Multi factorial ANOVA

ANalysis Of VAriance

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The General Linear Model Univariate

- The general linear model is an extension of multiple linear regression for a single dependent variable .
- Provides regression analysis and analysis of variance for one dependent variable by one or more factors and/or variables.
- Can investigate interactions between factors as well as the effects of individual factors, the effects of covariates and covariate interactions with factors.

Extended GLM Procedures

- Single outcome variable
  - GLM Univariate
    - One-way ANOVA, two-way ANOVA, Multi-factorial ANOVA
    - ANCOVA
- Single outcome variable measured at fixed time intervals
  - GLM Repeated Measures
- Multiple outcome variables
  - GLM Multivariate
    - MANOVA

ANOVA

- One way ANOVA:
  - To test the differences of one continuous variable between one categorical variable >2 groups.
- Two way ANOVA:
  - To test the effects of 2 categorical independent variables on one continuous dependent variable.
- Multi factorial ANOVA:
  - To test the effects of >2 categorical independent variables on one continuous dependent variable.

ONE-WAY ANOVA

ONE-WAY ANOVA

- Used to determine the effect of a single factor on one numerical outcome (dependent variable).
- To compare the means of more than 2 groups of an independent variable.
- For factors with 2 categories that compare means of 2 groups, Independent t-test is preferred.
- By logic can do independent t-test for each of pair but it will increase the type 1 error.

Variation

- Representation of the spread of scores
- The sum of the squares of the deviations between a value and the mean of the value
- Between group variance in relation to within group variance.
  - Individual differences
  - Which group you are in
- F = between group variation / within group variation
- When the groups are systematically different from one another, between group > within group variance

Concept F Ratio

- F = between group variation / within group variation
- **Within groups**
  - for each data value we look at the difference between that value and the mean of its group
  - variability or differences in particular groups (individual differences) =residual=error
- **Between groups**
  - for each data value look at the difference between its group mean and the overall mean
  - differences depending what group one is in or what treatment is received =group=treatment

F Statistic

- The ANOVA F-statistic is a ratio of the Between Group Variation divided by the Within Group Variation
- Sampling distribution of F ratio skewed to right.
- If variability between groups is large relatively to the variability within groups, the F statistic will large, thus p value would be small [the result is significant]

Assumptions

- Random samples
- Observations are independent

} By study design and method

- Normality of distribution
  - Larger sample size required (n=15 for each group)
  - Check for skewness of histogram
- Homogeneity of variance
  - Levene's test
  - If violated, use Dunnett's C procedure

Independent t test - comparing 2 means of a factor

Vitamin C
Placebo
→ number of days with cold symptoms

Factor → Dependent variable

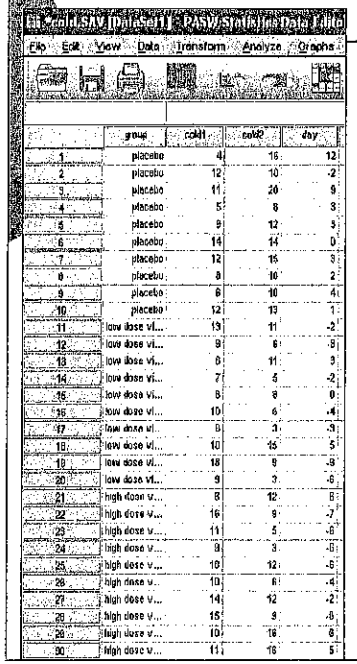
One-way ANOVA - comparing 3 or more means of a factor

Placebo
Low dose Vitamin C
High dose Vitamin C
→ number of days with cold symptoms

ONE-WAY ANOVA

- H_0: all population means are equal.
  H_0: ($\mu 1 = \mu 2 = \mu 3$)
- H_A: at least one population mean is different from the others.
  H_A: ($\mu 1 \neq \mu 2 \neq \mu 3$)
- ANOVA doesn't test that one mean is less than another, only whether they're all equal or at least one is different.

SPSS cold.sav

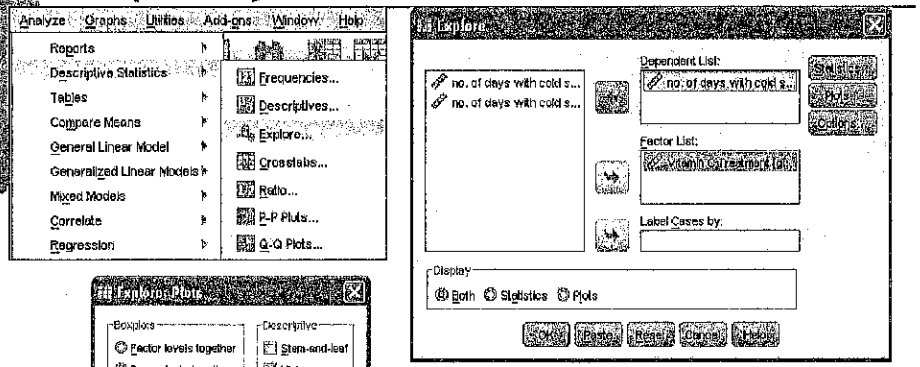


- Group
  - 1 = placebo
  - 2 = low dose Vitamin C
  - 3 = high dose Vitamin C
- Day = number of days with cold symptoms
  (second year - first year)

Research Questions

- Does the mean change in the number of days of cold symptoms differ among groups?
- Is there a relationship between the amount of Vitamin C taken and the change in the number of days of cold symptoms?

Explore your data

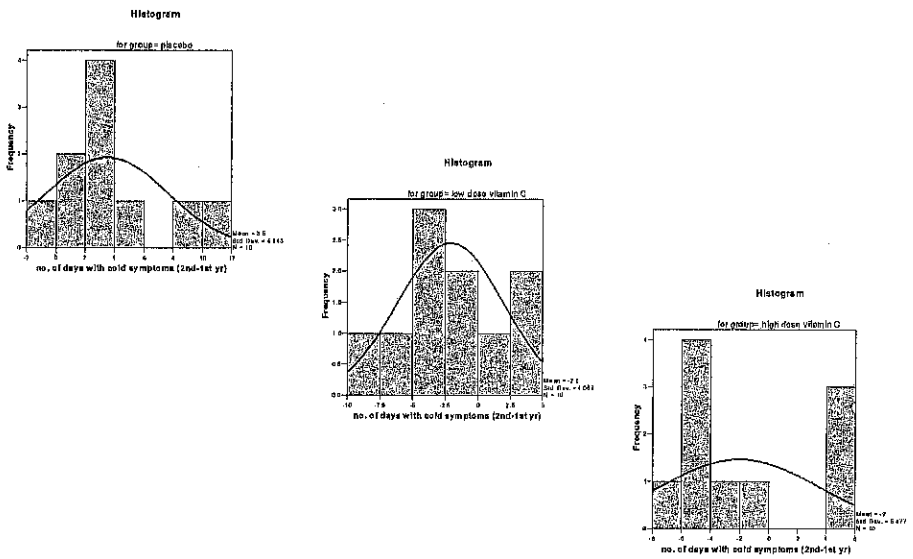


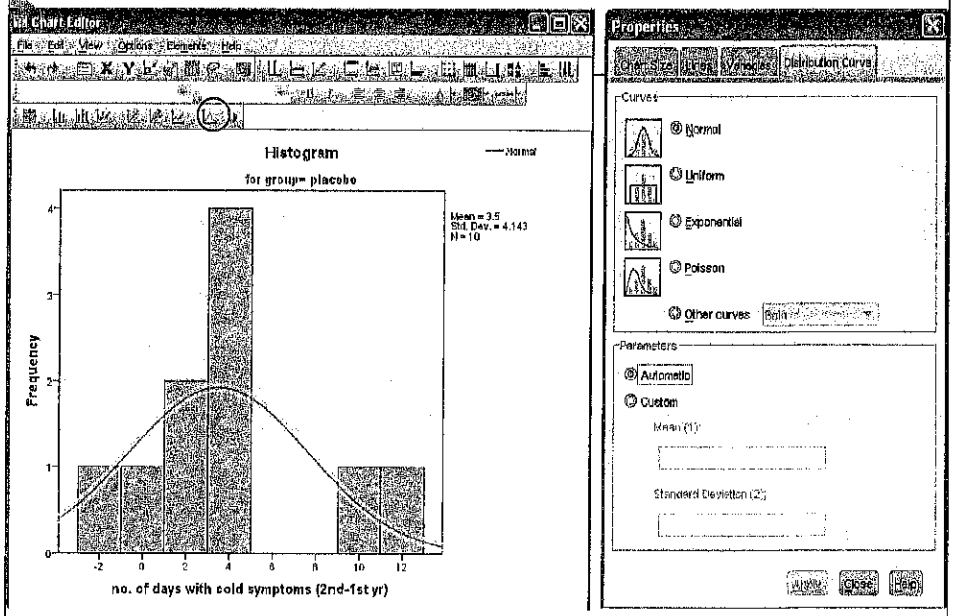
Output

Descriptives

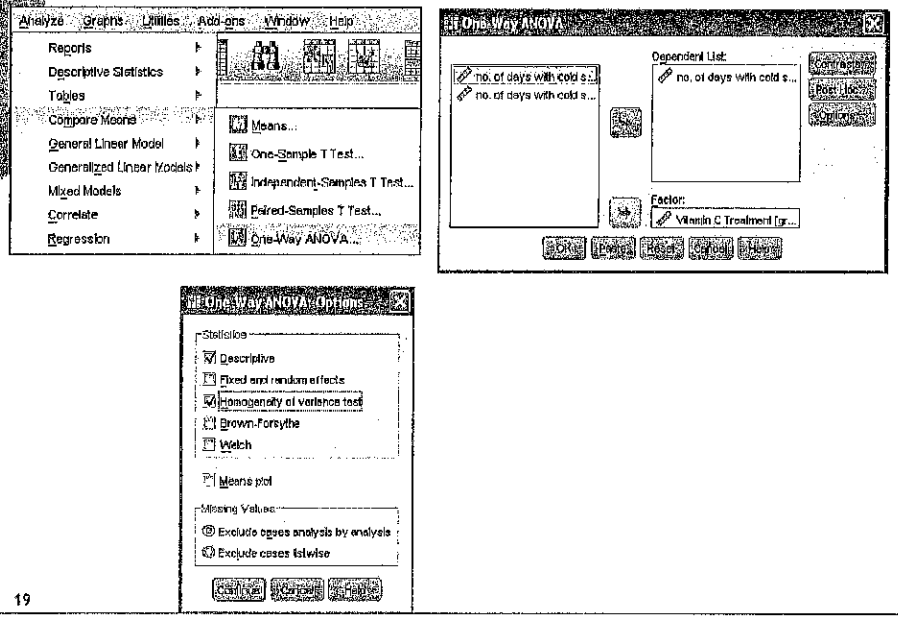
	Vitamin C Treatment			Statistic	Std. Error
no. of days with cold symptoms (2nd-1st yr)	placebo	Mean		3.60	1.310
		95% Confidence Interval for Mean	Lower Bound	.54	
			Upper Bound	6.46	
		5% Trimmed Mean		3.33	
		Median		3.00	
		Variance		17.167	
		Std. Deviation		4.143	
		Minimum		-2	
		Maximum		12	
		Range		14	
		Interquartile Range		6	
		Skewness		1.078	.687
		Kurtosis		1.028	1.334
	low dose vitamin C	Mean		-2.10	1.286
		95% Confidence Interval for Mean	Lower Bound	-5.01	
			Upper Bound	.81	
		5% Trimmed Mean		-2.11	
		Median		-2.50	
		Variance		16.544	
		Std. Deviation		4.067	
		Minimum		-9	
		Maximum		6	
		Range		14	
		Interquartile Range		6	
		Skewness		.214	.687
		Kurtosis		.245	1.334
	high dose vitamin C	Mean		-2.00	1.732
		95% Confidence Interval for Mean	Lower Bound	-5.92	
			Upper Bound	1.92	
		5% Trimmed Mean		-2.17	
		Median		-5.00	
		Variance		30.000	
		Std. Deviation		5.477	
		Minimum		-7	
		Maximum		8	
		Range		15	
		Interquartile Range		11	
		Skewness		.827	.687
		Kurtosis		-1.367	1.334

Assumption normality of distribution





SPSS Steps



Output

Descriptives

no. of days with cold symptoms (2nd-1st yr)

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
placebo	10	3.50	4.143	1.310	.54	6.46	-2	12
low dose vitamin C	10	-2.10	4.087	1.286	-5.01	.81	-9	5
high dose vitamin C	10	-2.00	5.477	1.732	-5.92	1.92	-7	6
Total	30	-.20	5.182	.946	-2.14	1.74	-9	12

Test of Homogeneity of Variances ← assumption

no. of days with cold symptoms (2nd-1st yr)

Levene Statistic	df1	df2	Sig.
1.343	2	27	.278

ANOVA

no. of days with cold symptoms (2nd-1st yr)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	205.400	2	102.700	4.836	.016
Within Groups	573.400	27	21.237		
Total	778.800	29			

Out of 778.8 variation, only 205.4 units explained

- **The mean change in the number of days of cold symptoms is significantly different among groups**

But which group??

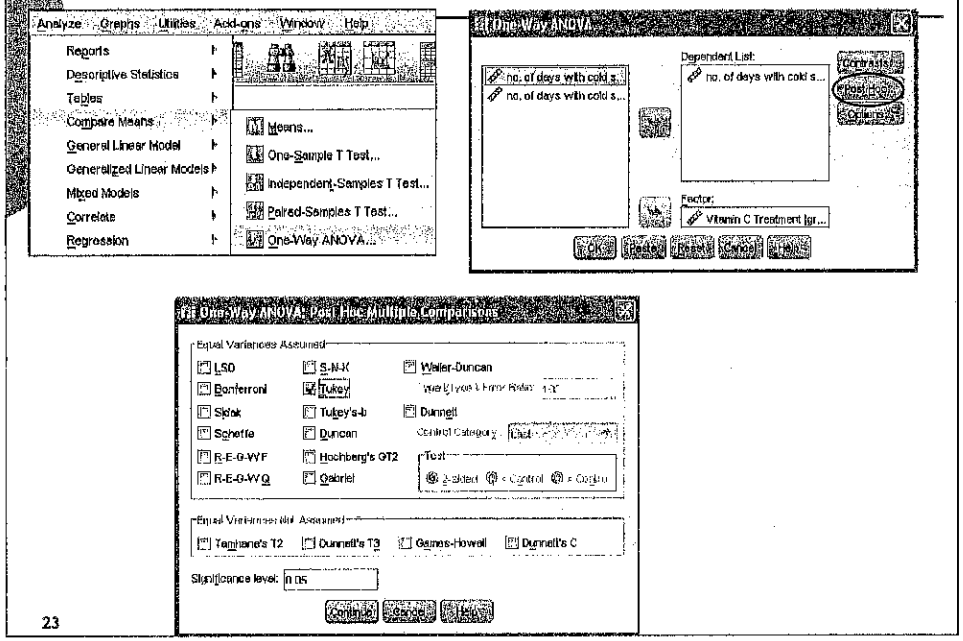
Post-hoc tests

- A significant F test does not tell which pairs of means are significantly different from one another.
- Need additional hypothesis tests to determine exactly which mean differences are significant.
- Called post hoc test / multiple comparison procedures / posteriori comparisons
- Which pair(s) that the significant differences lie?
  - ? $\mu_1 \neq \mu_2$, $\mu_1 \neq \mu_3$, $\mu_2 \neq \mu_3$
- Which post-hoc?
  - Scheffe test very strict, safest of all
  - Tukey HSD is more lenient, commonly used

Multiple Comparison Tests

- Bonferroni procedure
- Duncan Multiple range test
- Dunnett's multiple comparison test
- Scheffe's test
- Tukey's test

Post-hoc test



Post Hoc Tests

Multiple Comparisons

Dependent Variable: no. of days with cold symptoms (2nd-1st yr)
Tukey HSD

(I) Vitamin C Treatment	(J) Vitamin C Treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
placebo	low dose vitamin C	5.600*	2.061	.030	.49	10.71
	high dose vitamin C	5.500*	2.061	.033	.39	10.61
low dose vitamin C	placebo	-5.600*	2.061	.030	-10.71	-.49
	high dose vitamin C	-.100	2.061	.999	-5.21	5.01
high dose vitamin C	placebo	-5.500*	2.061	.033	-10.61	-.39
	low dose vitamin C	.100	2.061	.999	-5.01	5.21

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

no. of days with cold symptoms (2nd-1st yr)

Tukey HSD[a]

Vitamin C Treatment	N	Subset for alpha = .05	
		1	2
low dose vitamin C	10	-2.10	
high dose vitamin C	10	-2.00	
placebo	10		3.50
Sig.		.999	1.000

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 10.000.

Placebo vs low dose vitamin C, p=0.030

Placebo vs high dose vitamin C, p=0.033

High vs low doses vitamin C, p=0.999

How to report

Means and standard deviations of difference in number of days with cold symptoms

Vitamin C	Mean	SD	F-statistic (df)	p value
Placebo	3.50	4.14		
Low dose	-2.10	4.07	4.84 (2, 27)	0.016
High dose	-2.00	5.48		

Placebo vs low dose vitamin C, p=0.030

Placebo vs high dose vitamin C, p=0.033

High vs low doses vitamin C, p=0.999 (Tukey test)

- **The mean change in the number of days of cold symptoms is significantly different among groups.**
- **There is no significant relationship between the amount of Vitamin C taken and the change in the number of days of cold symptoms.**

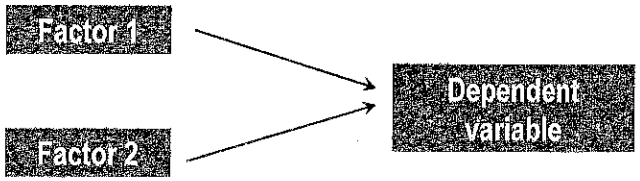
Steps multi-factorial ANOVA

- Step 1: Descriptive summary by mean/%
- Step 2: Bivariate exploration by one-way ANOVA / t test
- Step 3: Fit the model (no variable selection)
- Step 4: Checking interactions
- Step 5: Checking model assumption
  - Normality of residuals
  - Equal Variance
  - Overall Model Fitness
- Step 6: Post Hoc test
- Step 7: Interpretation & presentation of results

TWO-WAY ANOVA

Two-Way ANOVA

- To determine the effect of two factors (independent variables) on one numerical outcome (dependent variable).
-
- Each factor needs to have 2 or more levels.
- Same assumptions as one-way ANOVA.



Example

Method

Studying method 1

Studying method 2

Control

Gender

Male

Female

GPA

epa1.SAV [DataSet5] - PASW Statistics

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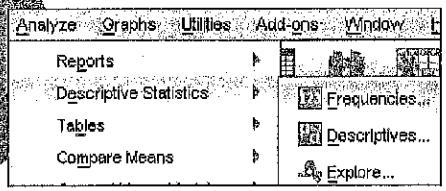
	gender	method	gpa
1	Male	Method 1	.25
2	Male	Method 2	1.00
3	Male	Control	.10
4	Male	Method 1	.20
5	Male	Method 2	.50
6	Male	Control	.15
7	Male	Method 1	.30
8	Male	Method 2	.80
9	Male	Control	.30
10	Male	Method 1	.90
11	Male	Method 2	.60
12	Male	Control	.20
13	Male	Method 1	.50
14	Male	Method 2	.60
15	Male	Control	.10
16	Male	Method 1	.40
17	Male	Method 2	.50
18	Male	Control	.20
19	Male	Method 1	.60
20	Male	Method 2	.60
21	Male	Control	.30
22	Male	Method 1	.50
23	Male	Method 2	.60
24	Male	Control	.40

Research questions

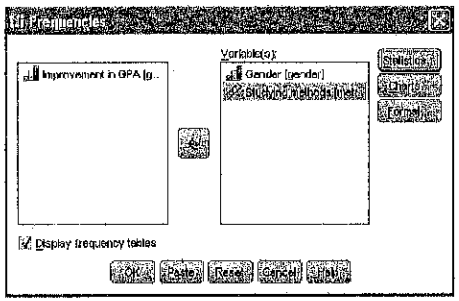
- First main effect
  - Do the means of GPA improvement differ among studying methods?
- Second main effect
  - Do the means of GPA improvement differ between gender?
- Interaction effect
  - Do the differences in the means of GPA improvement among the studying methods vary as a function of gender?

Step 1: Descriptive statistics



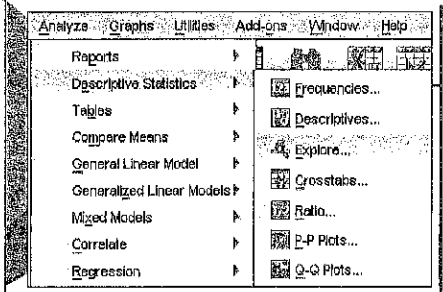
Gender

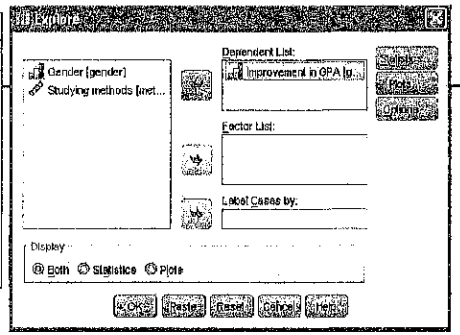
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	30	50.0	50.0	50.0
	Female	30	50.0	50.0	100.0
	Total	60	100.0	100.0	



Studying methods

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Method 1	20	33.3	33.3	33.3
	Method 2	20	33.3	33.3	66.7
	Control	20	33.3	33.3	100.0
	Total	60	100.0	100.0	





Descriptives

			Statistic	Std. Error
Improvement in GPA	Mean		.2867	.03220
	95% Confidence Interval for Mean	Lower Bound	.2222	
		Upper Bound	.3511	
	5% Trimmed Mean		.2741	
	Median		.2500	
	Variance		.062	
	Std. Deviation		.24938	
	Minimum		-.10	
	Maximum		1.00	
	Range		1.10	
	Interquartile Range		.40	
	Skewness		.665	.309
	Kurtosis		.012	.608

Step 2: Bivariate analysis

- Method vs GPA
- One-way ANOVA
- Gender vs GPA
- Independent *t* test

ANOVA

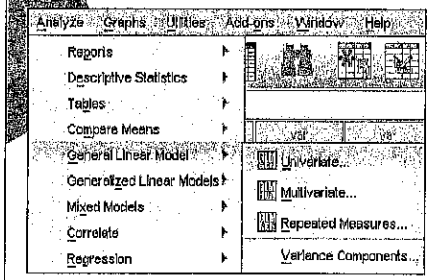
Improvement in GPA

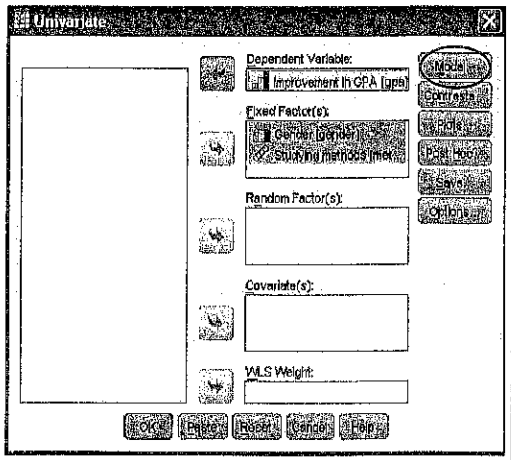
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.174	2	.587	13.410	.000
Within Groups	2.495	57	.044		
Total	3.669	59			

Independent Samples Test

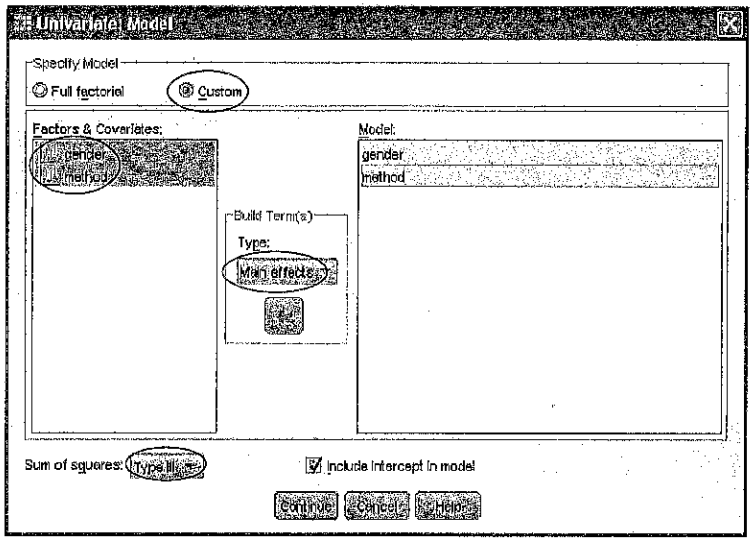
	t-test for Equality of M			
	t	df	Sig. (2-tailed)	Mean Difference
	3.104	58	.003	.16667
	3.104	51.894	.003	.16667

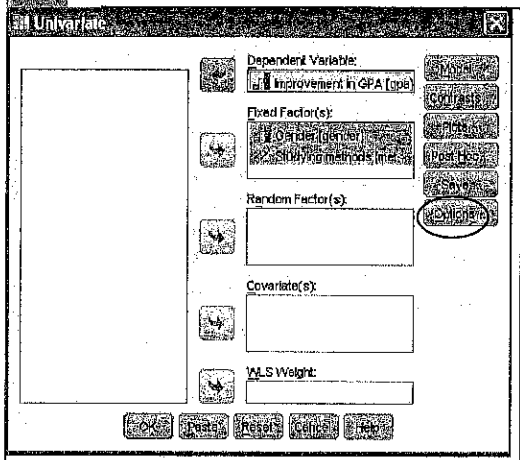
Step3: Fit the model

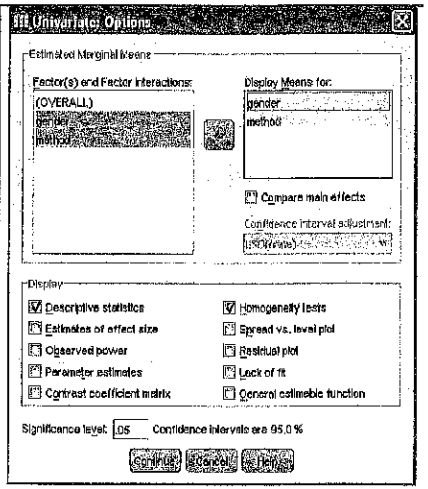




Main effects







Output

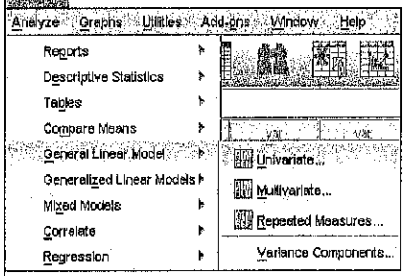
Tests of Between-Subjects Effects

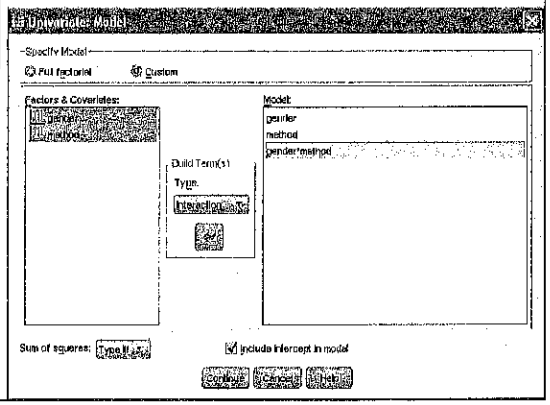
Dependent Variable: Improvement in GPA

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1.697[a]	3	.566	16.056	.000
Intercept	4.931	1	4.931	139.978	.000
gender	.523	1	.523	14.838	.000
method	1.174	2	.587	16.666	.000
Error	1.973	56	.035		
Total	8.600	60			
Corrected Total	3.669	59			

a. R Squared = .462 (Adjusted R Squared = .434)

Step 4: Check interaction





Check interaction

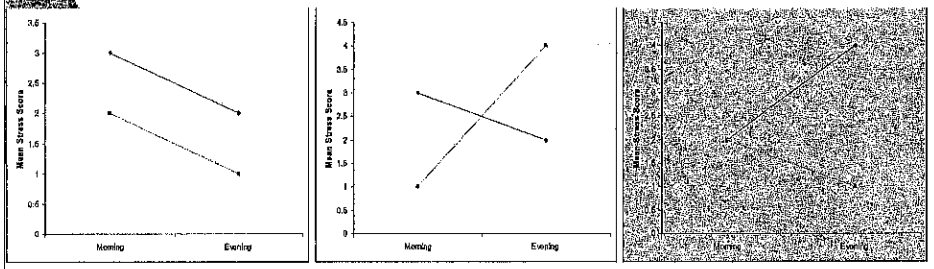
Tests of Between-Subjects Effects

Dependent Variable: Improvement in GPA

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1.889[a]	5	.378	11.463	.000
Intercept	4.931	1	4.931	149.582	.000
gender	.523	1	.523	15.866	.000
method	1.174	2	.587	17.809	.000
gender * method	.193	2	.096	2.921	.062
Error	1.780	54	.033		
Total	8.600	60			
Corrected Total	3.669	59			

a. R Squared = .515 (Adjusted R Squared = .470)

Interaction effects



No interaction | Cross interaction | Uncross interaction

Plot does not tell whether there is a significant interaction effect or not

- If the main effects are significant, should conduct follow up interaction effect test.
- If the interaction effect is significant, follow up tests should be conducted to evaluate simple main effect and interaction comparisons.
- If the interaction effect is not significant, need to focus on the main effect.

Step 5: Check assumption of homogeneity of variance

Levene's Test of Equality of Error Variances[a]

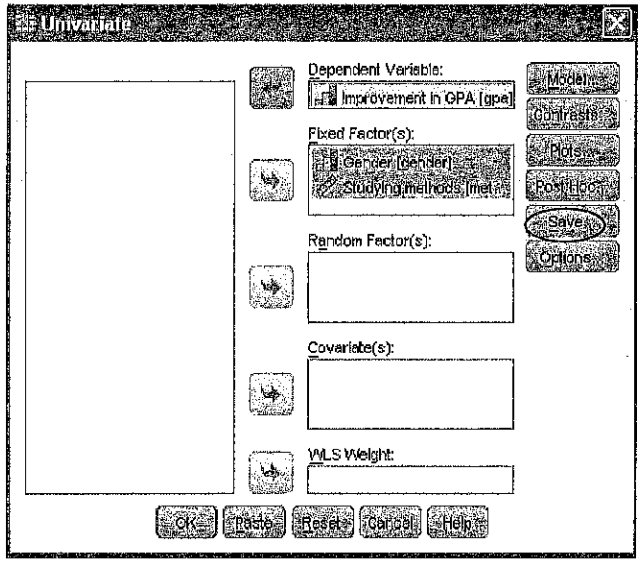
Dependent Variable:Improvement in GPA

F	df1	df2	Sig.
.450	5	54	.812

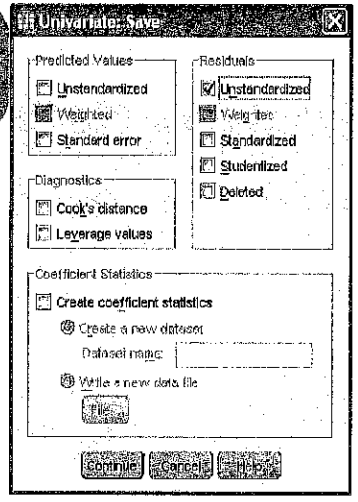
Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + gender + method

Step 5: check normality of residuals

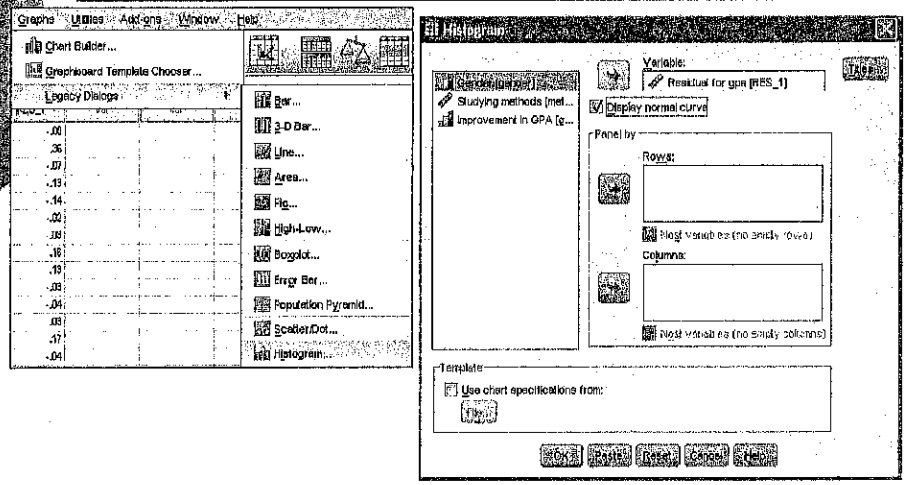


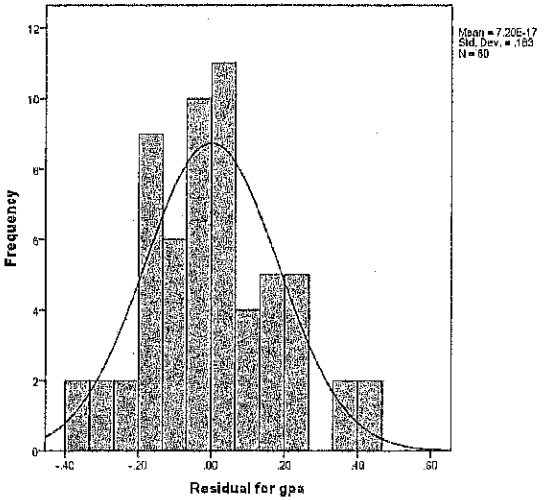
A new residual variable is created



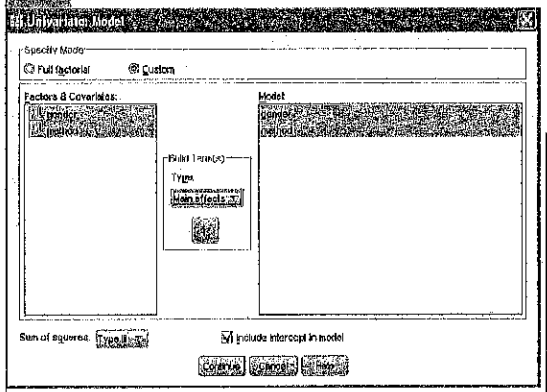
gender	method	gpa	RES_1
Male	Method 1	.25	-.08
Male	Method 2	1.00	.36
Male	Control	.10	-.07
Male	Method 1	.20	-.13
Male	Method 2	.50	-.14
Male	Control	.15	-.02
Male	Method 1	.30	-.03
Male	Method 2	.80	.16
Male	Control	.30	.13
Male	Method 1	.30	-.03
Male	Method 2	.60	-.04
Male	Control	.20	.03
Male	Method 1	.50	.17
Male	Method 2	.60	-.04
Male	Control	.10	-.07
Male	Method 1	.40	.07
Male	Method 2	.50	-.14
Male	Control	.20	.03
Male	Method 1	.60	.47
Male	Method 2	.80	.16
Male	Control	.30	.13
Male	Method 1	.50	.17
Male	Method 2	.80	-.04
Male	Control	.40	.23

Histogram of residual

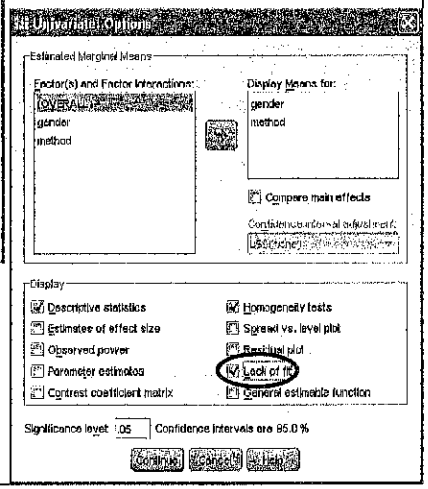




Step 5: check fitness of model



- Delete interaction



Lack of Fit Test

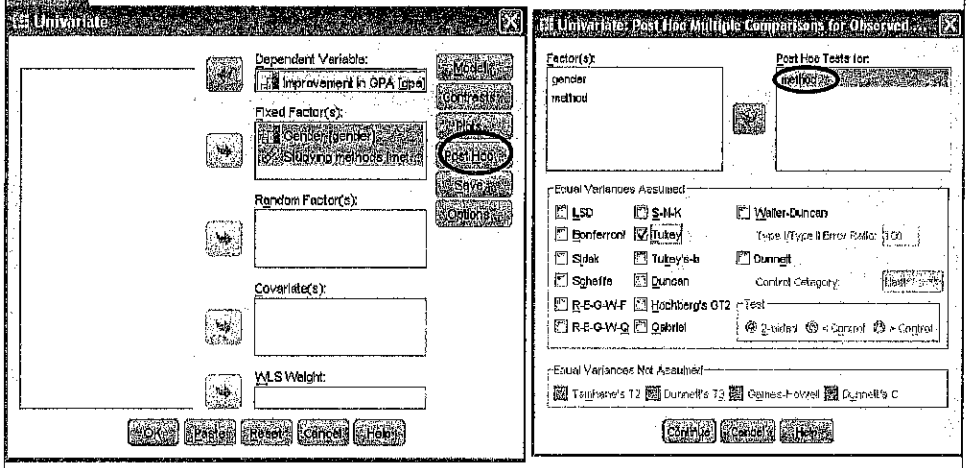
- H_0: Model is fit

Lack of Fit Tests

Dependent Variable: Improvement in GPA

Source	Sum of Squares	df	Mean Square	F	Sig.
Lack of Fit	.193	2	.096	2.921	.062
Pure Error	1.780	54	.033		

Step 6: Post Hoc test



Multiple Comparisons

Dependent Variable: Improvement in GPA

Tukey HSD

(I) Studying methods	(J) Studying methods	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Method 1	Method 2	-.2200*	.05741	.001	-.3584	-.0816
	Control	.1175	.05741	.111	-.0209	.2559
Method 2	Method 1	.2200*	.05741	.001	.0816	.3584
	Control	.3375*	.05741	.000	.1991	.4759
Control	Method 1	-.1175	.05741	.111	-.2559	.0209
	Method 2	-.3375*	.05741	.000	-.4759	-.1991

Based on observed means.

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

Improvement in GPA

Tukey HSD[a,b]

Studying methods	N	Subset	
		1	2
Control	20	.1350	
Method 1	20	.2525	
Method 2	20		.4725
Sig.		.111	1.000

Means for groups in homogeneous subsets are displayed.

Based on Type III Sum of Squares

The error term is Mean Square(Error) = .033.

a. Uses Harmonic Mean Sample Size = 20.000.

b. Alpha = .05.

Step 6: Interpretation

- No significant interaction between studying method and gender, F (2, 54) = 2.92, p = 0.062.
- Significant main effect for gender, F (1, 56) = 14.84, p < 0.001, male has a significantly higher mean GPA compared to female.
- Significant main effect for studying methods, F (2, 56) = 16.67, p < 0.001, students who practice studying method 2 has significantly higher mean GPA compared to those practice studying method 1 and control. But there was no significant difference in mean GPA between those practice method 1 and control.

Presentation eg graph

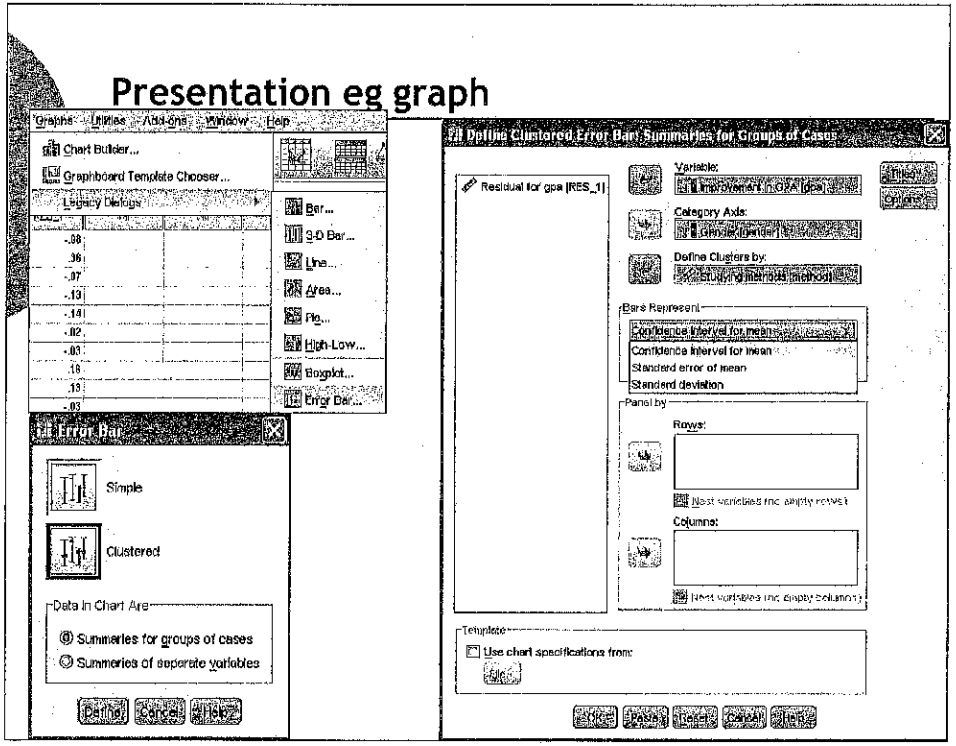
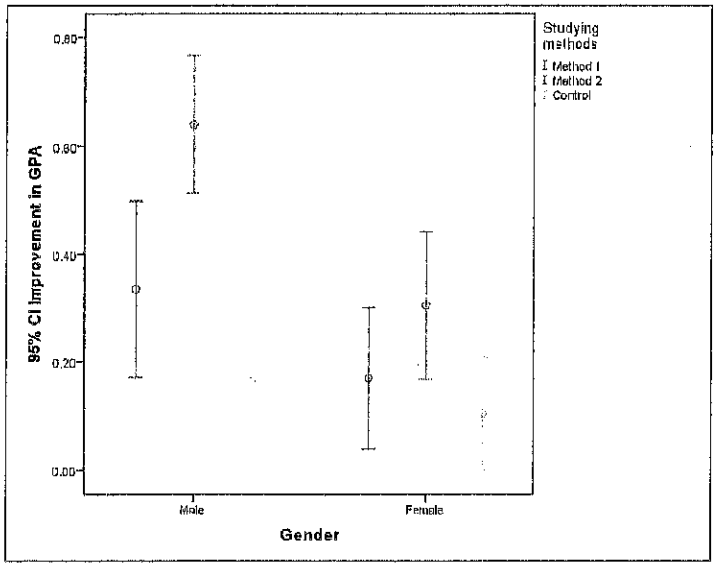


Figure 1. Mean improvement of GPA differences among studying methods and gender



Step 7: Presentation of results

Table 1. Adjusted mean and 95% confidence interval of the main effects of gender and studying method on the students' improvement of GPA

Factors		Adjusted mean (95% CI)	F statistic (df)	p value
Gender	Male	0.38 (0.31, 0.45)	14.839 (1,56)	<0.001
	Female	0.19 (0.12, 0.26)		
Studying method	Method 1	0.25 (0.17, 0.34)	16.666 (2,56)	<0.001
	Method 2	0.47 (0.39, 0.56)		
	Control	0.13 (0.05, 0.22)		

Studying method 1 vs studying method 2, p=0.001

Studying method 1 vs control, p=0.111

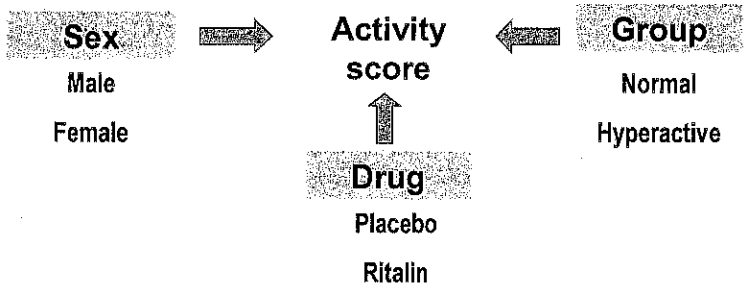
Studying method 2 vs control, p<0.001 (Tukey test)

Multi-factorial ANOVA

Multi-factorial ANOVA

- To determine the effect of multiple factors on one numerical outcome (dependent variable)

Research questions



- Effect of sex on the children's activity score
- Effect of group on the children's activity score
- Effect of drug on the children's activity score
- Effect of interaction – effect of Ritalin with the influence of group and sex

ritalin_3way.sav

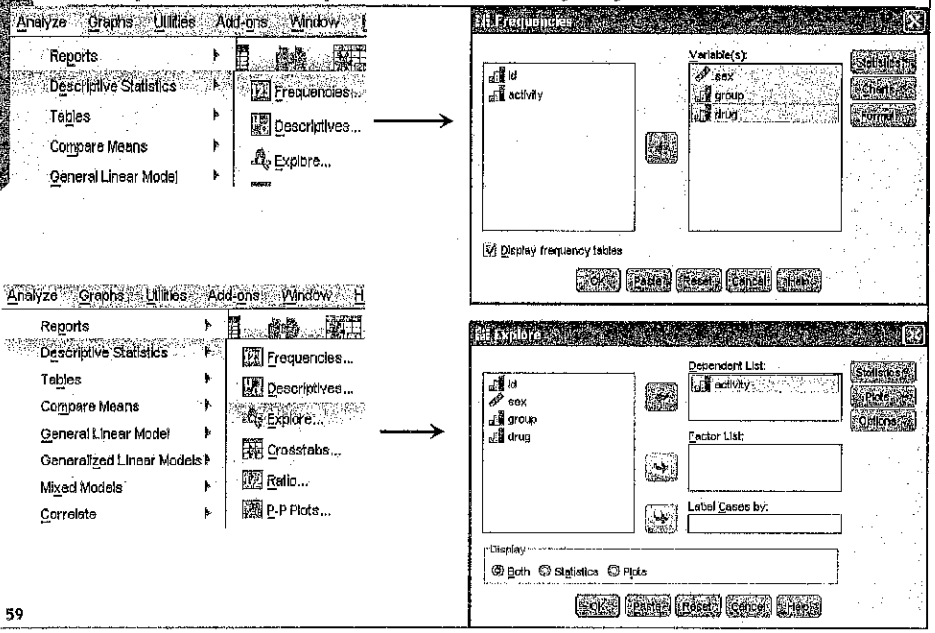
ritalin_3way.sav [DataSet6] - PASW Statistics Data Editor

File Edit View Data Transform Analyze Graphs Utilities

	id	sex	group	drug	activity
1	1	male	Normal	Placebo	67
2	2	male	Normal	Placebo	80
3	3	female	Normal	Placebo	58
4	4	female	Normal	Placebo	65
5	5	female	Normal	Ritalin	50
6	6	female	Normal	Ritalin	45
7	7	male	Normal	Ritalin	55
8	8	male	Normal	Ritalin	52
9	9	female	Hyperactive	Placebo	70
10	10	female	Hyperactive	Placebo	72
11	11	male	Hyperactive	Placebo	68
12	12	male	Hyperactive	Placebo	75
13	13	female	Hyperactive	Ritalin	51
14	14	female	Hyperactive	Ritalin	57
15	15	male	Hyperactive	Ritalin	48
16	16	male	Hyperactive	Ritalin	55

- Dependent variable is activity score
- Independent variable is effect of ritalin
- Sex, group of children are confounders (also independent variable)

Step 1: Descriptive summary by % or mean



sex

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	male	8	50.0	50.0	50.0
	female	8	50.0	50.0	100.0
	Total	16	100.0	100.0	

group

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Normal	8	50.0	50.0	50.0
	Hyperactive	8	50.0	50.0	100.0
	Total	16	100.0	100.0	

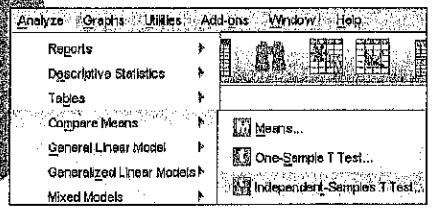
drug

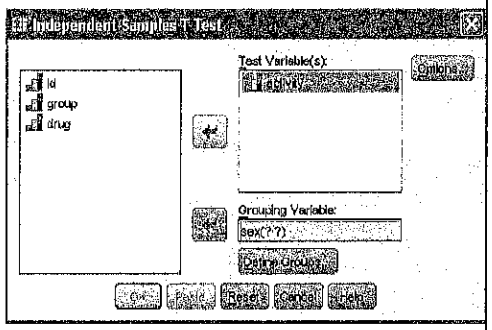
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Placebo	8	50.0	50.0	50.0
	Ritalin	8	50.0	50.0	100.0
	Total	16	100.0	100.0	

Descriptives

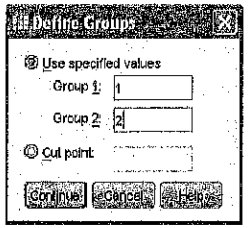
			Statistic	Std. Error
activity	Mean		59.25	2.305
	95% Confidence Interval for Mean	Lower Bound	54.34	
		Upper Bound	64.16	
	5% Trimmed Mean		59.17	
	Median		57.50	
	Variance		85.000	
	Std. Deviation		9.220	
	Minimum		45	
	Maximum		75	
	Range		30	
	Interquartile Range		17	
	Skewness		.226	.564
	Kurtosis		-1.184	1.091

Step 2: Bivariate exploration by one-way ANOVA / t test





Rerun the test for group & drug variables



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
sex		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference Lower	Upper
activity	Equal variances assumed	.026	.878	.315	14	.757	1.500	4.755	-8.698	11.698
	Equal variances not assumed			.315	13.952	.757	1.500	4.755	-8.701	11.701

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
group		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference Lower	Upper
activity	Equal variances assumed	3.259	.093	-1.212	14	.246	-5.500	4.540	-15.238	4.236
	Equal variances not assumed			-1.212	12.720	.248	-5.500	4.540	-16.329	4.329

Independent Samples Test

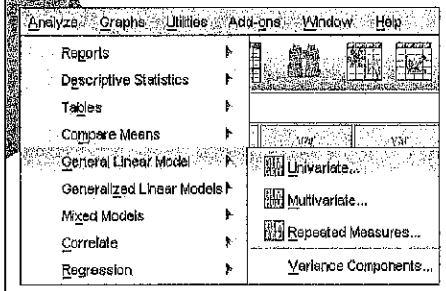
		Levene's Test for Equality of Variances		t-test for Equality of Means						
drug		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference Lower	Upper
activity	Equal variances assumed	.828	.379	6.146	14	.000	15.250	2.481	9.926	20.572
	Equal variances not assumed			6.146	12.465	.000	15.250	2.481	9.866	20.634

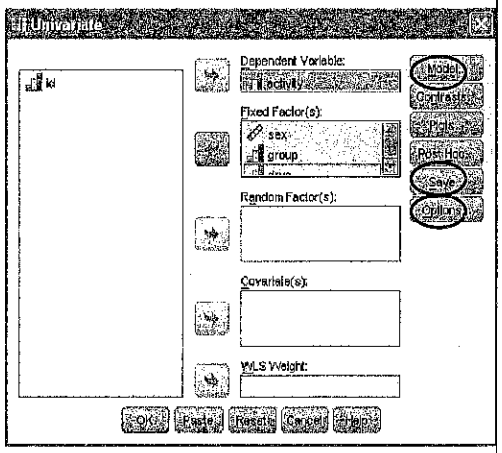
Create table yourself

Effects of study factors on activity score using independent *t* test

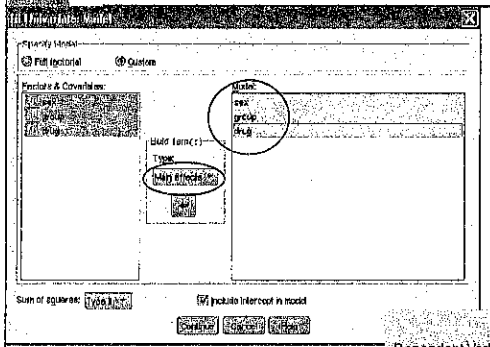
Factors		n	Mean (SD)	Mean diff. (95% CI)	T stat (df)	P value
Sex	Male	8	60.0 (9.2)	1.5 (-8.7,11.7)	0.315 (14)	0.757
	Female	8	58.5 (9.8)			
Group	Normal	8	56.5 (7.5)	-5.5 (-15.2,4.2)	-1.212 (14)	0.246
	Hyperactive	8	62.0 (10.4)			
Drug	Placebo	8	66.9 (5.8)	15.2 (9.9,20.6)	6.146 (14)	<0.001
	Ritalin	8	51.6 (3.9)			

Step 3: Fit the model (no variable selection)





The main effects



Check the main effect first

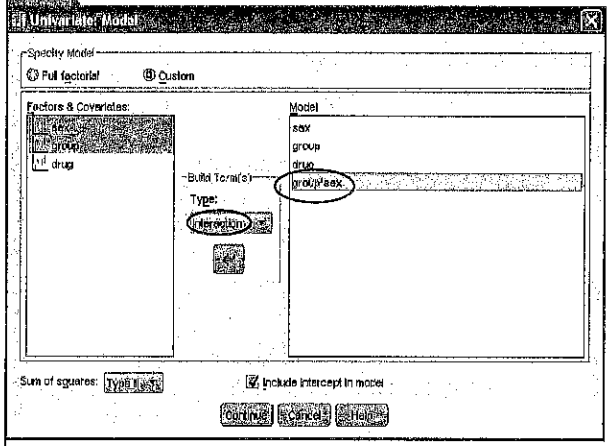
Tests of Between-Subjects Effects

Dependent Variable:activity

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1060.250[a]	3	353.417	19.749	.000
Intercept	56169.000	1	56169.000	3138.664	.000
sex	9.000	1	9.000	.503	.492
group	121.000	1	121.000	6.761	.023
drug	930.250	1	930.250	51.991	.000
Error	214.750	12	17.896		
Total	57444.000	16			
Corrected Total	1275.000	15			

a. R Squared = .832 (Adjusted R Squared = .789)

Step 4: Checking interactions



Rerun the test for all possible two-way interactions (3 pairs).

Check one by one:

1. sex*group
2. sex*drug
3. group*drug

Checking interactions

Tests of Between-Subjects Effects

Dependent Variable:activity

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1102.500[a]	4	275.625	17.576	.000
Intercept	56169.000	1	56169.000	3581.791	.000
sex	9.000	1	9.000	.574	.465
group	121.000	1	121.000	7.716	.018
drug	930.250	1	930.250	59.320	.000
group * drug	42.250	1	42.250	2.694	.129
Error	172.500	11	15.682		
Total	57444.000	16			
Corrected Total	1275.000	15			

a. R Squared = .865 (Adjusted R Squared = .818)

Tests of Between-Subjects Effects

Dependent Variable:activity

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1102.500[a]	4	275.625	15.728	.000
Intercept	56169.000	1	56169.000	3256.174	.000
sex	9.000	1	9.000	.522	.485
group	121.000	1	121.000	7.014	.023
drug	930.250	1	930.250	53.928	.000
sex * group	25.000	1	25.000	1.449	.254
Error	172.500	10	17.250		
Total	57444.000	15			
Corrected Total	1275.000	14			

a. R Squared = .865 (Adjusted R Squared = .797)

Tests of Between-Subjects Effects

Dependent Variable:activity

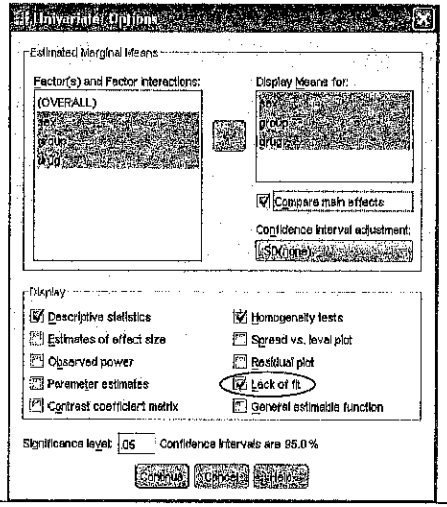
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1060.250[a]	3	353.417	19.749	.000
Intercept	56169.000	1	56169.000	3138.664	.000
group	121.000	1	121.000	6.761	.023
drug	930.250	1	930.250	51.991	.000
sex * drug	.250	1	.250	.013	.912
Error	214.500	11	19.500		
Total	57444.000	15			
Corrected Total	1275.000	14			

a. R Squared = .832 (Adjusted R Squared = .771)

None of the interactions are significant

Step 5: Checking model assumption:

1. Homogeneity of variance
2. Fitness of model



Levene's Test of Equality of Error Variances[a]

Dependent Variable: activity

F	df1	df2	Sig.
.130	7	8	.993

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

a. Design: Intercept+sex+group+drug

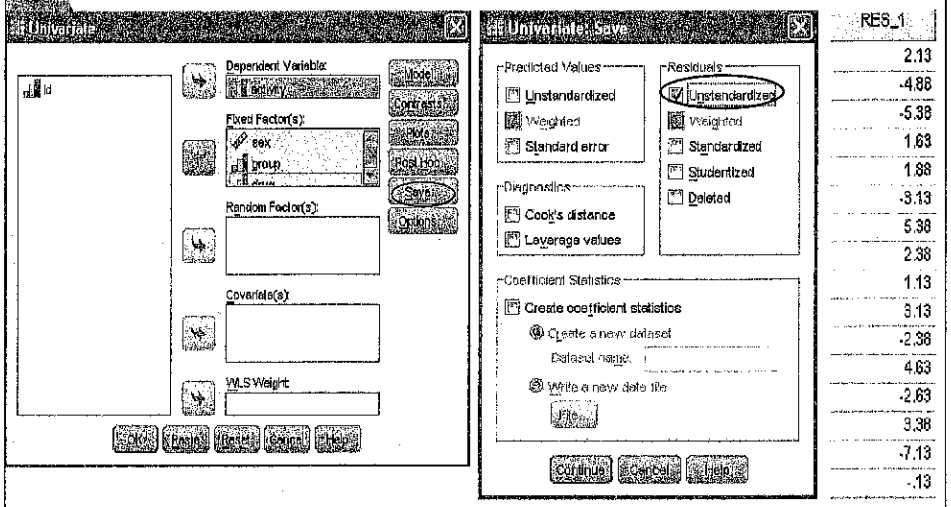
Lack of Fit Tests

Dependent Variable: activity

Source	Sum of Squares	df	Mean Square	F	Sig.
Lack of Fit	79.750	4	19.938	1.181	.388
Pure Error	135.000	8	16.875		

Non-significant results mean assumptions are met

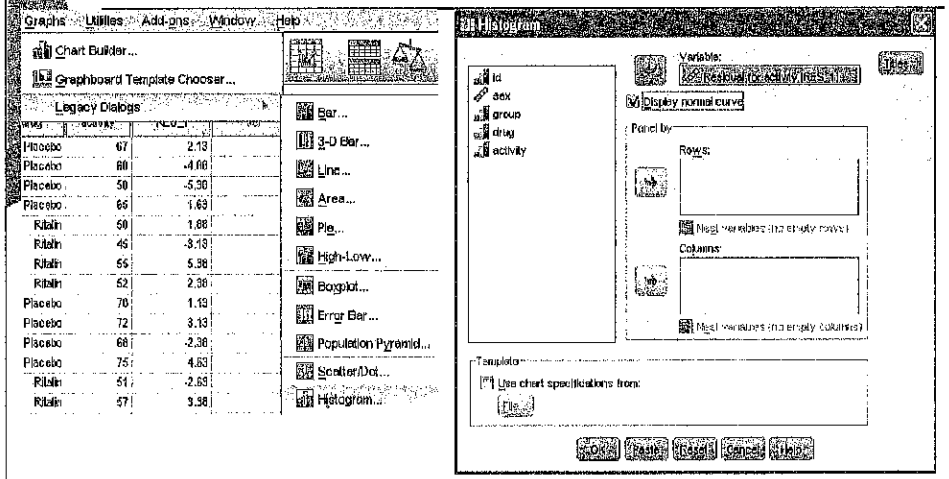
Step 5: Checking model assumption: Normality of residuals



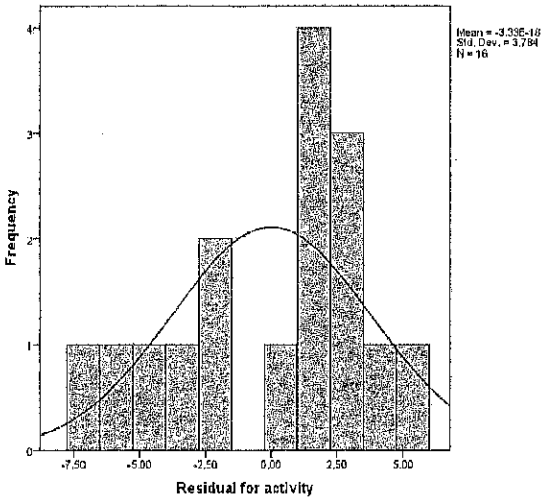
RES_1
2.13
-4.88
-5.38
1.63
1.88
-3.13
5.38
2.38
1.13
3.13
-2.38
4.63
-2.63
9.38
-7.13
-.13

Look at data view: A new variable is created

Checking normality of residuals



Look for the curve, ? skewed



Step 6: Post Hoc test not applicable

Step 7: Interpretation

Tests of Between-Subjects Effects

Dependent Variable: activity

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1060.250[a]	3	353.417	19.749	.000
Intercept	56169.000	1	56169.000	3138.664	.000
sex	9.000	1	9.000	.503	.492
group	121.000	1	121.000	6.761	.023
drug	930.250	1	930.250	51.981	.000
Error	214.750	12	17.896		
Total	57444.000	16			
Corrected Total	1275.000	15			

a. R Squared = .832 (Adjusted R Squared = .789)

Estimates

Dependent Variable: ACTIVITY

SEX	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
male	60.000	1.496	56.741	63.259
female	58.500	1.496	55.241	61.759

Estimates

Dependent Variable: ACTIVITY

GROUP	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Normal	56.500	1.496	53.241	59.759
Hyperactive	62.000	1.496	58.741	65.259

Estimates

Dependent Variable: ACTIVITY

DRUG	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Placebo	66.875	1.496	63.616	70.134
Ritalin	51.625	1.496	48.366	54.884

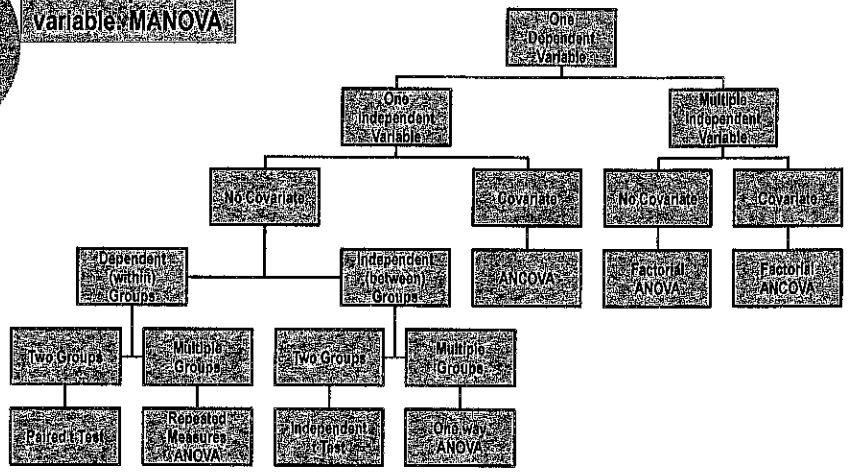
Step 7: Presentation of results

Table 1. Adjusted mean and 95% confidence interval of the main effects of sex, group of children and type of drug on the children's activity score

Factors		Adjusted mean (95% CI)	F statistic	p value
Sex	Male	60.0 (56.7, 63.3)	0.503	0.492
	Female	58.5 (55.2, 61.8)		
Group	Normal	56.5 (53.2, 59.8)	6.761	0.023
	Hyperactive	62.0 (58.7, 65.3)		
Drug	Ritalin	51.6 (48.4, 54.9)	51.891	<0.001
	Placebo	66.9 (63.6, 70.1)		

Summary

>one dependent variable: MANOVA



Thank you