Factorial design (CRD-ab) tutorial

For this experiment we will have a 2 factor factorial design with each factor having 2 levels.

Problem description

Nitrogen dioxide (NO2) is an automobile emission pollutant, but less is known about its effects than those of other pollutants, such as particulate matter. Several animal models have been studied to gain an understanding of the effects of NO2. Sherwin and Layfield (1976) studied protein leakage in the lungs of mice exposed to 0.5 part per million (ppm) NO2 for 10, 12, and 14 days. Half of a total group of 36 animals were exposed to the NO2; the other half served as controls. Control and experimental animals were matched on the basis of weight, but this aspect will be ignored in the analysis since the matching did not appear to influence the results. The response is the percent of serum fluorescence. High serum fluorescence values indicate a greater protein leakage and some kind of insult to the lung tissue. The data is available at U:_MT Student File Area\hjkim\STAT375\SPSS tutorial\SerumFluorescence.sav.

	Serum fluorescence					
	10 Days	12 Days	14 days			
Control	143	179	76			
	169	160	40			
	95	87	119			
	111	115	72			
	132	171	163			
	150	146	78			
Exposed	152	141	119			
_	83	132	104			
	91	201	125			
	86	242	147			
	150	209	200			
	108	114	178			

In SPSS, the data should be entered the following manner.

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		SerumF	Exposed	Days	var
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14		40	0	3	
15		119	0	3	
16		72	0	3	
17		163	0	3	
18		78	0	3	
19		152	1	1	
20		83	1	1	
21		91	1	1	
22		86	1	1	
23		150	1	1	
24		108	1	1	
25		141	1	2	
26		132	1	2	
27		201	1	2	
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Analysis of Factorial Design

Now we can begin our analysis of the data. We click on Analyze-General Linear Model-Univariate in the pull down menus to start the process. This will take you to the Univariate window. We will need to define which of the variables is the dependent variable and which are the factor variables. After moving each of them to the proper field, we can choose several options from the menus.

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Profile Plot and Main effect plot

🖬 Univariate: Profile Plo	ts 💈
<u>Factors:</u> Exposed Days	Horizontal Axis: Days Separate Lines: Exposed Segarate Plots:
Plots: <u>A</u> dd	Change Remove
Exposed*Days	
Continue	Cancel Help

Univariate: Options	<u> </u>
Eactor(s) and Factor Interactions: (OVERALL) Exposed Days Exposed*Days	Display Means for: Cognpare main effects Cognidence interval adjustment: LSD(none)
Display	
☑ Descriptive statistics	Homogeneity tests
Estimates of effect size	Spread vs. level plot
Observed power	<u>R</u> esidual plot
Parameter estimates	Lack of fit
Contrast coefficient matrix	General estimable function
Significance level: .05 Confidence	e intervals are 95.0% ancel Help

Clicking on the **Plot** button will bring up the profile plot window. We can create both of the interaction plot (Exposed*Days and Days*Exposed) by placing each of the factors in on the respective axis and hitting the **Add** button. After defining the plots we hit **Continue** return to the **Univariate** window.

Note that by placing a factor to Horizontal Axis only, we can generate main effect plot. If there is no interaction effect, generating main effect plots will be useful.

Once in the **Univariate** window click on the **options** button to bring up the **Options** window. There are several available options but the ones that we will commonly use will be the descriptive statistics and Homogeneity tests. After clicking the appropriate box hit the **Continue** button and then the OK button on the **Univariate** window.

<u>Output</u>

Besides the usual descriptive statistics you will see output for Levene's test of equal variance. Without going into the details of the test it checks the null hypothesis of equal variances using F test.

$$H_{_{o}}: \sigma_{_{1}}^{^{2}} = \sigma_{_{2}}^{^{2}} = \sigma_{_{3}}^{^{2}} = \sigma_{_{4}}^{^{2}}$$
 $H_{_{A}}:$ At least one variance is different

By looking at the p-value (Sig) we can see if the null is rejected. As P-value is greater than .05, we would not reject the null hypothesis, but instead conclude that there is no evidence that the variances are unequal.

Levene's Test of Equality of Error Variances^a

Dependent Variable:SerumF

F	df1	df2	Sig.
.904	5	30	.491

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + Exposed + Days + Exposed * Days

The standard ANOVA from SPSS contains several lines that we will not use for our analysis. I suggest deleting those lines from the output. This can easily be done by double clicking on the ANOVA in the output window, which bring up the editor mode. Use your mouse to highlight the desired lines and hit delete. After cleaning up the output you should be left with the ANOVA as we typically use it. We begin by checking to see if there are significant interactions amongst the factors. We see that the interaction (Exposed*Days) is not significant, (p-value= .086), so we should check to see if the main effects of Exposed or Days are significant. The profile plots are not exactly parallel, but they are not too far away from parallel.

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Exposed	4356.000	1	4356.000	2.840	.102
Days	11867.389	2	5933.694	3.868	.032
Exposed * Days	8184.500	2	4092.250	2.668	.086
Error	46019.000	30	1533.967		
Corrected Total	70426.889	35			

Dependent Variable:SerumF

a. R Squared = .347 (Adjusted R Squared = .238)





We see that the main effect Exposed is not significant (p-value = .102) but Days is significant (p-value = .032). The main effect plot is generated by going back to plot option.

🔛 Univariate: Profile Plots 🛛 🔀	Estimated Naccinel Manager of Sources
Exposed Horizontal Axis:	
Days Separate Lines:	2 155-
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Continue Cancel Help	110- 10 Days 12 Days 14 Days Days

Post Hoc Test

LSD, HSD, and Scheffe's s will be used as a post hoc test. The post hoc test is need to be done only for Days since it is only significant factor. By clicking **post hoc** in **Univariate** window, you will see post hoc window. Place Days to the **Post Hoc Tests for** and clck LSD, Tukey, and Scheffe. This will generate output including the following homogeneous subsets.

Factor(s):		Post Hoc Tests for:		
Exposed		Days		
Days		•		
Equal Variance	es Assumed			
	<u>s-N-K</u>	VValler-Duncan		
Bonferroni	V Tukey	Type I/Type II Error Ratio: 100		
Sidak	Tu <u>k</u> ey's-b	Dunn <u>e</u> tt		
Scheffe	Duncan	Control Category: Last		
<u>R</u> -E-G-W-F	Hochberg's GT2	Test		
R-E-G-W-Q	<u>G</u> abriel	● 2-sided ○ < Control ○ > Control		
Equal Variance	es Not Assumed 2 Dunnett's T <u>3</u>	Games-Howell Dunnett's C		
	Continue	Cancel Help		

Homogeneous subsets

		Serunn		
	_		Sul	oset
	Days	Ν	1	2
Tukey HSDª	14 Days	12	118.42	
	10 Days	12	120.83	120.83
	12 Days	12		158.08
	Sig.		.987	.067
Scheffe ^a	14 Days	12	118.42	
	10 Days	12	120.83	
	12 Days	12	158.08	
	Sig.		.061	

0

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Means for groups in homogeneous subsets are displayed. Based on observed means.

The error term is Mean Square(Error) = 1533.967.

a. Uses Harmonic Mean Sample Size = 12.000.

Note: If there is an interaction effect, doing post hoc test is a little bit more complicated. First, you need make a new column in data window for interaction that will recognize all the different combinations. To make a new column, say interaction, go do **Transform** and **Compute** as below. It will bring **Compute Variable** window.



Put variable name in **Target variable**. Click **If** button at the bottom of the **Compute Variable** window. This will bring **Compute variable**: **If case window**

Function group:

CDF & Noncentral CDF Conversion

Current Date/Time

Date Arithmetic

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Arithmetic

Compute Variable: If Co	ises	 ○ Include gli cases ⊙ Include it case satisfies condition: Exposed = 0 & Days = 1 	E E
			Functions group: Al Artimetic COF & Noncentral COF Conversion Current Date/Time Date Artimetic Penctions and Special Variables:
🚾 Compute Variable			X

Numeric Expression

• < > 7 8 9

- <= >= 4 5 6

* = ~= 1 2 3

OK Paste Reset Cancel Help

** ~ () Delete 🗲

+

Click **Include if case satisfies condition** and write the condition as the picture in the left side. Click **Continue**.



Repeat this for all possible treatment combination. Here, 2*3 = 6 groups should be defined.

Then run post hoc test (Analyze-General Linear Model- Univariate) for interaction.

Again, the current dataset do not have a significant interaction, thus this step is not necessary.

Exposed = 0 & Days = 1

Target Variable: Interaction

SerumF Exposed Days

Type & Label...