Latin Square Design Analysis

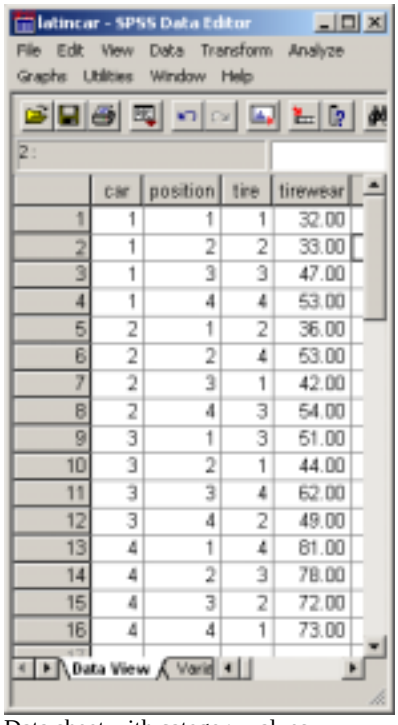
Goal: Comparing the performance of four different brands of tires (A, B, C, and D).

Background: There are four cars available for this comparative study of tire performance. It is believed that tires wearing out in a different rate at different location of a car. Tires were installed in four different locations: Right-Front (RF), Left-Front (LF), Right-Rear (RR) and Left-Rear (LR). The measurements of the wearing of tires in this investigation are listed in the following table from a Latin Square Design setting. Three factors are considered in this study. They are tire position, car and the different tires studied in this investigation.

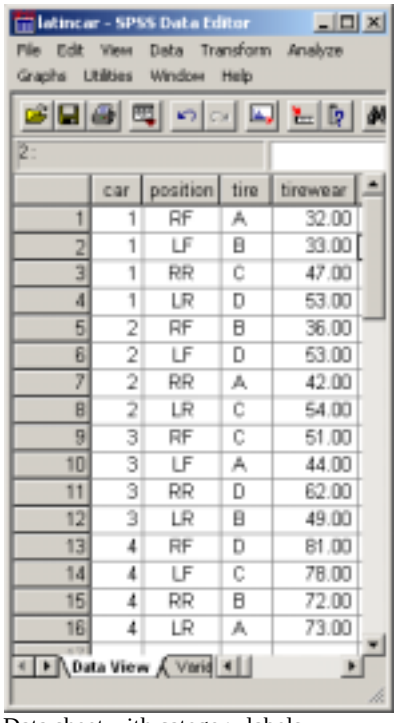
		Positions			
		RF	LF	RR	LR
Cars	1	A(32)	B(33)	C(47)	D(53)
	2	B(36)	D(53)	A(42)	C(54)
	3	C(51)	A(44)	D(62)	B(49)
	4	D(81)	C(78)	B(72)	A(73)

I. Data Entry

Tire wearing measurements variable (**tirewear**), car ID's variable (**car**), positions of tires (**position**), and the type of tires (**tire**) can be entered as the way entered in the following tables. Table on the left shows numbers for categories and table on the right is properly labeled.



Data sheet with category values.



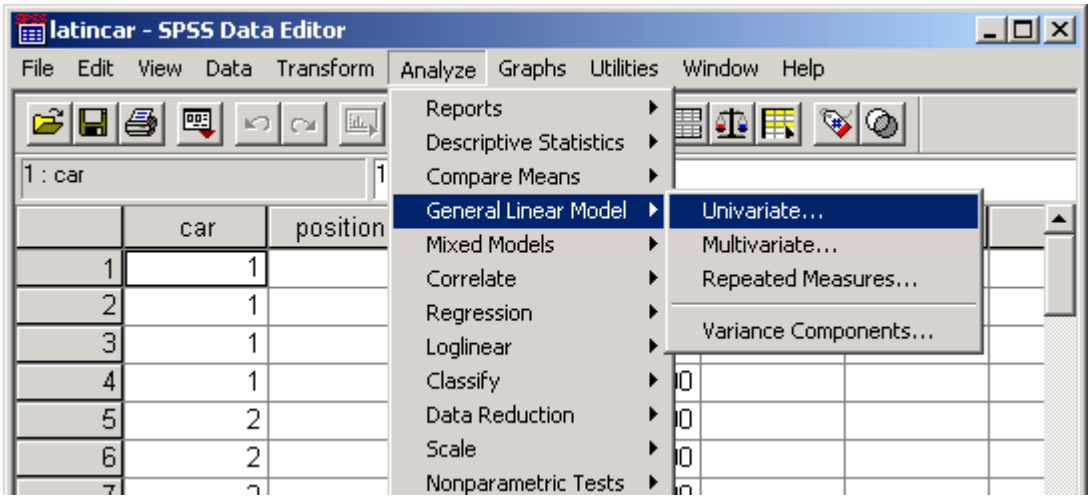
Data sheet with category labels.

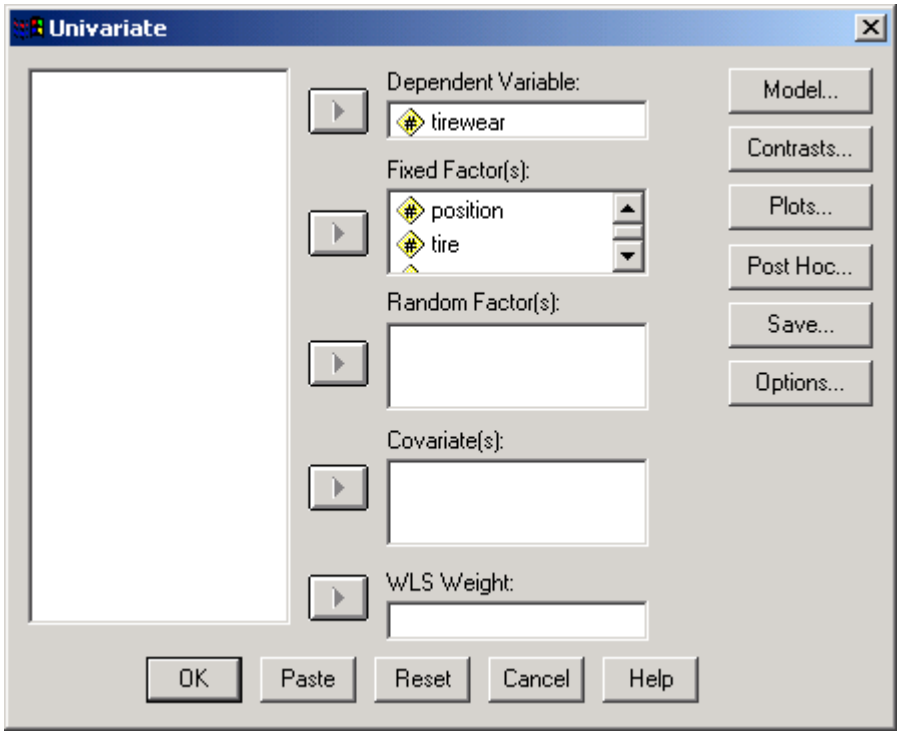
II. Hypothesis

The null hypotheses can be considered are: 1) there is no significant difference in average tire wearing between different tire positions, 2) there is no significant difference in average tire wearing between different cars used, 3) no significant difference in average tire wearing between different brands of tires.

III. Analysis

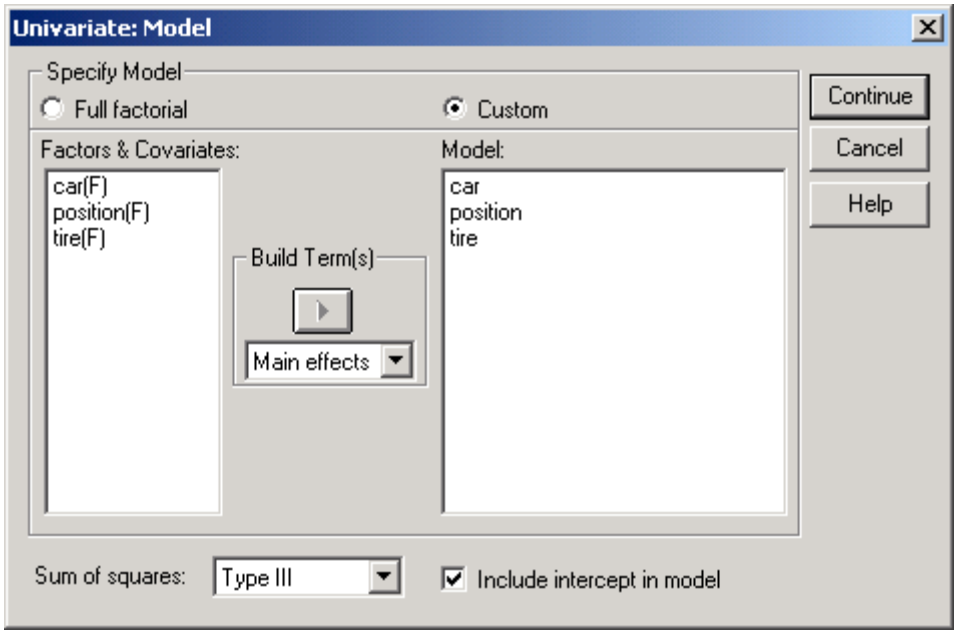
To perform the ANOVA for the Latin-Square design, click through **Analyze ⇒ General Linear Model ⇒ Univariate …** and select **tirewear** for the **Dependent Variable** box. Select **car, position** and **tire** to the **Fixed Factor(s)** box. Then, click **Model** in the upper right hand corner. In that dialogue box put the circle for **Custom** and then click **car, position** and **tire** over to the right hand box. In the middle, click the down arrow to **Main Effects**. Then click off the arrow in the box labeled **Include Intercept in Model**. Then hit **Continue**. For multiple comparisons, click **Post Hoc** and select the factors for performing multiple comparison procedure, and check on the box for selecting the method for comparisons (Tukey), and then click **Continue** and hit **OK**.



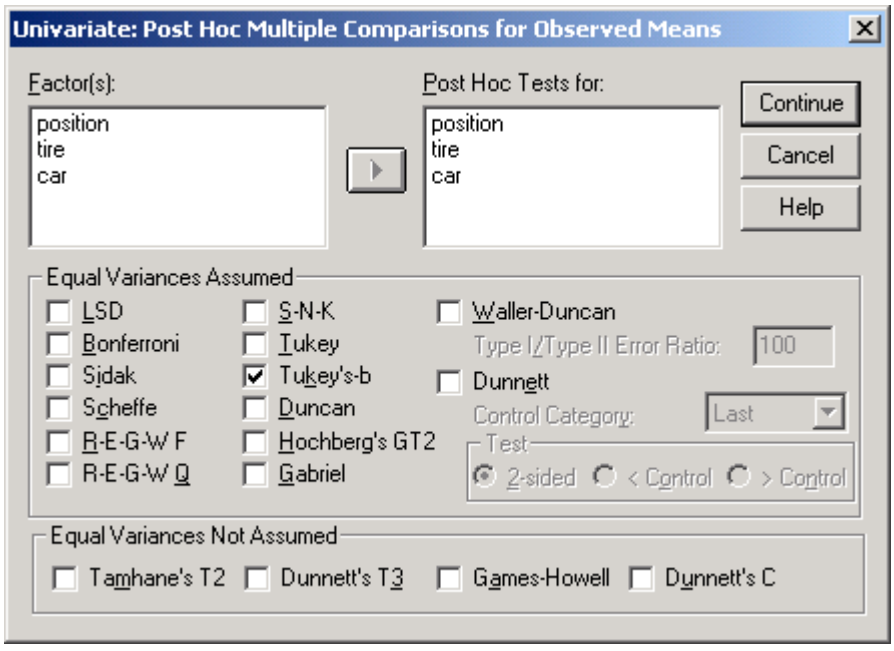


In the Univariate dialog box, select tirewear as the Dependent Variable and position, tire, and car as the Fixed Factors. Click the Model… button to specify the Three-way ANOVA model. Plots… and Post Hoc … buttons can be used for multiple comparisons as in other ANOVA procedures.

In the model specification window, check on Custom bullet and select all three factors in the model and use **Main effects** option to build the terms in the model as in the figure below. Then, click Continue button to complete the model specification.



For Post Hoc analysis, Tukey's-b procedure was chosen and all three factors were selected in the following figure.



ANOVA

Tests of Between-Subjects Effects

Dependent Variable: TIREWEAR

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Model	49854.500[a]	10	4985.450	19941.800	.000
CAR	2850.500	3	950.167	3800.667	.000
POSITION	133.500	3	44.500	178.000	.000
TIRE	645.500	3	215.167	860.667	.000
Error	1.500	6	.250		
Total	49856.000	16			

a. R Squared = 1.000 (Adjusted R Squared = 1.000)

Multiple Comparisons

Multiple Comparisons

Dependent Variable: TIREWEAR

Tukey HSD

(I) TIRE	(J) TIRE	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
A	B	.2500	.3536	.891	-.9739	1.4739
	C	-9.7500*	.3536	.000	-10.9739	-8.5261
	D	-14.5000*	.3536	.000	-15.7239	-13.2761
B	A	-.2500	.3536	.891	-1.4739	.9739
	C	-10.0000*	.3536	.000	-11.2239	-8.7761
	D	-14.7500*	.3536	.000	-15.9739	-13.5261
C	A	9.7500*	.3536	.000	8.5261	10.9739
	B	10.0000*	.3536	.000	8.7761	11.2239
	D	-4.7500*	.3536	.000	-5.9739	-3.5261
D	A	14.5000*	.3536	.000	13.2761	15.7239
	B	14.7500*	.3536	.000	13.5261	15.9739
	C	4.7500*	.3536	.000	3.5261	5.9739

Based on observed means.

*. The mean difference is significant at the .05 level.

TIREWEAR

Tukey HSD[a,b]

TIRE	N	Subset		
		1	2	3
B	4	47.5000		
A	4	47.7500		
C	4		57.5000	
D	4			62.2500
Sig.		.891	1.000	1.000

Means for groups in homogeneous subsets are displayed.
Based on Type III Sum of Squares
The error term is Mean Square(Error) = .250.

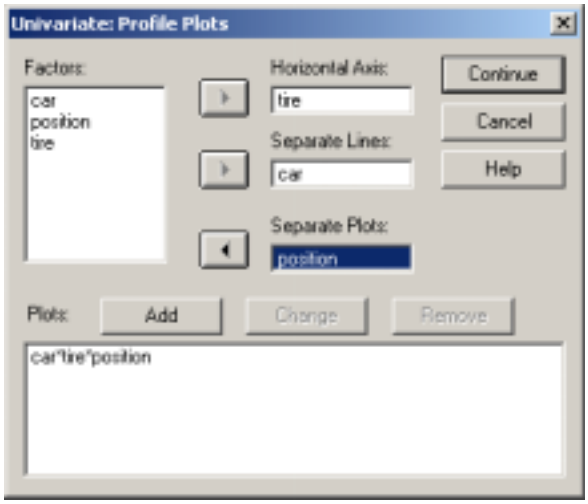
a. Uses Harmonic Mean Sample Size = 4.000.

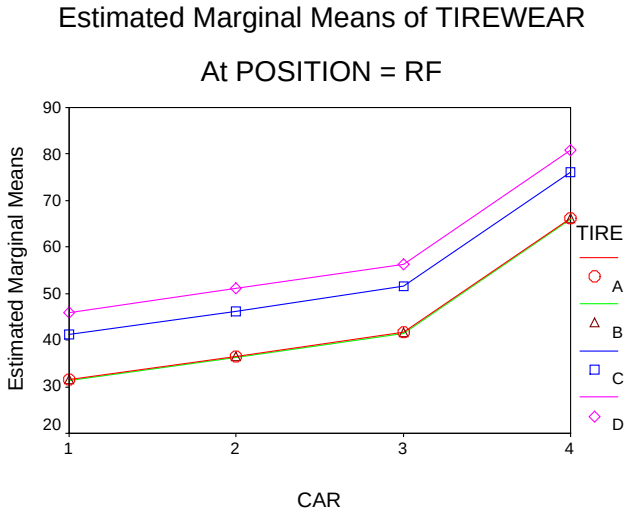
b. Alpha = .05.

From Tukey's multiple comparison procedure, there are three homogeneous subsets. There is no significant difference between tires brand A and brand B. C and D are different from each other and also significantly different from A and B. Similar interpretations can be done for other blocking factors, car and position variables.

Profile Plots

If one wishes to make profile plots, after click through **Analysis(Statistics)/General Linear Model/Univariate...**, in Univariate dialog box, click the **Plot…** button. Select the factors to make plots. To make a plot for comparing different tires used on different cars and also for different positions, in the following dialog box, select **tire** in **Horizontal Axis**, and select **car** for **Separate Lines**, and select **position** in **Separate Plots** for separate plots for each position.





One of the profile plots for tires on RF of the cars.

Residual Plots

To make residual plot, for examining the model assumptions, in Univariate dialog box of the General Linear Model option, click **Save** button, and check Unstandardized Predicted values and Unstandardized Residuals, and then click **Continue** and click **OK**. The unstandardized predicted values and unstandardized residuals will be placed in the data editor with names **pre_1** and **res_1**. Make a simple scatter plot with pre_1 for x-axis and res_1 for y-axis. The chart, with a Fit Total option checked, should look like the one shown below.