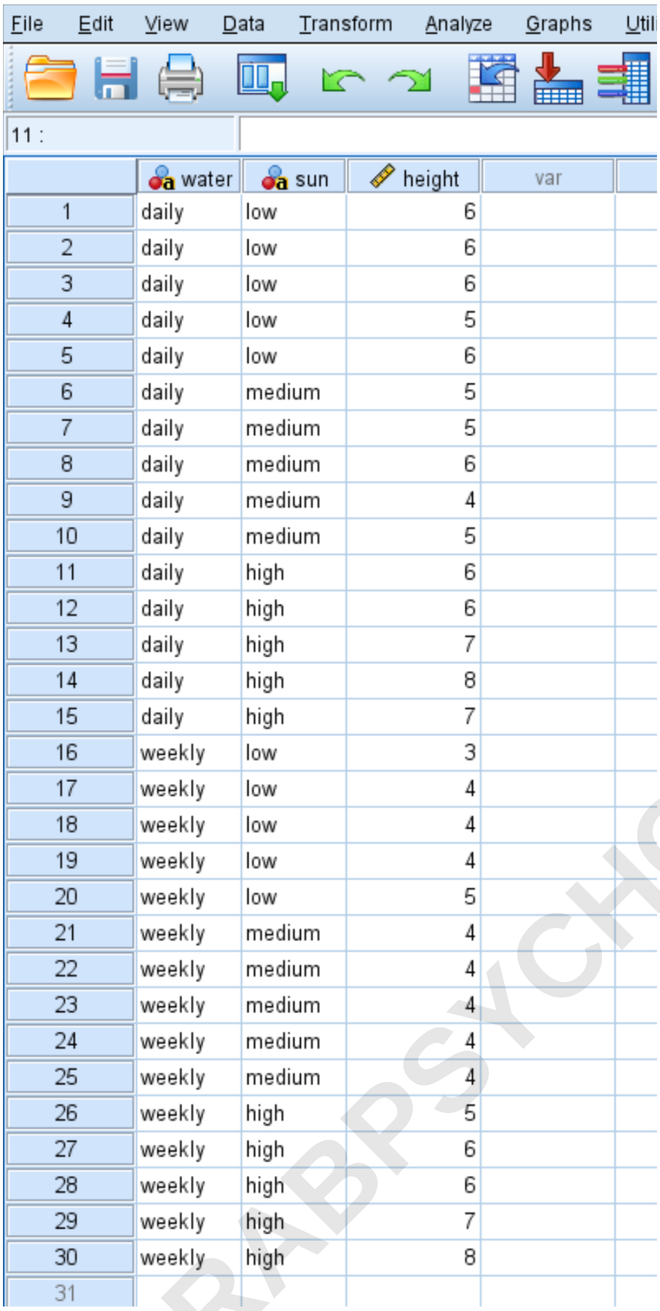
The primary purpose of conducting a two-way ANOVA is twofold: first, to ascertain the individual effect (main effect) of each factor on the response variable, and second, to investigate the potential **interaction effect** between the two factors. An interaction effect occurs when the effect of one factor on the dependent variable changes depending on the level of the other factor. Understanding this interaction is often the most insightful part of the analysis, providing a nuanced view of the relationships within the data.

This comprehensive tutorial is designed to guide you through the process of conducting a valid and reliable two-way ANOVA specifically using the statistical software package, SPSS Statistics, from data entry to interpretation of the output.

Case Study: Analyzing Plant Growth Factors

To illustrate the application of a two-way ANOVA, we will consider a scenario involving a botanist studying plant growth. Her primary research question is whether plant height (the dependent variable) is significantly influenced by two primary factors: **sunlight exposure** and **watering frequency**. The experimental setup involves planting 30 seeds and allowing them to grow for a period of two months under varying combinations of these two categorical factors.

Upon completion of the two-month growth period, the botanist meticulously records the final height of each plant, measured in inches. This data set, structured with columns for 'height' (dependent variable), 'water' (Factor 1), and 'sun' (Factor 2), is prepared for analysis in SPSS. The results, as formatted for the software, are displayed in the image below.

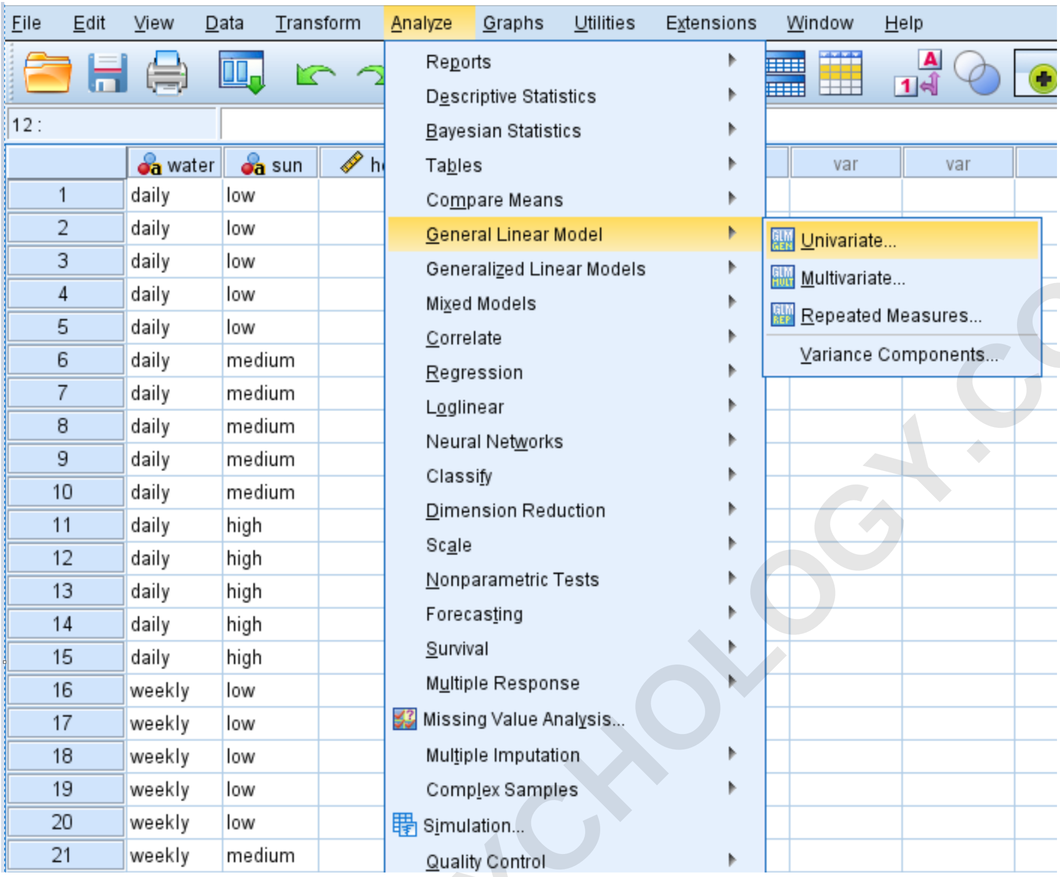


	water	sun	height	var
1	daily	low	6	
2	daily	low	6	
3	daily	low	6	
4	daily	low	5	
5	daily	low	6	
6	daily	medium	5	
7	daily	medium	5	
8	daily	medium	6	
9	daily	medium	4	
10	daily	medium	5	
11	daily	high	6	
12	daily	high	6	
13	daily	high	7	
14	daily	high	8	
15	daily	high	7	
16	weekly	low	3	
17	weekly	low	4	
18	weekly	low	4	
19	weekly	low	4	
20	weekly	low	5	
21	weekly	medium	4	
22	weekly	medium	4	
23	weekly	medium	4	
24	weekly	medium	4	
25	weekly	medium	4	
26	weekly	high	5	
27	weekly	high	6	
28	weekly	high	6	
29	weekly	high	7	
30	weekly	high	8	
31				

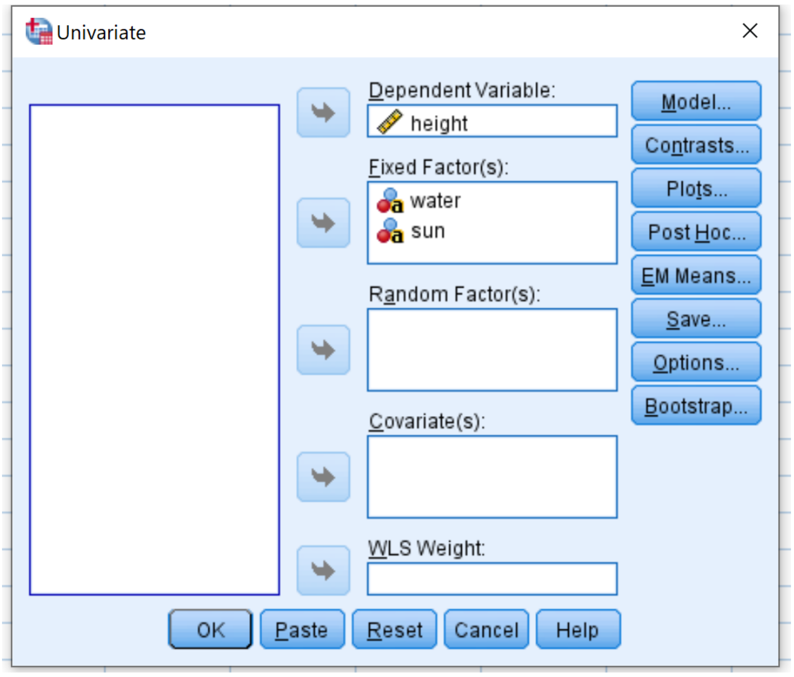
The subsequent steps detail the precise methodology for performing a Two-Way ANOVA on this data. We aim to determine the individual significance of watering frequency and sunlight exposure on plant growth, and critically, to ascertain if a combined **interaction effect** exists between watering frequency and sunlight exposure.

Step 1: Executing the Two-Way ANOVA in SPSS

To initiate the analysis, navigate to the main menu bar in SPSS. Select the **Analyze** tab, hover over **General Linear Model**, and finally click on **Univariate**. This sequence opens the core dialog box necessary for configuring the Two-Way ANOVA model. It is essential to choose 'Univariate' as our analysis involves only one dependent variable (plant height).

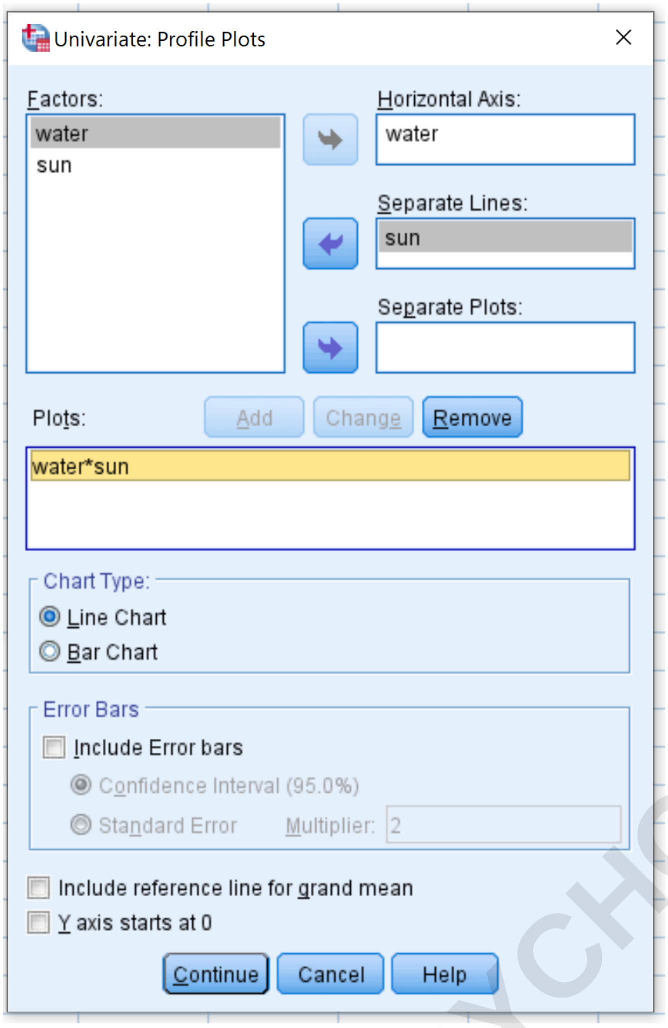


In the subsequent dialog box, proper variable assignment is crucial. Begin by dragging the continuous **response variable**, labeled **height**, into the box designated as **Dependent variable**. Following this, the two categorical factors--**water** (watering frequency) and **sun** (sunlight exposure)--must be dragged into the **Fixed Factor(s)** box. These factors represent the independent variables whose main and interactive effects we intend to test.

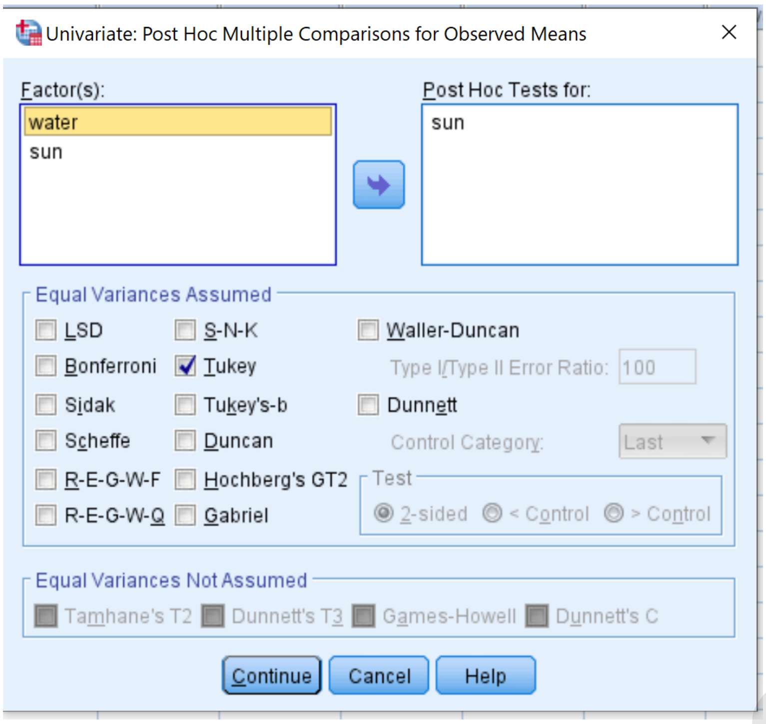


Configuring Interaction Plots and Post Hoc Tests

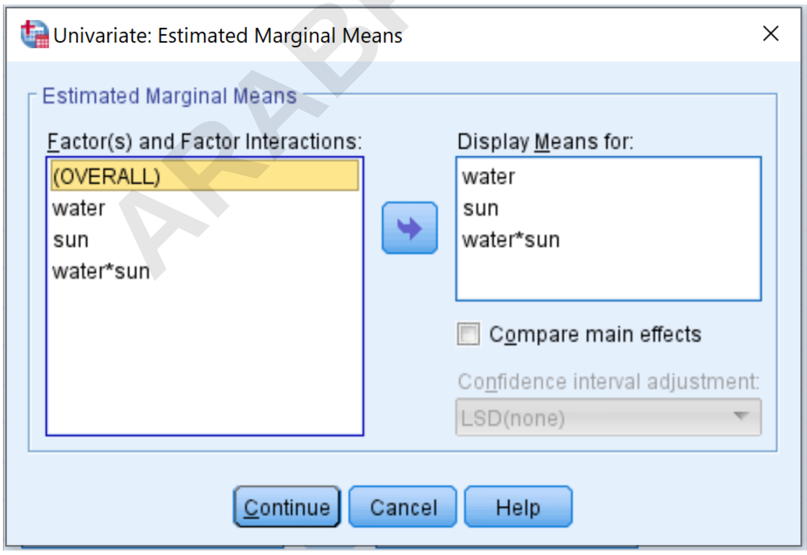
To visualize the potential interaction between the two factors, click the **Plots** button. In this dialog, drag the factor intended for the x-axis, **water**, into the **Horizontal axis** box. Drag the second factor, **sun**, into the **Separate lines** box. Immediately click the **Add** button; this action registers the interaction term (**water*sun**) in the Plots list. This plot will graphically represent how the effect of watering changes across different levels of sunlight exposure. Click **Continue** to save the plot configuration.



Next, we must select appropriate multiple comparison tests to identify precisely which group means differ significantly, should the overall ANOVA prove significant for a specific factor. Click the **Post Hoc** button. Since the factor **sun** has three levels (low, medium, high), we drag this variable into the **Post Hoc Tests for** box. We then check the box next to **Tukey**, a conservative and commonly used method for pairwise comparisons when sample sizes are equal. Click **Continue** to return to the main dialog.



While optional, it is highly recommended to click the **Options** button and select **Estimated Marginal Means** for both factors and the interaction term. This generates tables of the adjusted group means, which are critical for interpretation. The resulting table format, showing the Estimated Marginal Means, is previewed below. Once all configurations--including plots, post hoc tests, and options--are complete, click the **OK** button in the main Univariate window to generate the output results.



Step 2: Interpreting the ANOVA Output

After clicking **OK**, SPSS generates the comprehensive output window containing numerous tables. The most critical table for determining main effects and interaction effects is the **Tests of Between-Subjects Effects** table. This table summarizes the F-statistics and associated p-values (Sig.) for the two independent factors (water and sun) and their combined interaction (water*sun).

We analyze the p-values to determine the statistically significant difference in plant growth across the factor levels. Generally, a p-value less than the chosen significance level (typically α = 0.05) indicates significance. The table derived from our analysis is presented below:

Tests of Between-Subjects Effects

Dependent Variable: height

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	36.855[a]	5	7.371	13.960	.000
Intercept	853.333	1	853.333	1616.162	.000
water	9.408	1	9.408	17.818	.000
sun	25.633	2	12.816	24.273	.000
water * sun	1.814	2	.907	1.718	.201
Error	12.672	24	.528		
Total	902.860	30			
Corrected Total	49.527	29			

a. R Squared = .744 (Adjusted R Squared = .691)

A detailed examination of the p-values reveals the following conclusions regarding the impact on plant height:

Watering Frequency (water): p-value = **.000**
Sunlight Exposure (sun): p-value = **.000**
Interaction Effect (water*sun): p-value = **.201**

Since the p-values for both **water** and **sun** are substantially less than 0.05, we conclude that both factors individually have a statistically significant effect on the mean height of the plants. Conversely, the p-value for the interaction effect (.201) is greater than 0.05, leading us to conclude that there is **no significant interaction effect** between sunlight exposure and watering frequency; the effect of one factor does not depend on the level of the other.

Analysis of Estimated Marginal Means

The **Estimated Marginal Means** tables provide the average height for each level of the factors, adjusting for the presence of the other factor. Reviewing these means helps us understand the direction of the significant effects identified in the main ANOVA table. The output clearly segregates the means based on watering frequency, sunlight exposure, and the combination of both levels.

Estimated Marginal Means

1. water

Dependent Variable: height

water	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
daily	5.893	.188	5.506	6.281
weekly	4.773	.188	4.386	5.161

2. sun

Dependent Variable: height

sun	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
high	6.620	.230	6.146	7.094
low	4.890	.230	4.416	5.364
medium	4.490	.230	4.016	4.964

3. water * sun

Dependent Variable: height

water	sun	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
daily	high	6.920	.325	6.249	7.591
	low	5.780	.325	5.109	6.451
	medium	4.980	.325	4.309	5.651
weekly	high	6.320	.325	5.649	6.991
	low	4.000	.325	3.329	4.671
	medium	4.000	.325	3.329	4.671

We can extract several key findings from these marginal means, providing immediate insights into which treatment conditions fostered the greatest growth:

The average height for plants watered **Daily** was **5.893** inches, indicating better growth compared to weekly watering.

Plants subjected to **High** sunlight exposure achieved a mean height of **6.62** inches, suggesting this is the most beneficial light level.
The specific cell mean for plants watered daily and receiving high sunlight exposure was **6.32** inches, demonstrating the mean height under optimal conditions, according to the data.

Interpreting Tukey's Post Hoc Comparisons

Since the overall ANOVA determined that the factor of **sunlight exposure** had a statistically significant difference ($p < .001$), we proceed to examine the Post Hoc Tests table. This table, specifically generating results for the selected Tukey HSD procedure, performs pairwise comparisons between the three levels of sunlight exposure (low, medium, and high) to pinpoint where the differences lie.

Post Hoc Tests

sun

Multiple Comparisons

Dependent Variable: height
Tukey HSD

(I) sun	(J) sun	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
high	low	1.73*	.325	.000	.92	2.54
	medium	2.13*	.325	.000	1.32	2.94
low	high	-1.73*	.325	.000	-2.54	-.92
	medium	.40	.325	.447	-.41	1.21
medium	high	-2.13*	.325	.000	-2.94	-1.32
	low	-.40	.325	.447	-1.21	.41

Based on observed means.
The error term is Mean Square(Error) = .528.
*. The mean difference is significant at the 0.05 level.

By reviewing the significance column (Sig.), we can draw the following conclusions regarding the comparisons:

High vs. Low Sunlight: p-value = **0.000**. This indicates a significant difference.
High vs. Medium Sunlight: p-value = **0.000**. This also indicates a significant difference.
Low vs. Medium Sunlight: p-value = **0.447**. Since this value is greater than 0.05, there is no significant difference between the low and medium sunlight groups.

In summary, the high sunlight group produced significantly taller plants than both the medium and low sunlight groups, but the distinction between low and medium sunlight exposure was negligible.

Step 3: Reporting the Two-Way ANOVA Findings

The final stage of any statistical analysis involves accurately reporting the findings in a clear, concise manner, typically following APA format guidelines for academic or professional contexts. The report must summarize the method, the main effects, the interaction effect, and the results of any follow-up Post Hoc Tests.

The following block provides a model structure for presenting the conclusions derived from the analysis of plant growth data. Note the clear separation of the main effects and the absence of a significant interaction effect.

A Two-Way ANOVA was conducted using SPSS to evaluate the effects of watering frequency (daily vs. weekly) and sunlight exposure (low, medium, high) on plant growth, utilizing a sample of 30 plants. The analysis confirmed that both watering frequency ($p < .001$) and sunlight exposure ($p < .001$) exerted a statistically significant difference on plant height.

Specifically regarding the main effects, plants that were watered **daily** demonstrated significantly greater growth compared to those watered weekly. Further analysis using Tukey's HSD test for multiple comparisons revealed that plants exposed to **high sunlight** grew significantly taller than plants exposed to medium or low sunlight. However, the difference between the medium and low sunlight groups was not statistically significant ($p = 0.447$).

Crucially, the analysis indicated no statistically significant interaction effect between watering frequency and sunlight exposure ($p = 0.201$). This suggests that the impact of watering frequency on plant height remains consistent regardless of the level of sunlight provided.