9. Comparing Means Using Factorial ANOVA

Objectives

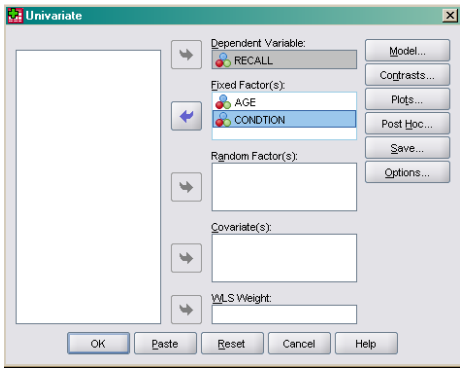
- ♦Examine main effects and interactive effects
- ♦Calculate effect size
- ♦Calculate multiple comparisons for main effects
- ♦Calculate simple effects for interactive effects
- ♦Display means graphically

Factorial ANOVA using GLM Univariate

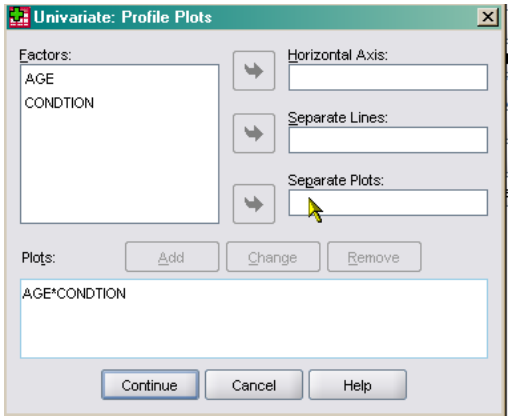
A Factorial ANOVA is an analysis of variance that includes more than one independent variable and calculates main effects for each independent variable and calculates interactive effects between independent variables. To calculate Factorial ANOVAs in SPSS we will use the General Linear Model again. Let's try an example together. We will use the extension of the Eysenck study described in the textbook in Chapter 17. Now there are 2 independent variables, condition and age, being considered in relation to the dependent variable, recall.

✔ **Open** *Eysenck recall factorial.sav*.

✔ Select **Analyze/General Linear Model/Univariate**. Univariate means there is only one dependent variable.

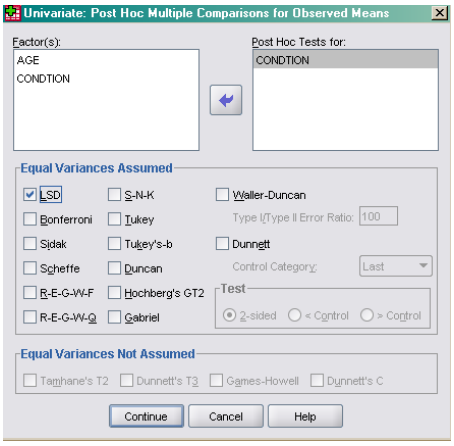


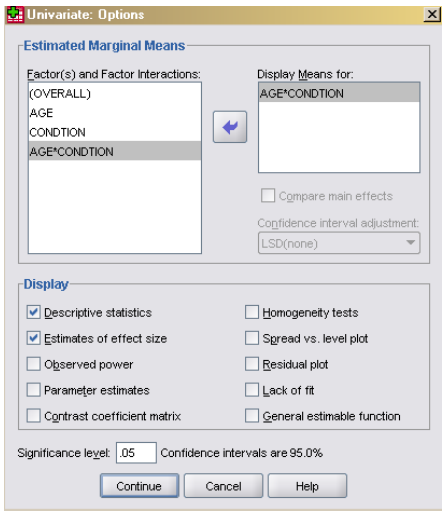
✔ Select recall as the **Dependent Variable**. Select age and condition as the **Fixed Factors** or independent variables. Then click on **Plots**.



- Since we are testing 3 effects, 2 main and one interactive, we may want to display 3 different graphs. First, select age for the **Horizontal Axis** and click **Add**. Then, select condition for the **Horizontal Axis** and click **Add**. Finally, select condition as the **Horizontal Axis** and age for **Separate Lines** to illustrate any interactive effect. I want to organize the interactive graph this way because I think it will be easier to interpret 2 lines representing the age groups than 5 separate lines representing the conditions. Click **Continue**.

- Click on **Post Hoc**. Since age only has 2 levels, there is no need to calculate multiple comparisons. If the effect is significant it can only mean the older and younger groups differ. Condition has 5 levels, so select it in **Post Hoc Tests for**. Select **LSD** as the procedure. Then, click **Continue**.





- Click **Options**. Select **Display Means for** and choose Age*Condtion. Select **Descriptive Statistics** and **Estimates of Effect Size** under **Display**. Then, click **Continue**, and finally, **Ok**. The output

Between-Subjects Factors

		Value Label	N
AGE	1	Older	50
	2	Younger	50
CONDITIO	1	Counting	20
	2	Rhyming	20
	3	Adjective	20
	4	Imagery	20
	5	Intentional	20

Descriptive Statistics

Dependent Variable: RECALL

AGE	CONDITIO	Mean	Std. Deviation	N
Older	Counting	7.00	1.83	10
	Rhyming	6.90	2.13	10
	Adjective	11.00	2.49	10
	Imagery	13.40	4.50	10
	Intentional	12.00	3.74	10
	Total	10.06	4.01	50
Younger	Counting	6.50	1.43	10
	Rhyming	7.60	1.96	10
	Adjective	14.80	3.49	10
	Imagery	17.60	2.59	10
	Intentional	19.30	2.67	10
	Total	13.16	5.79	50
Total	Counting	6.75	1.62	20
	Rhyming	7.25	2.02	20
	Adjective	12.90	3.54	20
	Imagery	15.50	4.17	20
	Intentional	15.65	4.90	20
	Total	11.61	5.19	100

Tests of Between-Subjects Effects

Dependent Variable: RECALL

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared
Corrected Model	1945.490[a]	9	216.166	26.935	.000	.729
Intercept	13479.210	1	13479.210	1679.536	.000	.949
AGE	240.250	1	240.250	29.936	.000	.250
CONDITIO	1514.940	4	378.735	47.191	.000	.677
AGE * CONDITIO	190.300	4	47.575	5.928	.000	.209
Error	722.300	90	8.026			
Total	16147.000	100				
Corrected Total	2667.790	99				

a. R Squared = .729 (Adjusted R Squared = .702)

Post Hoc Tests

CONDTION

Multiple Comparisons

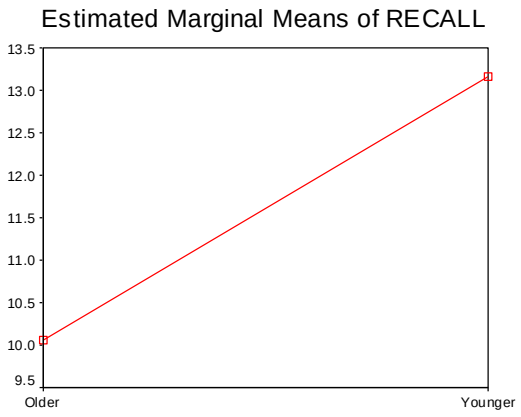
RECALL
LSD

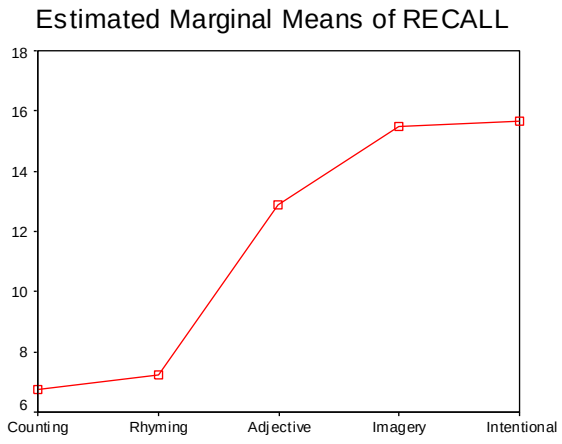
(I) CONDTION	(J) CONDTION	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1	2	-.50	.896	.578	-2.28	1.28
	3	-6.15*	.896	.000	-7.93	-4.37
	4	-8.75*	.896	.000	-10.53	-6.97
	5	-8.90*	.896	.000	-10.68	-7.12
2	1	.50	.896	.578	-1.28	2.28
	3	-5.65*	.896	.000	-7.43	-3.87
	4	-8.25*	.896	.000	-10.03	-6.47
	5	-8.40*	.896	.000	-10.18	-6.62
3	1	6.15*	.896	.000	4.37	7.93
	2	5.65*	.896	.000	3.87	7.43
	4	-2.60*	.896	.005	-4.38	-.82
	5	-2.75*	.896	.003	-4.53	-.97
4	1	8.75*	.896	.000	6.97	10.53
	2	8.25*	.896	.000	6.47	10.03
	3	2.60*	.896	.005	.82	4.38
	5	-.15	.896	.867	-1.93	1.63
5	1	8.90*	.896	.000	7.12	10.68
	2	8.40*	.896	.000	6.62	10.18
	3	2.75*	.896	.003	.97	4.53
	4	.15	.896	.867	-1.63	1.93

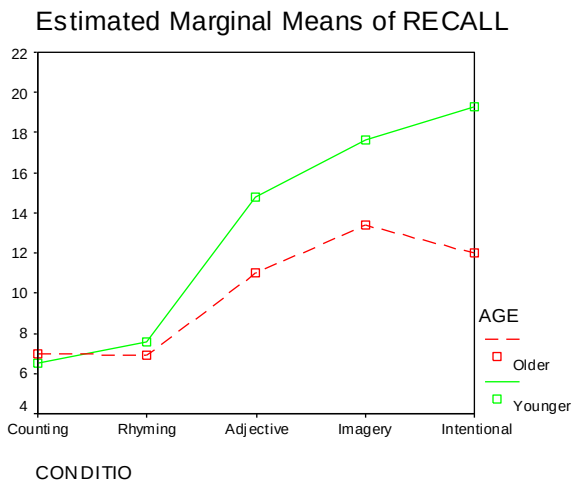
Based on observed means.
The error term is Mean Square(Error) = 8.026.

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

Profile Plots







✔ Compare this output to the results presented in the text.

As you can see, most of these results are in agreement. However, this is not the case for effect size. The reason is that SPSS calculates partial eta squared which is different from the computation in the text. SPSS uses the following equation:

$\frac{SS_A}{SS_{error} + SS_A}$ where A refers to an independent variable. The result will be the same as eta squared if there is only one independent variable because the denominator would equal SS_{total}, but will differ when there are multiple independent variables. That explains why the eta squared calculated in the previous chapter was in agreement with the value in the text. This leaves us with 3 options: either report the adjusted eta squared, figure out another way to calculate eta squared with SPSS, or calculate eta squared by hand. You can use **Compare Means/Means** to calculate eta squared for the main effects. See if you can remember how. (But you still don't have any of the **d**-family measures, and I don't know any way to get them except by hand.)

✔ Select **Analyze/Compare Means/Means**. Select recall for the **Dependent List**, and age and condition in Layer 1 of the **Independent List**. Click **Options** and select **ANOVA table and eta**. Click **Continue** and **Ok**. Just the relevant output is displayed below.

Measures of Association

	Eta	Eta Squared
RECALL * AGE	.300	.090

Measures of Association

	Eta	Eta Squared
RECALL * CONDITIO	.754	.568

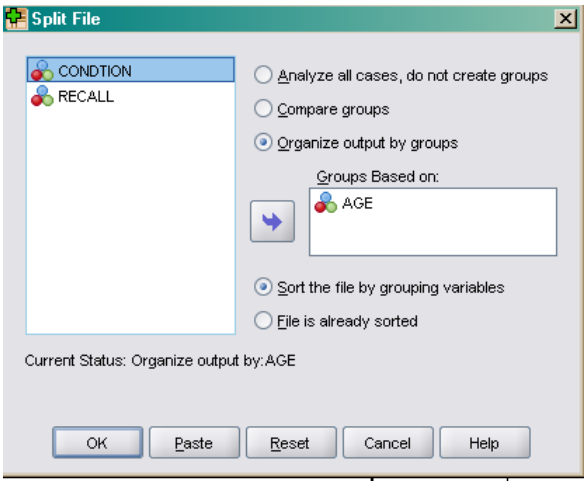
As you can see, these values agree with those in the text for age and condition. You would still need to calculate eta squared for the interaction between age and condition.

Simple Effects

Now that we know there is a significant interaction between age and condition, we need to calculate the simple effects to help us interpret the interaction. The easiest way to do this is to split the file using the **Data/Split File** menu selections. Then, we can re-run the ANOVA testing the effects one independent variable on the dependent variable at each level of the other independent variable. For example, we can see the effect of condition on recall for younger participants and older participants. Because we will most likely wish to run our significance test using MS_{error} from the overall ANOVA, we will have to perform some hand calculations. After we get the new MS values for condition in each group, we will need to divide them by MS_{error} from the original analysis as noted in the text.

- In Data Editor View, click on **Data/Split file**.

- Select **Organize output by groups**, and select age for **Groups Based on**. Then, click **Ok**.



- Now, we are going to calculate the effect of condition on recall for each age group, so select **Analyze/Compare Means/One-Way ANOVA**.

- Select recall as the **Dependent Variable** and condition as the **Factor**. Then click **Continue**. There is no need to use Options to calculate means or create plots since we already did that when we ran the factorial ANOVA. So, click **Ok**. The output follows.

AGE = Older

ANOVA[a]

RECALL

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	351.520	4	87.880	9.085	.000
Within Groups	435.300	45	9.673		
Total	786.820	49			

a. AGE = Older

AGE = Younger

ANOVA[a]

RECALL

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1353.720	4	338.430	53.064	.000
Within Groups	287.000	45	6.378		
Total	1640.720	49			

a. AGE = Younger

✔ Compare $MS_{condition}$ (between groups) in the above tables to those presented in the text. As you can see, they are in agreement. Now, divide them by the MS_{error} from the original ANOVA, 8.026. The calculations follow.

$$F_{conditions\ at\ old} = \frac{87.88}{8.026} = 10.95 \qquad F_{conditions\ at\ young} = \frac{338.43}{8.026} = 42.15$$

Thus, we end up with the same results. Although we had to perform some hand calculations, having SPSS calculate the mean square for conditions for us certainly simplifies things.

In this chapter you learned to calculate Factorial ANOVAs using GLM Univariate. In addition, you learned a shortcut to assist in calculating simple effects. Complete the following exercises to better familiarize yourself with these commands and options.

Exercises

1. Using *Eysenck factorial.sav*, calculate the simple effects for age at various conditions and compare them to the data in Table 17.4. [Hint: Split the file by condition now, and run the ANOVA with age as the independent variable.]

2. Use the data in *adaptation factorial.sav* to run a factorial ANOVA where group and education are the independent variables and maternal role adaptation is the dependent variable. Compare your results to Table 17.5 in the textbook.

3. Create a graph that illustrates the lack of an interactive effect between education and group on adaptation from the previous exercise.