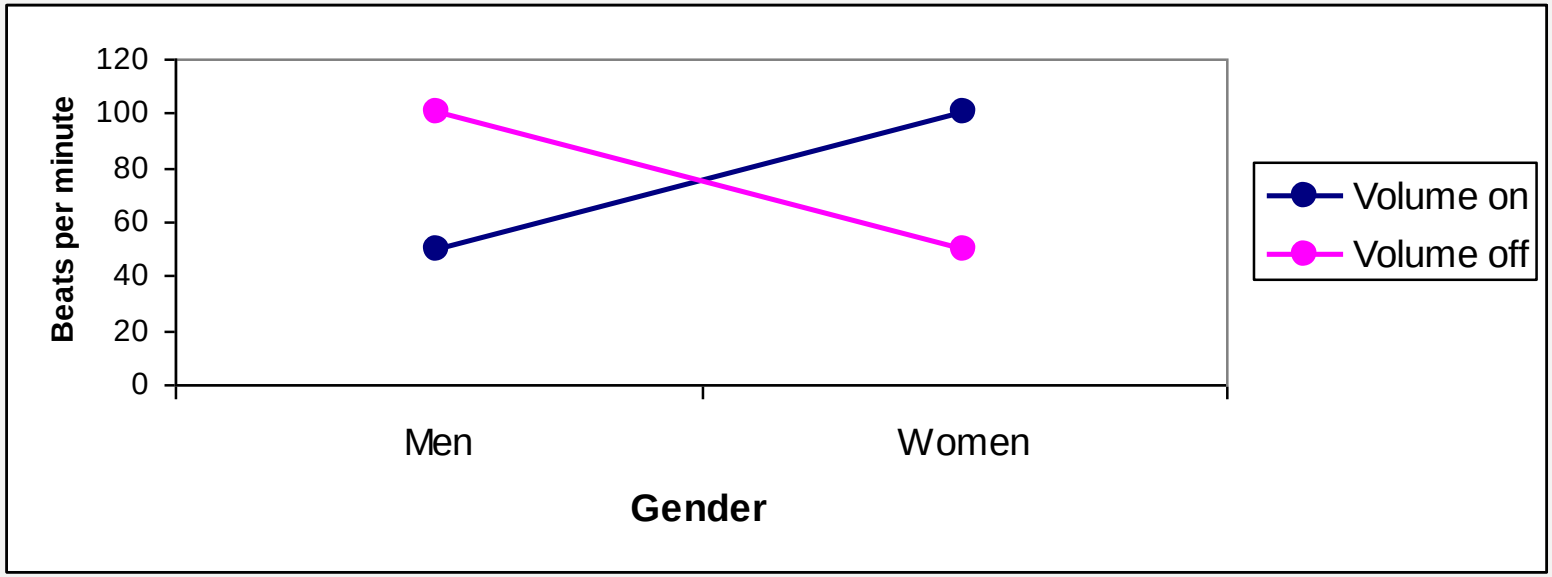
EXAMPLE 1:

When the volume is on, heart rates are higher for women than for men, but when the volume is off, women have lower heart rates than men.

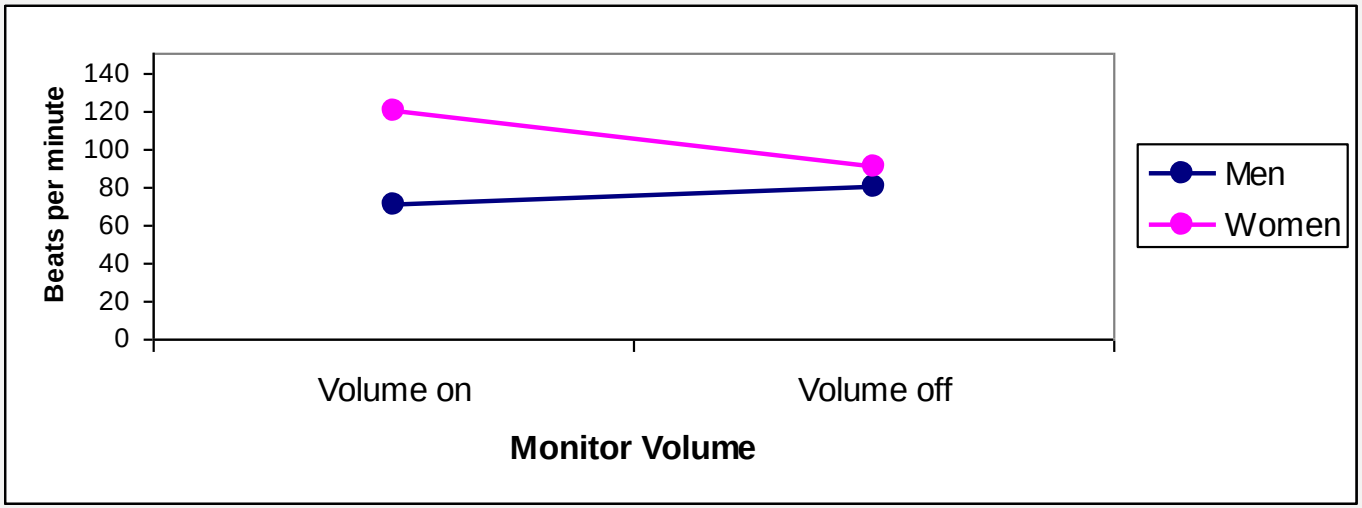
So it is not true that women's heart rates are the same as men's heart rates, as you might have concluded if you only looked at the main effect.



EXAMPLE 2:

Maybe when the volume is on, women's heart rates are higher than men, but when the volume is off, women and men have similar heart rates.

So it is not true that women's heart rates are always higher, as you might have concluded if you only looked at the main effect



In those cases, your write up should emphasize the patterns seen in the interaction, and not the main effects.

SAMPLE WRITE UPS FOR EXAMPLES 1 AND 2

Although the main effect of [IV] on [DV] was significant, F(df, df) = x.xx, p < .xxx, there was a significant interaction between [IV1] and [IV2], F(dfIV1xIV2, dferror) = x.xx, p < .xxx.

The describe the patterns, incorporating CELL MEANS & SDs into the sentence:

EXAMPLE 1:

When the volume of the monitor was on, women's average heart rate (M=x.xx, SD=x.xx) was higher than men's average heart rate (M=x.xx, SD=x.xx).

However, when the volume was off, women's heart rates (M=x.xx, SD=x.xx) were lower than men's heart rates (M=x.xx, SD=x.xx), on average.

EXAMPLE 2:

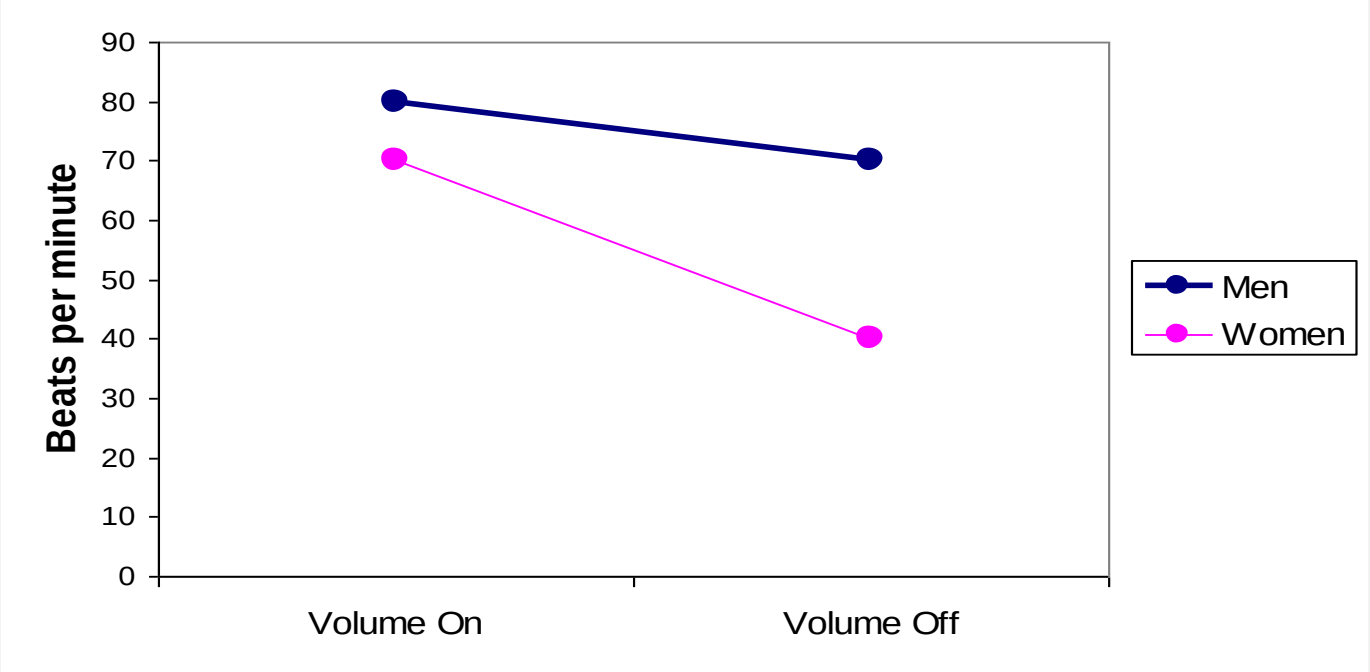
When the volume of the monitor was on, women's average heart rate (M=x.xx, SD=x.xx) was higher than men's average heart rate (M=x.xx, SD=x.xx).

However, when the volume was off, women's heart rates (M=x.xx, SD=x.xx) did not differ from men's heart rates (M=x.xx, SD=x.xx), on average.

EXAMPLE 3:

What happens if you examine the cell means and you observe that the pattern for one IV is the same across the other IV –

e.g., when the volume is on, men's heart rate is higher than women's; likewise, when the volume is off, men's heart rate is higher than women's



If the interaction was significant but is saying the same thing as the main effect does, then it indicates that the pattern is more pronounced at one level of an IV than at the other level.

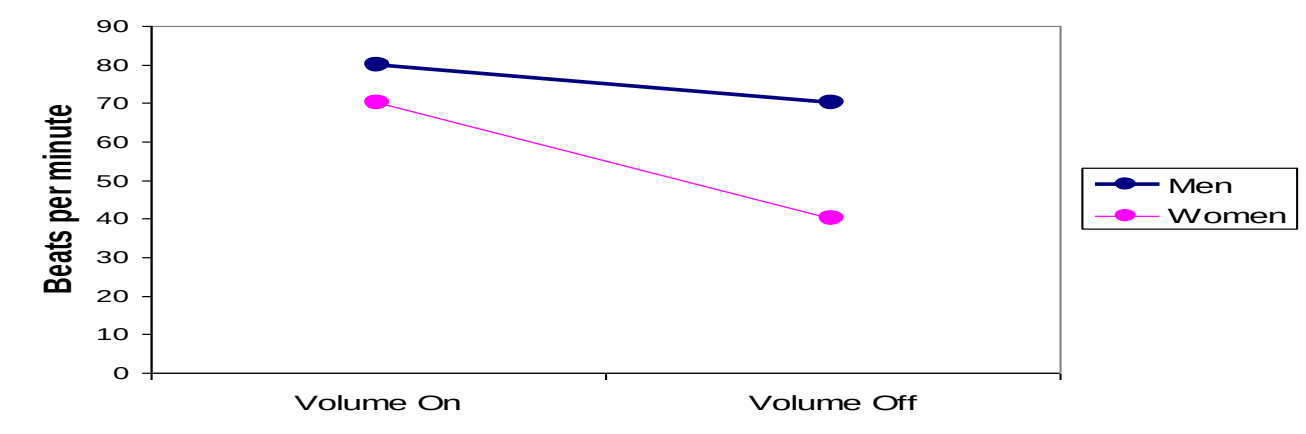
That is, the main effects tell the story (men have higher heart rates than women in the ER, and this is true whether the monitor's volume is on or off).

What is driving the significant interaction can be seen if you drew this as a graph – the lines are moving in the same direction but one slope is steeper than the other. HOW much higher men's heart rates are relative to woman's differs depending on whether the volume is on or off

Sample Write Up for Example 3

The [fill in name of IV1] and [fill in name of IV2] interaction was significant, F(df, df) = x.xx, p < .xxx, though it was consistent with the patterns seen in the main effects.

When the volume was off, average heart rates were higher for men (M=x.xx, SD=x.xx) than for women (M=x.xx, SD=x.xx). Likewise, when the volume was on, heart rates were higher for men (M=x.xx, SD=x.xx) than for women (M=x.xx, SD=x.xx), on average, though the relative difference was more pronounced with the volume off.



EFFECT SIZE IN TWO-WAY ANOVAS

There are 3 different effect sizes that can be calculated:

- Effect size for IV1
- Effect size for IV2
- Effect size for IV1xIV2 interaction

All three are measured by eta squared:

$$\eta^2 = SS_{factor}/SS_{total}$$

Note: SPSS will calculate this for you

Small	0 - .20
Medium	.21 - .40
Large	> .40

SPSS

EXAMPLE

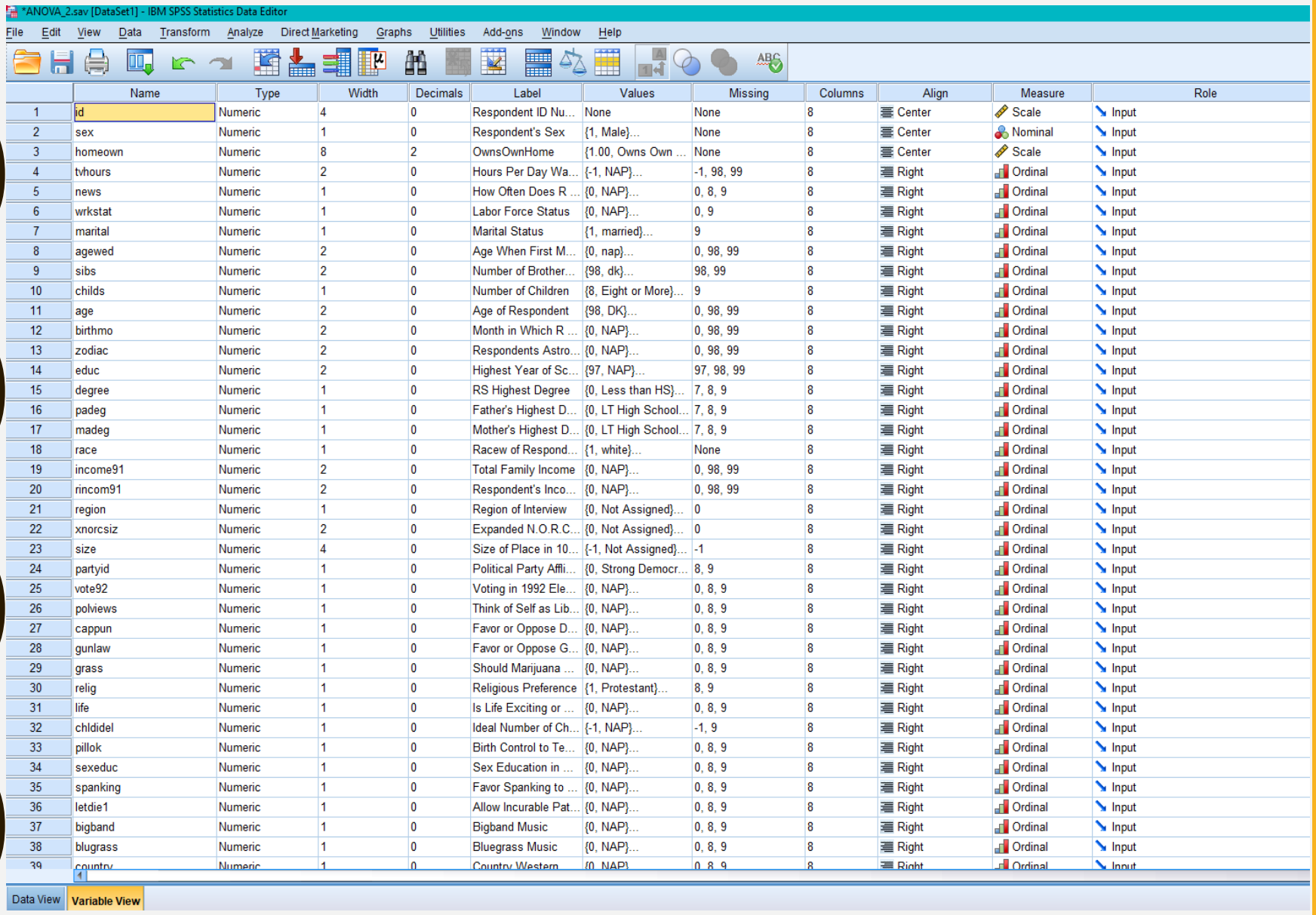
A researcher is interested in whether the amount of time a person spent on watching TV each day was influenced by two factors, their gender and home ownership.

(This will be a 2 X 2 design with two levels of gender (male and female), and two levels of home ownership status (owns own home and doesn't own home).

As a result, he is going to test the hypotheses that:

- Sex of respondent has a significant main effect on hours per day spent watching TV
- Home ownership has a significant main effect on hours per day spent watching TV
- Sex of respondent & home ownership have a significant interaction effect on hours per day spent watching TV

- First, open ANOVA_2.sav data file



	Name	Type	Width	Decimals	Label	Values	Missing	Columns	Align	Measure	Role
1	id	Numeric	4	0	Respondent ID Nu...	None	None	8	Center	Scale	Input
2	sex	Numeric	1	0	Respondent's Sex	{1, Male}...	None	8	Center	Nominal	Input
3	homeown	Numeric	8	2	OwnsOwnHome	{1.00, Owns Own ...	None	8	Center	Scale	Input
4	tvhours	Numeric	2	0	Hours Per Day Wa...	{-1, NAP}...	-1, 98, 99	8	Right	Ordinal	Input
5	news	Numeric	1	0	How Often Does R ...	{0, NAP}...	0, 8, 9	8	Right	Ordinal	Input
6	wrkstat	Numeric	1	0	Labor Force Status	{0, NAP}...	0, 9	8	Right	Ordinal	Input
7	marital	Numeric	1	0	Marital Status	{1, married}...	9	8	Right	Ordinal	Input
8	agewed	Numeric	2	0	Age When First M...	{0, nap}...	0, 98, 99	8	Right	Ordinal	Input
9	sibs	Numeric	2	0	Number of Brother...	{98, dk}...	98, 99	8	Right	Ordinal	Input
10	childs	Numeric	1	0	Number of Children	{8, Eight or More}...	9	8	Right	Ordinal	Input
11	age	Numeric	2	0	Age of Respondent	{98, DK}...	0, 98, 99	8	Right	Ordinal	Input
12	birthmo	Numeric	2	0	Month in Which R ...	{0, NAP}...	0, 98, 99	8	Right	Ordinal	Input
13	zodiac	Numeric	2	0	Respondents Astro...	{0, NAP}...	0, 98, 99	8	Right	Ordinal	Input
14	educ	Numeric	2	0	Highest Year of Sc...	{97, NAP}...	97, 98, 99	8	Right	Ordinal	Input
15	degree	Numeric	1	0	RS Highest Degree	{0, Less than HS}...	7, 8, 9	8	Right	Ordinal	Input
16	padeg	Numeric	1	0	Father's Highest D...	{0, LT High School...	7, 8, 9	8	Right	Ordinal	Input
17	madeg	Numeric	1	0	Mother's Highest D...	{0, LT High School...	7, 8, 9	8	Right	Ordinal	Input
18	race	Numeric	1	0	Racew of Respond...	{1, white}...	None	8	Right	Ordinal	Input
19	income91	Numeric	2	0	Total Family Income	{0, NAP}...	0, 98, 99	8	Right	Ordinal	Input
20	rincom91	Numeric	2	0	Respondent's Inco...	{0, NAP}...	0, 98, 99	8	Right	Ordinal	Input
21	region	Numeric	1	0	Region of Interview	{0, Not Assigned}...	0	8	Right	Ordinal	Input
22	xnorcsiz	Numeric	2	0	Expanded N.O.R.C...	{0, Not Assigned}...	0	8	Right	Ordinal	Input
23	size	Numeric	4	0	Size of Place in 10...	{-1, Not Assigned}...	-1	8	Right	Ordinal	Input
24	partyid	Numeric	1	0	Political Party Affli...	{0, Strong Democr...	8, 9	8	Right	Ordinal	Input
25	vote92	Numeric	1	0	Voting in 1992 Ele...	{0, NAP}...	0, 8, 9	8	Right	Ordinal	Input
26	polviews	Numeric	1	0	Think of Self as Lib...	{0, NAP}...	0, 8, 9	8	Right	Ordinal	Input
27	cappun	Numeric	1	0	Favor or Oppose D...	{0, NAP}...	0, 8, 9	8	Right	Ordinal	Input
28	gunlaw	Numeric	1	0	Favor or Oppose G...	{0, NAP}...	0, 8, 9	8	Right	Ordinal	Input
29	grass	Numeric	1	0	Should Marijuana ...	{0, NAP}...	0, 8, 9	8	Right	Ordinal	Input
30	relig	Numeric	1	0	Religious Preference	{1, Protestant}...	8, 9	8	Right	Ordinal	Input
31	life	Numeric	1	0	Is Life Exciting or ...	{0, NAP}...	0, 8, 9	8	Right	Ordinal	Input
32	chldidel	Numeric	1	0	Ideal Number of Ch...	{-1, NAP}...	-1, 9	8	Right	Ordinal	Input
33	pillok	Numeric	1	0	Birth Control to Te...	{0, NAP}...	0, 8, 9	8	Right	Ordinal	Input
34	sexeduc	Numeric	1	0	Sex Education in ...	{0, NAP}...	0, 8, 9	8	Right	Ordinal	Input
35	spanking	Numeric	1	0	Favor Spanking to ...	{0, NAP}...	0, 8, 9	8	Right	Ordinal	Input
36	letdie1	Numeric	1	0	Allow Incurable Pat...	{0, NAP}...	0, 8, 9	8	Right	Ordinal	Input
37	bigband	Numeric	1	0	Bigband Music	{0, NAP}...	0, 8, 9	8	Right	Ordinal	Input
38	blugrass	Numeric	1	0	Bluegrass Music	{0, NAP}...	0, 8, 9	8	Right	Ordinal	Input
39	country	Numeric	1	0	Country Western	{0, NAP}	0, 8, 9	8	Right	Ordinal	Input

*ANOVA_2.sav [DataSet1] - IBM SPSS Statistics Data Editor

File Edit View Data Transform Analyze Direct Marketing Graphs Utilities Add-ons Window Help

Visible: 68 of 68 Variables

	id	sex	homeown	tvhours	news	wrkstat	marital	agewed	sibs	childs	age	birthmo	zodiac	educ	degree	padeg	madeg	race	income91	rincm91	region	xnorcsiz
1	1	Male	.	4	NAP	Working ful...	divorced	20	3	1	43	May	Taurus	11	High school	NAP	LT High Sc...	white	$40000-49...	$35000-39...	Middle Atla...	City, GT 2...
2	2	Male	Doesn't O...	5	Everyday	Working ful...	never married	nap	2	0	44	August	Virgo	16	Bachelor	LT High Sc...	LT High Sc...	black	$40000-49...	$40000-49...	Middle Atla...	City, GT 2...
3	3	Female	.	2	NAP	Working ful...	divorced	25	2	0	43	February	Aquarius	16	Bachelor	High School	LT High Sc...	white	$40000-49...	$40000-49...	Middle Atla...	City, GT 2...
4	4	Female	Doesn't O...	4	Everyday	Working p...	never married	nap	4	0	45	NA	NA	15	High school	High School	DK	white	Refused	Refused	Middle Atla...	City, GT 2...
5	5	Female	Doesn't O...	1	Everyday	Retired	never married	nap	1	0	78	October	Libra	17	Graduate	High School	Junior Coll...	white	$75000+	NAP	Middle Atla...	City, GT 2...
6	6	Male	.	4	NAP	Retired	married	25	2	2	83	March	Pisces	11	High school	LT High Sc...	LT High Sc...	white	$20000-22...	NAP	Middle Atla...	City, GT 2...
7	7	Female	.	3	NAP	Working ful...	married	22	2	2	55	October	Libra	12	High school	LT High Sc...	LT High Sc...	white	$50000-59...	$25000-29...	Middle Atla...	City, GT 2...
8	8	Male	.	3	NAP	Retired	married	24	3	2	75	November	Sagittarius	12	High school	LT High Sc...	LT High Sc...	white	$12500-14...	NAP	Middle Atla...	City, GT 2...
9	9	Male	Doesn't O...	1	Few Times...	Working ful...	divorced	22	1	2	31	July	Cancer	18	Graduate	High School	High School	white	$75000+	$60000-74...	Middle Atla...	City, GT 2...
10	10	Female	Doesn't O...	1	Few Times...	Working p...	never married	nap	1	0	54	March	Pisces	18	Graduate	LT High Sc...	High School	white	$10000-12...	$1000-2999	Middle Atla...	City, GT 2...
11	11	Female	Doesn't O...	2	Never	Working ful...	never married	nap	1	0	29	April	Taurus	18	Graduate	LT High Sc...	LT High Sc...	white	$30000-34...	$30000-34...	Middle Atla...	City, GT 2...
12	12	Female	.	4	NAP	Working ful...	never married	nap	0	0	23	October	Scorpio	15	High school	NAP	Junior Coll...	white	$40000-49...	$3000-3999	Middle Atla...	City, GT 2...
13	13	Female	Doesn't O...	3	Never	Working ful...	married	31	0	1	61	NA	NA	12	High school	High School	High School	white	$22500-24...	$8000-9999	Middle Atla...	City, GT 2...
14	14	Female	.	6	NAP	Retired	separated	24	3	4	63	March	Aries	4	Less than ...	NAP	LT High Sc...	other	$5000-5999	NAP	Middle Atla...	City, GT 2...
15	15	Female	Doesn't O...	4	Few Times...	Unempl, lai...	never married	nap	4	3	33	March	Pisces	10	Less than ...	DK	DK	other	$10000-12...	$10000-12...	Middle Atla...	City, GT 2...
16	16	Female	Doesn't O...	2	Few Times...	Working ful...	never married	nap	0	1	36	November	Scorpio	14	High school	NAP	High School	black	$12500-14...	$12500-14...	Middle Atla...	City, GT 2...
17	17	Female	Doesn't O...	5	Less Than ...	Keeping ho...	never married	nap	dk	4	39	March	Pisces	8	Less than ...	NA	LT High Sc...	black	$5000-5999	NAP	Middle Atla...	City, GT 2...
18	18	Male	Doesn't O...	2	Few Times...	Working ful...	married	22	9	0	55	January	Capricorn	15	High school	High School	LT High Sc...	other	Refused	Refused	Middle Atla...	City, GT 2...
19	19	Female	Owns Own...	2	Everyday	Working ful...	married	32	1	1	55	September	Libra	16	Bachelor	High School	LT High Sc...	white	$75000+	$22500-24...	Middle Atla...	UnInc, Lrg ...
20	20	Male	Owns Own...	4	Everyday	Working ful...	married	24	2	2	34	April	Taurus	16	Bachelor	LT High Sc...	High School	white	$75000+	$75000+	Middle Atla...	UnInc, Lrg ...
21	21	Female	Owns Own...	1	Everyday	Temp not ...	married	24	5	2	36	June	Gemini	14	Junior colle...	Bachelor	Bachelor	white	$60000-74...	$25000-29...	Middle Atla...	UnInc, Lrg ...
22	22	Female	Owns Own...	2	Everyday	Working p...	married	23	0	3	44	August	Leo	18	Bachelor	High School	High School	white	$75000+	$40000-49...	Middle Atla...	UnInc, Lrg ...
23	23	Male	Owns Own...	3	Everyday	Retired	widowed	25	2	2	80	May	Taurus	18	Graduate	NAP	LT High Sc...	white	$40000-49...	NAP	Middle Atla...	UnInc, Lrg ...
24	24	Male	Doesn't O...	3	Less Than ...	Working ful...	never married	nap	5	1	32	July	Leo	16	Bachelor	Bachelor	Bachelor	other	$25000-29...	$15000-17...	Pacific	City, GT 2...
25	25	Male	Doesn't O...	2	Once a W...	Working p...	married	32	7	4	37	September	Virgo	5	Less than ...	LT High Sc...	LT High Sc...	other	$20000-22...	$4000-4999	Pacific	City, GT 2...
26	27	Female	Doesn't O...	3	Once a W...	Working ful...	married	40	5	0	49	September	Virgo	16	Bachelor	Bachelor	Bachelor	other	$30000-34...	$25000-29...	Pacific	City, GT 2...
27	28	Female	.	2	NAP	Working ful...	divorced	16	6	2	45	November	Sagittarius	16	Bachelor	High School	NAP	other	$60000-74...	$60000-74...	Pacific	City, GT 2...
28	29	Female	.	2	NAP	Working ful...	never married	nap	2	0	36	April	Taurus	18	Bachelor	High School	Graduate	white	$30000-34...	$10000-12...	Pacific	City, GT 2...
29	30	Female	Doesn't O...	1	Less Than ...	Working p...	never married	nap	5	0	23	March	Aries	16	High school	NAP	Bachelor	black	$10000-12...	$5000-5999	Pacific	City, GT 2...
30	31	Male	.	3	NAP	Working ful...	never married	nap	1	0	29	May	Taurus	16	Graduate	Bachelor	Bachelor	white	$50000-59...	$50000-59...	Pacific	City, GT 2...
31	32	Female	Doesn't O...	2	Few Times...	Working ful...	never married	nap	3	1	30	February	Aquarius	14	Junior colle...	High School	LT High Sc...	black	$30000-34...	$30000-34...	Pacific	City, GT 2...
32	33	Female	.	2	NAP	Working ful...	never married	nap	8	1	40	July	Cancer	16	Bachelor	LT High Sc...	High School	black	$30000-34...	$30000-34...	Pacific	City, GT 2...
33	34	Female	Doesn't O...	1	Less Than ...	Working ful...	never married	nap	8	2	26	August	Virgo	11	Less than ...	High School	High School	white	$30000-34...	$15000-17...	Pacific	Suburb, Lr...
34	35	Male	Owns Own...	3	Everyday	Retired	married	21	3	4	66	February	Pisces	12	High school	LT High Sc...	LT High Sc...	white	$75000+	NAP	Pacific	Suburb, Lr...
35	36	Female	Owns Own...	2	Few Times...	Unempl, lai...	married	22	11	1	53	October	Scorpio	14	High school	High School	High School	other	$40000-49...	$12500-14...	Pacific	Suburb, Lr...
36	37	Female	Owns Own...	3	Few Times...	Working p...	married	19	2	0	20	December	Sagittarius	12	High school	LT High Sc...	LT High Sc...	other	$8000-9999	$1000-2999	Pacific	Suburb, Lr...
37	38	Female	.	4	NAP	Working ful...	divorced	24	4	2	63	July	Cancer	12	High school	LT High Sc...	LT High Sc...	white	$10000-12...	$10000-12...	Pacific	Suburb, Lr...

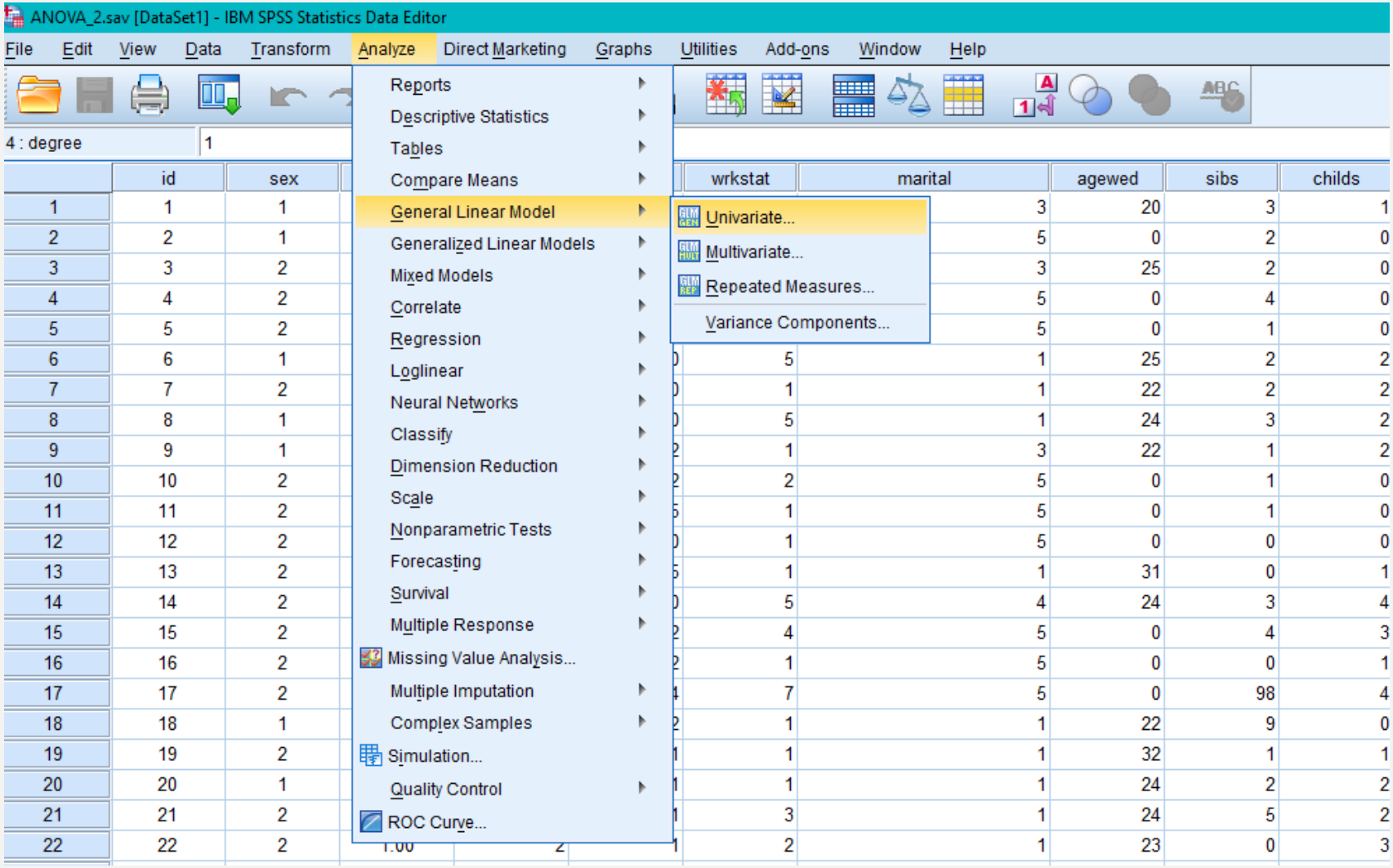
Data View Variable View

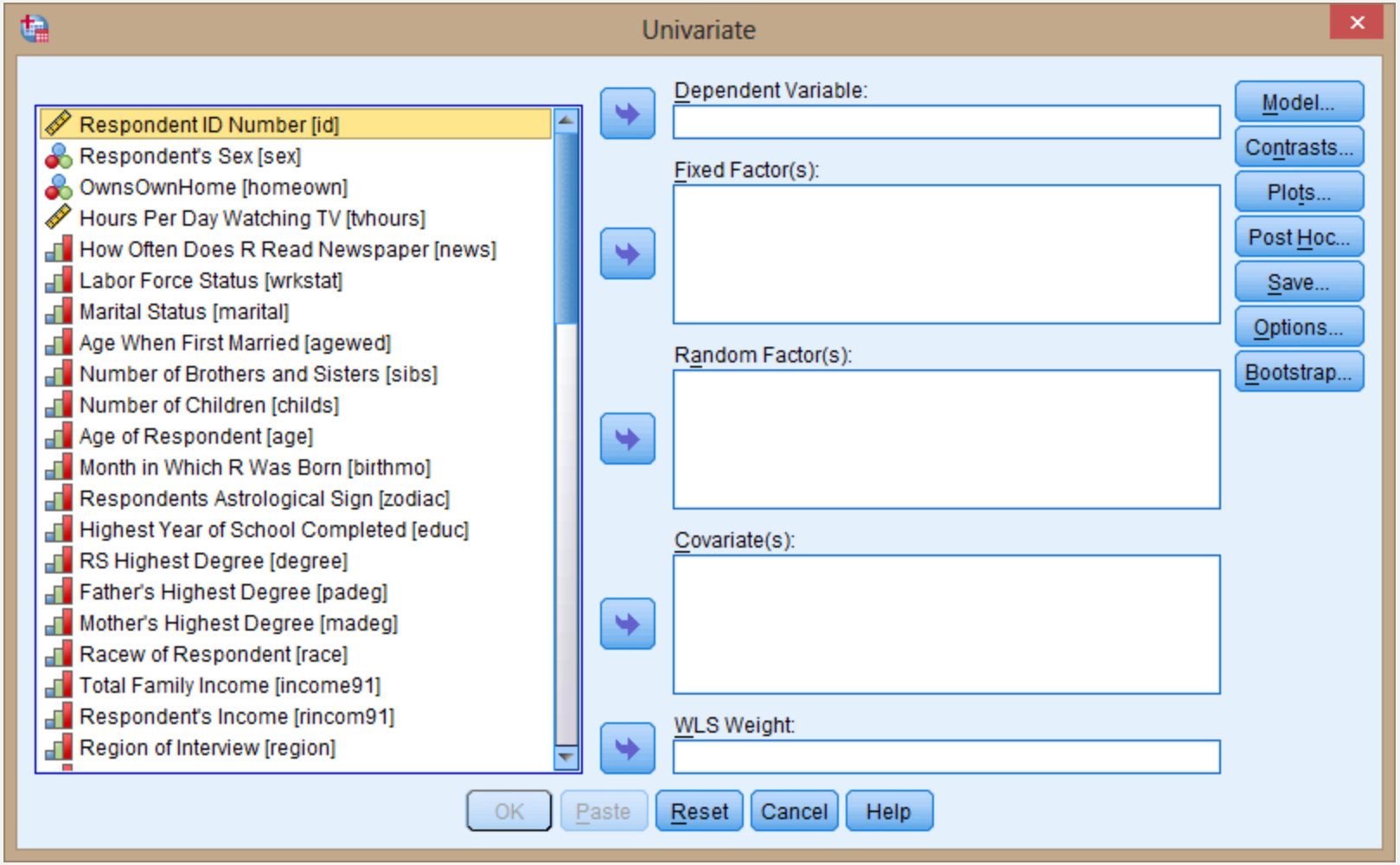
IBM SPSS Statistics Processor is ready

Unicode:ON

GO TO:

Analyze ➔ General Linear Model ➔ Univariate



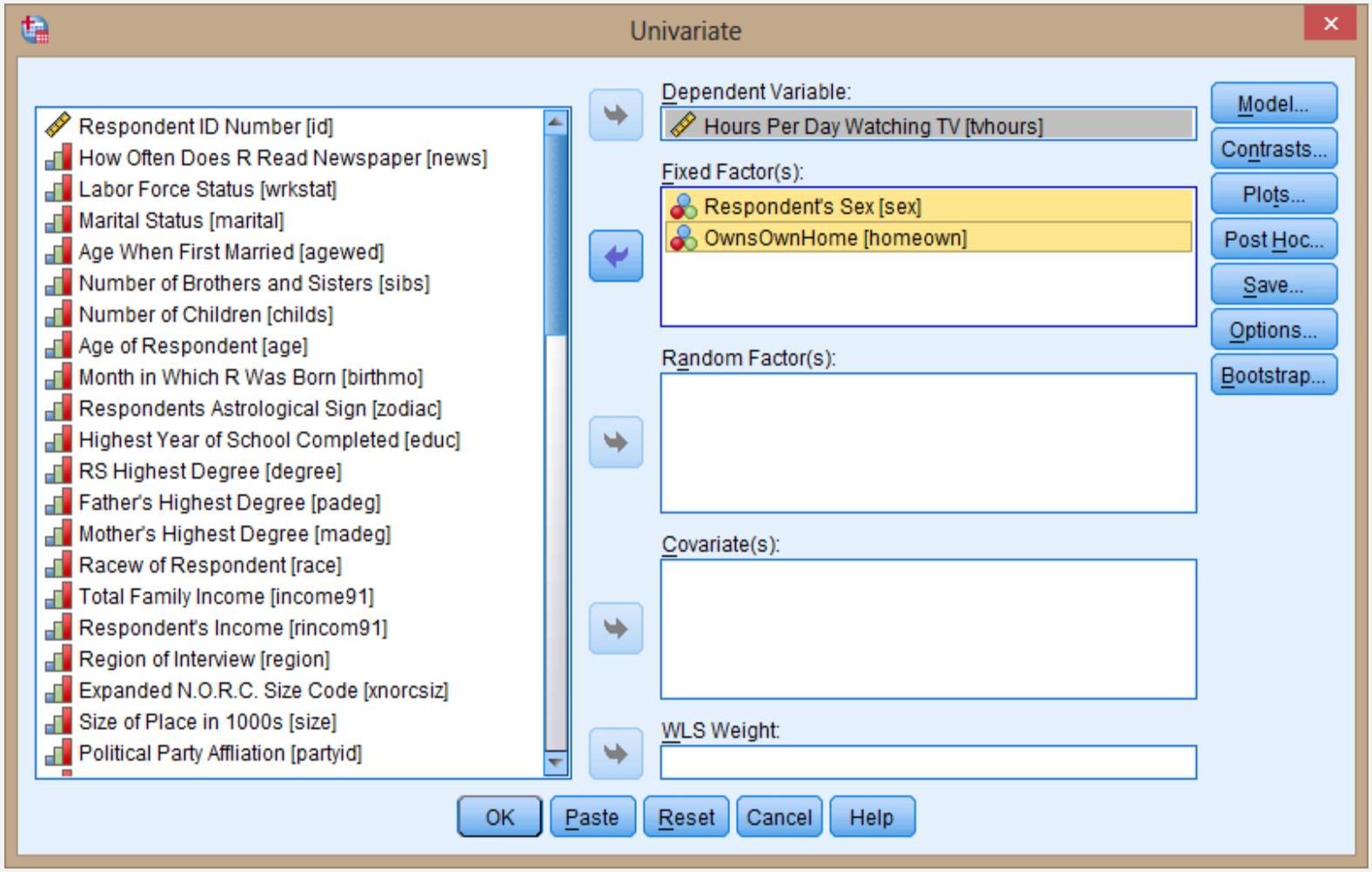

Univariate
Respondent ID Number [id]
Respondent's Sex [sex]
OwnsOwnHome [homeown]
Hours Per Day Watching TV [tvhours]
How Often Does R Read Newspaper [news]
Labor Force Status [wrkstat]
Marital Status [marital]
Age When First Married [agewed]
Number of Brothers and Sisters [sibs]
Number of Children [childs]
Age of Respondent [age]
Month in Which R Was Born [birthmo]
Respondents Astrological Sign [zodiac]
Highest Year of School Completed [educ]
RS Highest Degree [degree]
Father's Highest Degree [padeg]
Mother's Highest Degree [madeg]
Racew of Respondent [race]
Total Family Income [income91]
Respondent's Income [rincom91]
Region of Interview [region]
Dependent Variable:
Fixed Factor(s):
Random Factor(s):
Covariate(s):
WLS Weight:
Model...
Contrasts...
Plots...
Post Hoc...
Save...
Options...
Bootstrap...
OK
Paste
Reset
Cancel
Help

Move the variables:

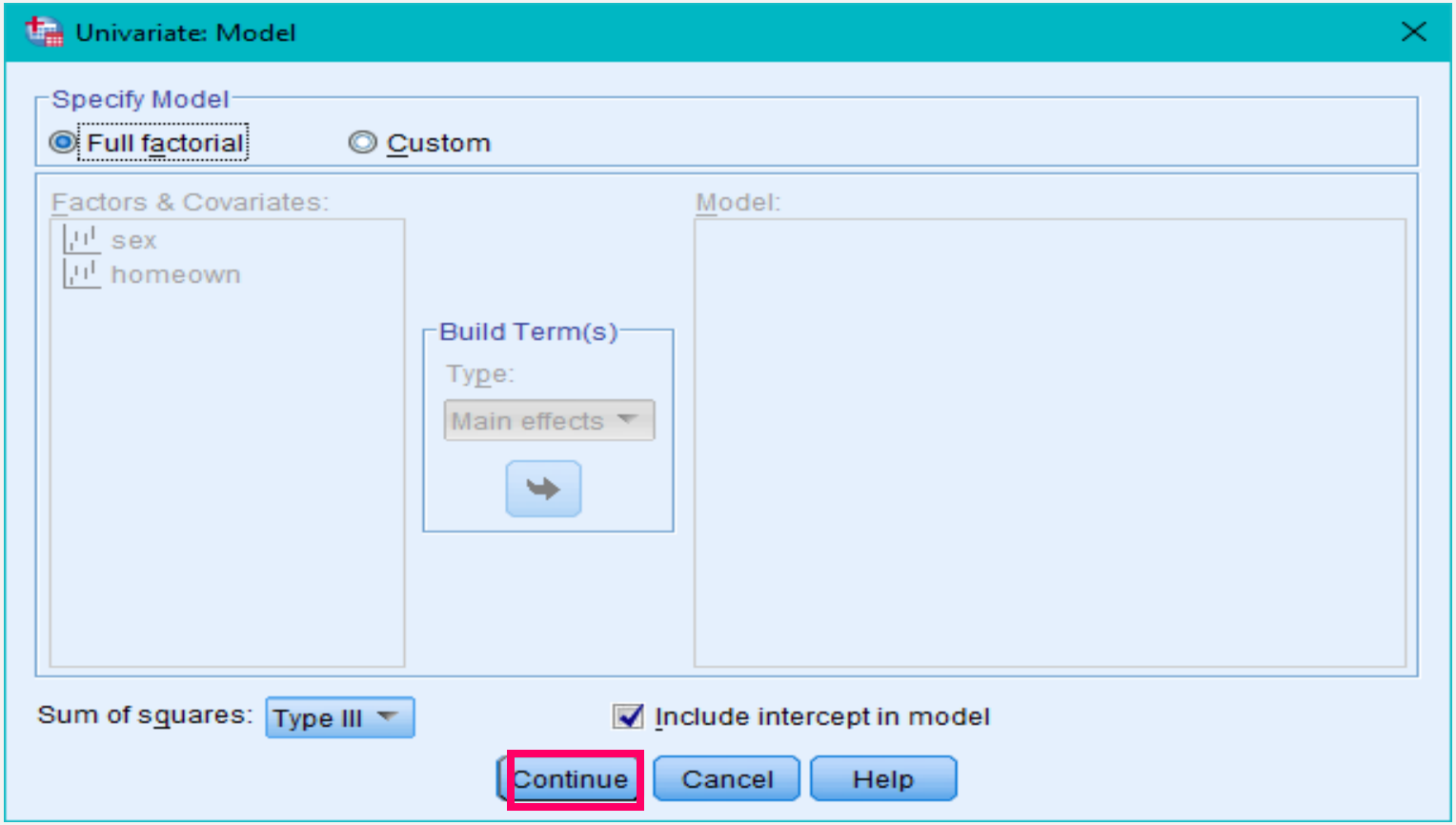
- Respondent's Sex & OwnsOwnHome into the Fixed Factor window

Move the variable:

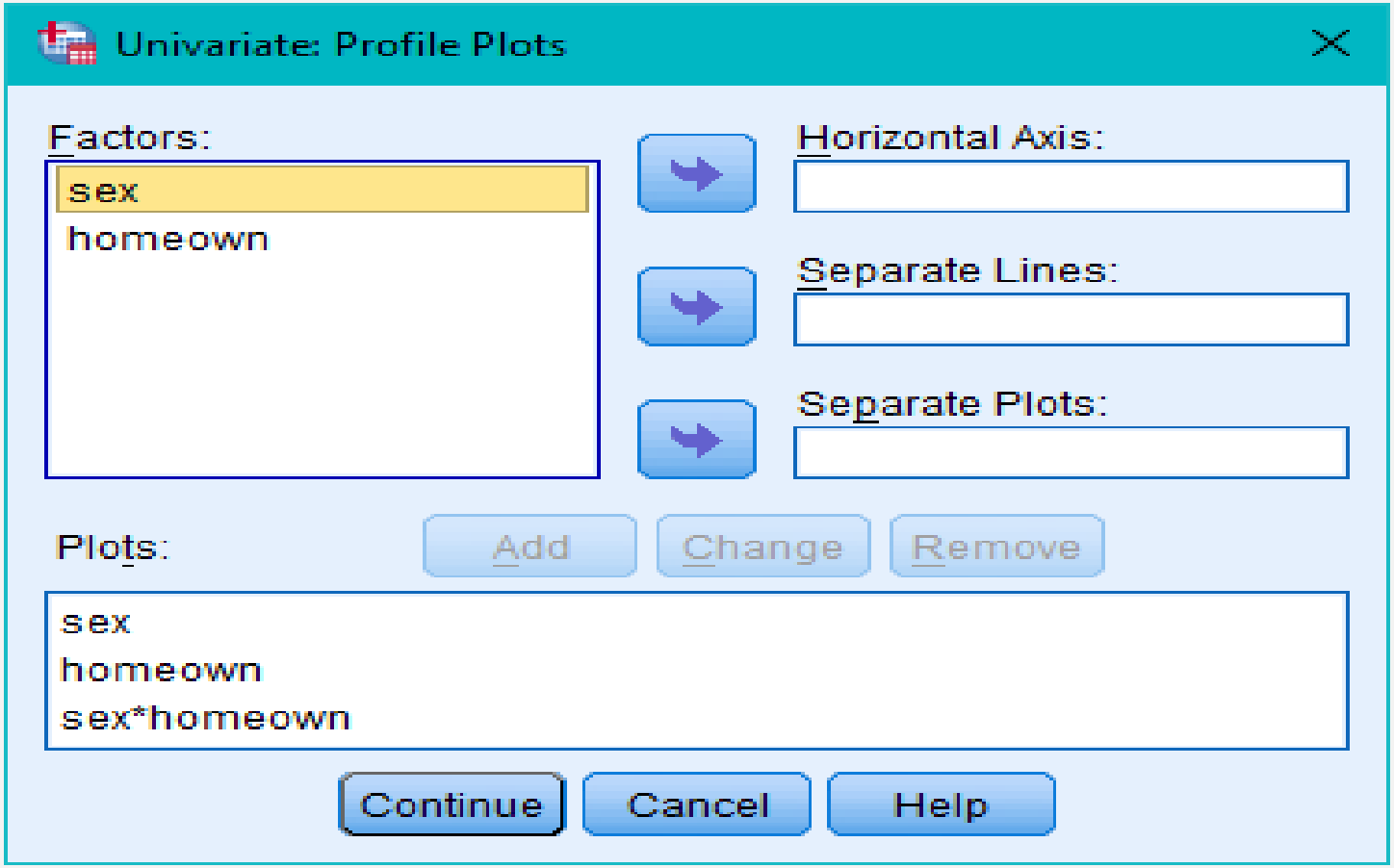
- Hours per Day Watching TV variable into the Dependent Variables window


Univariate
Respondent ID Number [id]
How Often Does R Read Newspaper [news]
Labor Force Status [wrkstat]
Marital Status [marital]
Age When First Married [agewed]
Number of Brothers and Sisters [sibs]
Number of Children [childs]
Age of Respondent [age]
Month in Which R Was Born [birthmo]
Respondents Astrological Sign [zodiac]
Highest Year of School Completed [educ]
RS Highest Degree [degree]
Father's Highest Degree [padeg]
Mother's Highest Degree [madeg]
Racew of Respondent [race]
Total Family Income [income91]
Respondent's Income [rincom91]
Region of Interview [region]
Expanded N.O.R.C. Size Code [xnorcsiz]
Size of Place in 1000s [size]
Political Party Affliation [partyid]
Dependent Variable:
Hours Per Day Watching TV [tvhours]
Fixed Factor(s):
Respondent's Sex [sex]
OwnsOwnHome [homeown]
Random Factor(s):
Covariate(s):
WLS Weight:
Model...
Contrasts...
Plots...
Post Hoc...
Save...
Options...
Bootstrap...
OK
Paste
Reset
Cancel
Help

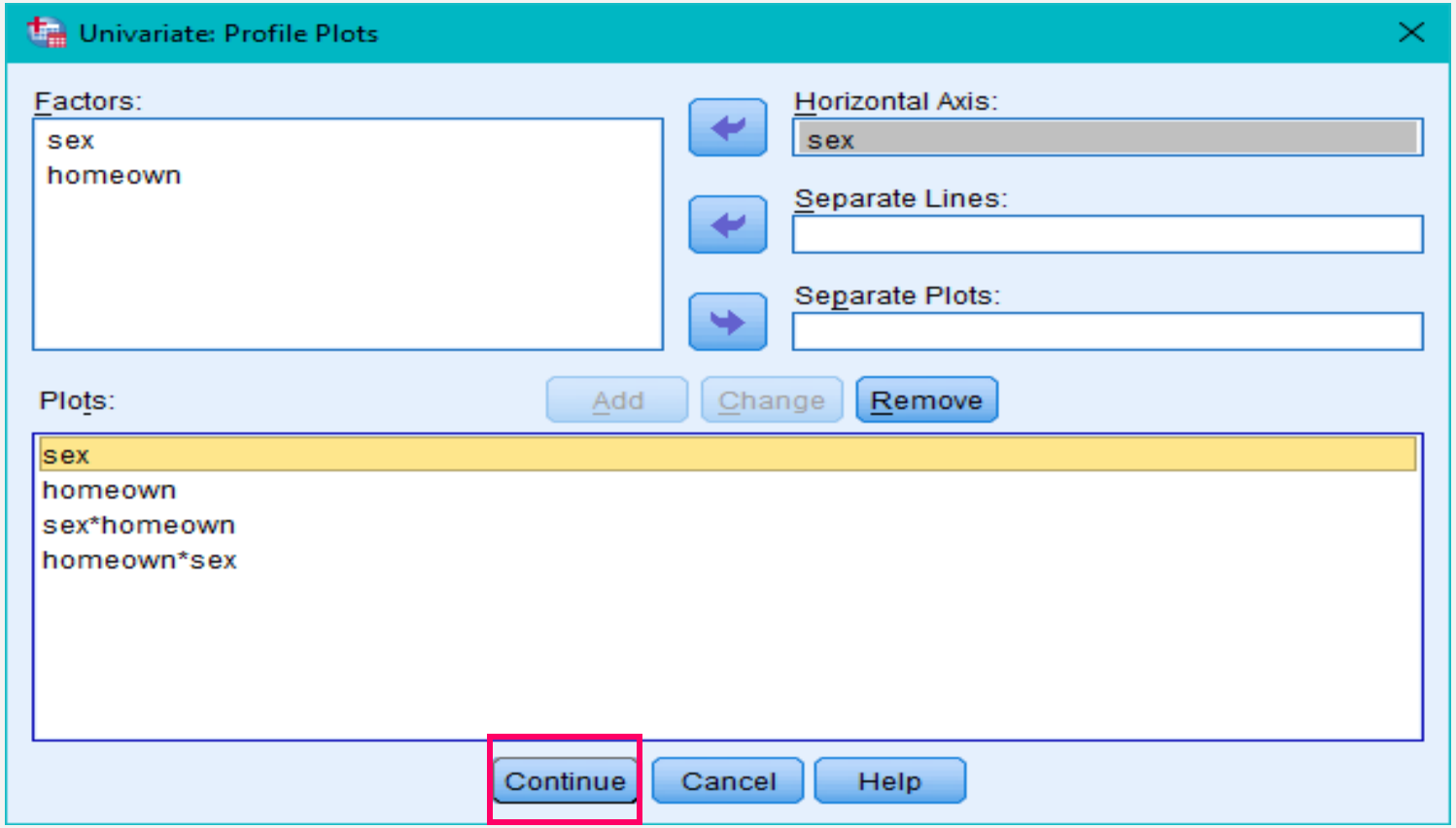
- Click on **Model** ➔ select **Full Factorial** ➔ and **Continue**
- Ignore the Contrasts Button for now



Click on the **Plots** button to select the plots we want.



- **First we get plots for the main effects:**
  - Move the Sex factor into the Horizontal Axis window ➔ click the Add button
  - Move the Homeown factor into the Horizontal Axis window ➔ click the Add button.
- **Next we will get plots for the interaction effect:**
  - Move the Sex factor into the Horizontal Axis window & the Homeown factor into the Separate Lines window ➔ click the Add button
  - Move the Homeown factor into the Horizontal Axis window and the Sex factor into the Separate Lines window ➔ click the Add button

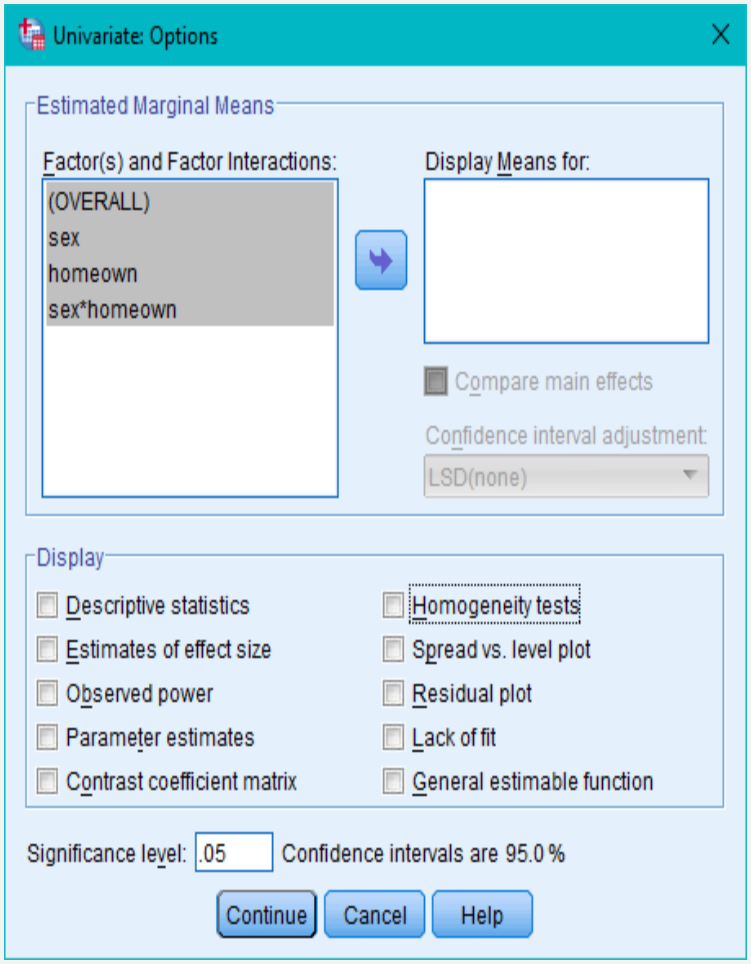


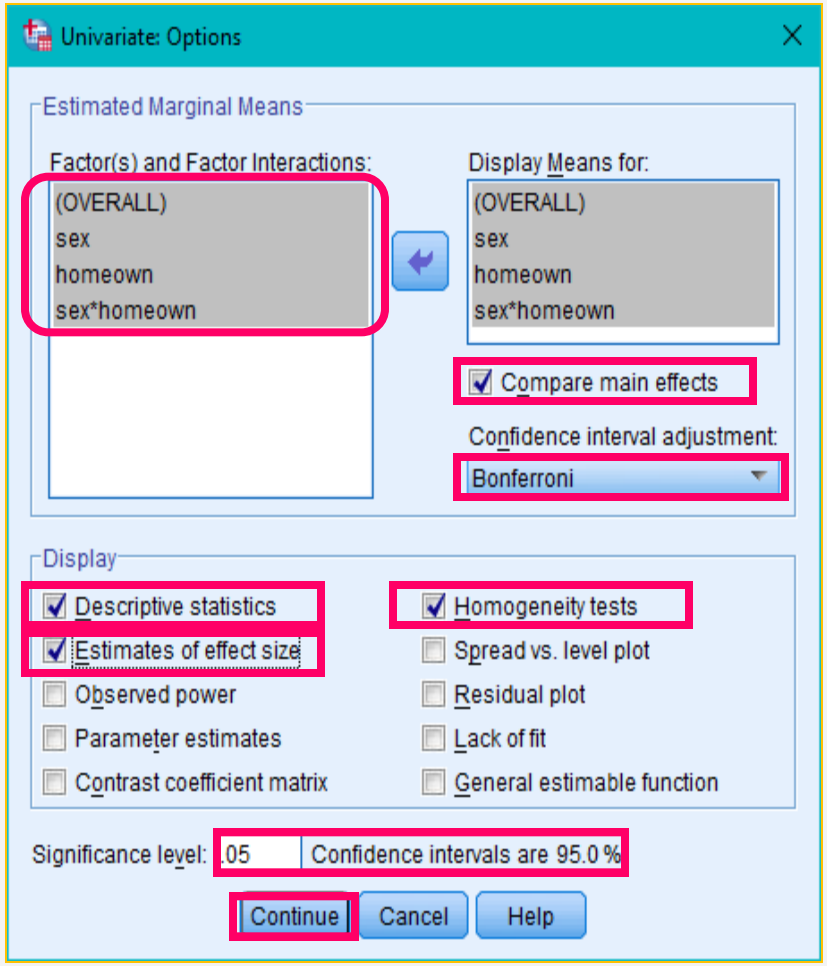
Click Continue

Since the post-hoc tests are only performed when there are more than two levels, we will skip the post-hoc tests button this time because our variables only have two levels.

Otherwise you do the post hoc tests just as you did for one-way ANOVA by moving the factors you want to test into the Post Hoc Tests box and selecting Sheffe and Tamhane tests.

CLICK ON: Options ➔ move all of the Factors (overall, Sex, Homeown, and Sex*Homeown) into the Display Means for box.



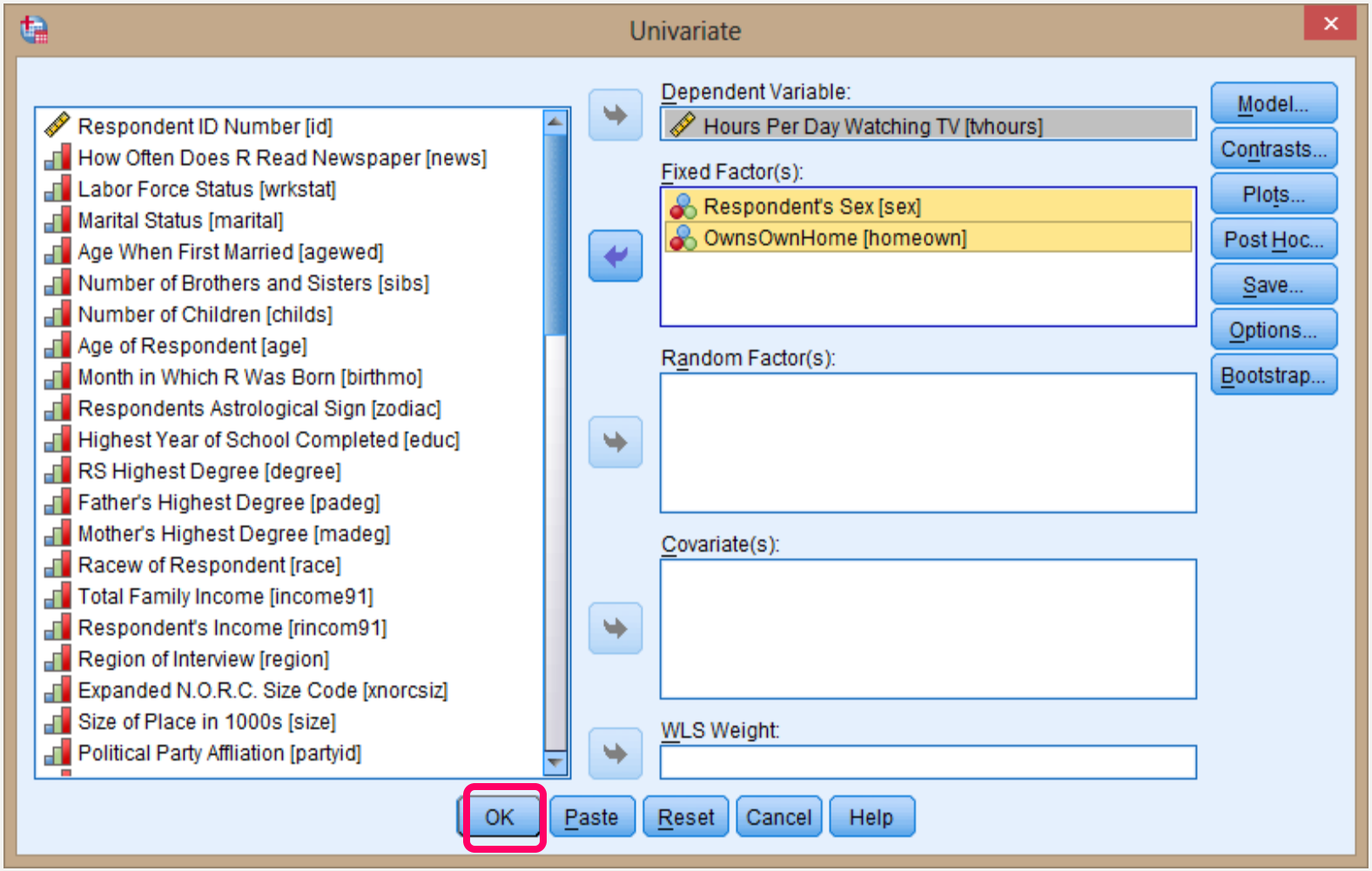


CHECK:

Compare Main Effects ➔ Bonferroni ➔ Descriptive ➔ Estimates of Effect Size ➔ Homogeneity Tests.

Set the level of significance for example 0.05 for confidence interval to 95%

CLICK CONTINUE YOU HAVE:



Then OK, you will have the output results as follows:

Univariate Analysis of Variance

Between-Subjects Factors

		Value Label	N
Respondent's Sex	1	Male	451
	2	Female	554
OwnsOwnHome	1.00	Owns Own Home	658
	2.00	Doesn't Own Home	347

Descriptive Statistics

Dependent Variable: Hours Per Day Watching TV

Respondent's Sex	OwnsOwnHome	Mean	Std. Deviation	N
Male	Owns Own Home	2.77	2.197	305
	Doesn't Own Home	2.93	2.249	146
	Total	2.82	2.213	451
Female	Owns Own Home	2.63	1.790	353
	Doesn't Own Home	3.69	3.173	201
	Total	3.02	2.436	554
Total	Owns Own Home	2.70	1.989	658
	Doesn't Own Home	3.37	2.842	347
	Total	2.93	2.339	1005

As you can see in the table of means, there is a trend for females to watch more TV than males and for non- homeowners to watch more TV than homeowners, but there is a particularly pronounced trend for female non-homeowners to watch more TV than everybody else.

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

Dependent Variable: Hours Per Day Watching TV

F	df1	df2	Sig.
9.951	3	1001	.000

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

a. Design: Intercept + sex + homeown + sex * homeown

Tests of Between-Subjects Effects

Dependent Variable: Hours Per Day Watching TV

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	153.307[a]	3	51.102	9.576	.000	.028
Intercept	8063.923	1	8063.923	1511.094	.000	.602
sex	21.146	1	21.146	3.963	.047	.004
homeown	81.594	1	81.594	15.290	.000	.015
sex * homeown	44.587	1	44.587	8.355	.004	.008
Error	5341.817	1001	5.336			
Total	14125.000	1005				
Corrected Total	5495.124	1004				

a. R Squared = .028 (Adjusted R Squared = .025)

1. Sex of respondent has a significant main effect on hours per day spent watching TV.

2. Home ownership has a significant main effect on hours per day spent watching TV.

3. Sex of respondent home ownership have a significant interaction effect on hours per day spent watching TV.

Now write a paragraph in which you report the results of the significance tests! Remember that the interpretation of the main effects in a straightforward way is complicated by the significant interaction.
We also need to be a bit skeptical since the partial eta squares are very low and as you will see on the next slide there is a very large SD in one of the conditions

Descriptive Statistics

Dependent Variable: Hours Per Day Watching TV

Respondent's Sex	OwnsOwnHome	Mean	Std. Deviation	N
Male	Owns Own Home	2.77	2.197	305
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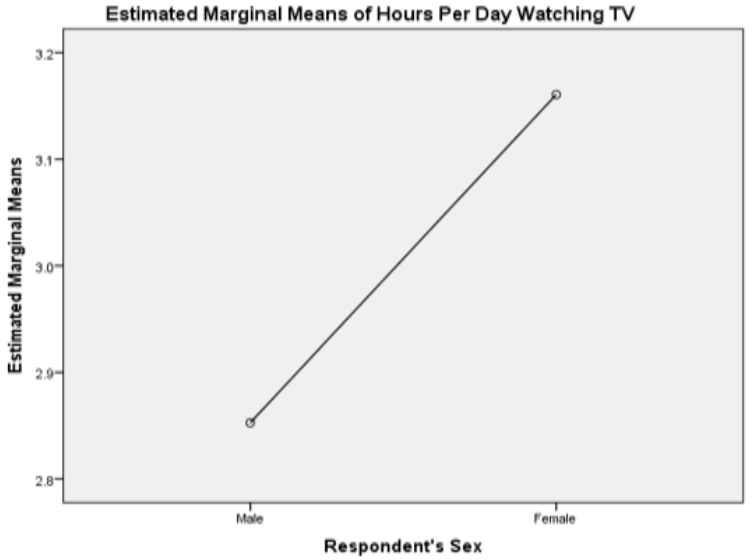
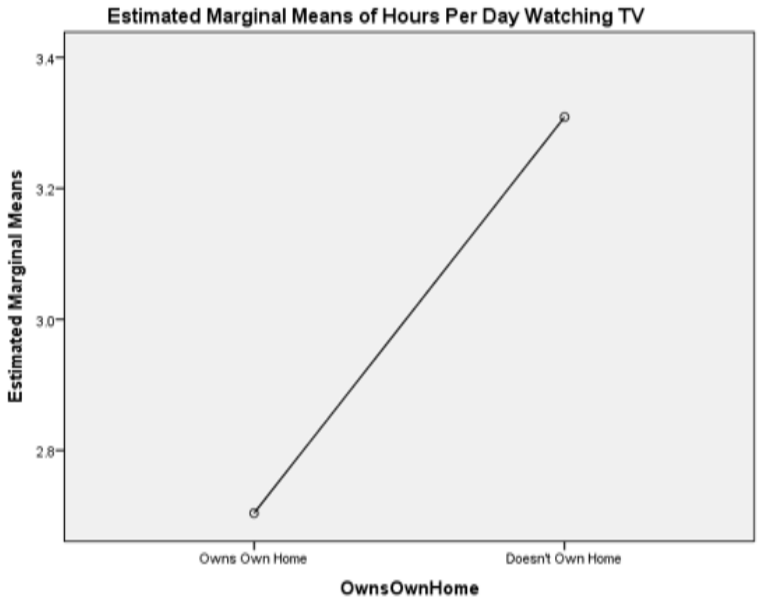
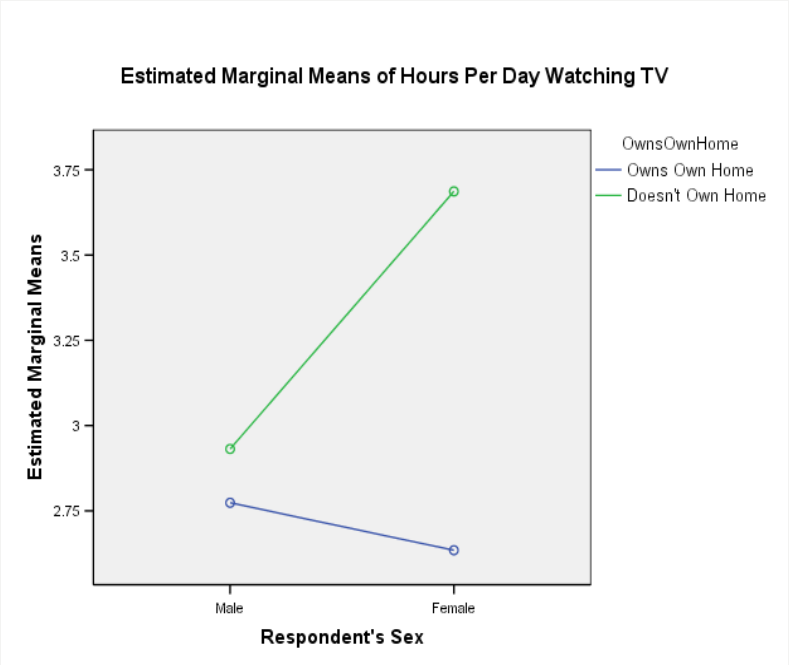
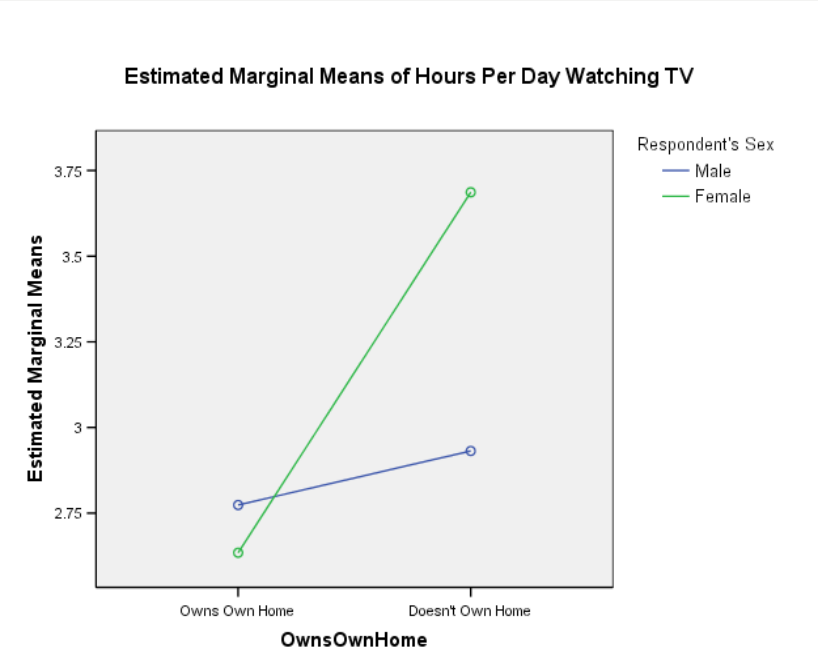


- As you can see in the table of means, there is a trend for females to watch more TV than males and for non- homeowners to watch more TV than homeowners, but there is a particularly pronounced trend for female non-homeowners to watch more TV than everybody else.







Although the interaction effect is not extremely strong, there is a trend for the relationship between homeownership and hours spent watching TV to be **different** for men than women;

Women who don't own homes are much more likely to spend more time watching TV than owners, compared to men, for whom homeownership makes less of a difference.

To know overall whether that IV influenced the DV, ignoring the other IV (Mane effect ➔ marginal means)

	Male	Female	
Owns Own Home	2.77	2.63	(2.7)
Doesn't Own Home	2.93	3.96	(3.31)
	(2.85)	(3.16)	

Main effect for ownership:

Does ownership matter? Does it effect time spent watching TV? 3.31 vs. 2.7

Main effect for Gender:

Does gender matter?

Does it effect time spent watching TV?

2.85 vs. 3.16

REPORT:

- Time a person spent on watching TV was analyzed in a two-way [between, within, mixed] ANOVA, with gender (male, female) as a [between subjects; within subjects] variable and home ownership (owns own home, doesn't own home) as a [between subjects; within subjects] variable.

- Main effect for Gender:

The main effect of gender on time a person spent on watching TV was significant, F= 3.963, p = 0.047.

Time a person spent on watching TV was higher for [gender, female] (M = 3.16) than for [gender, male] (M = 2.85).

In addition, time a person spent on watching TV was higher for [homeown, doesn't Own Home] (M = 3.31) than for [homeown, owns own Home] (M = 2.7).

The gender x homeown interaction was significant, $F=8.355, p = 0.004$

Since the interaction is significant, we need to report the cell means and describe their patterns as follows:

When the person Owns Own Home, women's average time spent on watching TV (M=2.63, SD=1.790) was lower than men's average time spent on watching TV (M=2.77, SD=2.197).
However, when the person Doesn't Own Home, women's average time spent on watching TV (M=3.69, SD=3.173) were higher than men's heart rates (M=2.93, SD=2.249), on average.

CONCLUSIONS

- T-tests assess if two group means differ significantly.
- ANOVAs compare more than two groups. They use variances instead of means.
- Described two-way analysis of variance
  - Examined effects of multiple factors and interaction

REPEATED MEASURES

ONE WAY REPEATED MEASURES ANOVA

- **A statistical technique for <u>testing for differences between the means of several groups:</u>**
  - **Groups are related in some way.**
  - **The same measurement is made several times on each subject or case.**
  - **Comparing the same subjects under several different treatments.**

Similar to the paired samples T-Test, but no restriction on the number of groups.

BETWEEN AND WITHIN FACTORS

Between factors:

A grouping or classification variables such as sex, age, grade levels, treatment conditions etc.

Within factors:

Is the one with multiple measures from a group of people such as time.

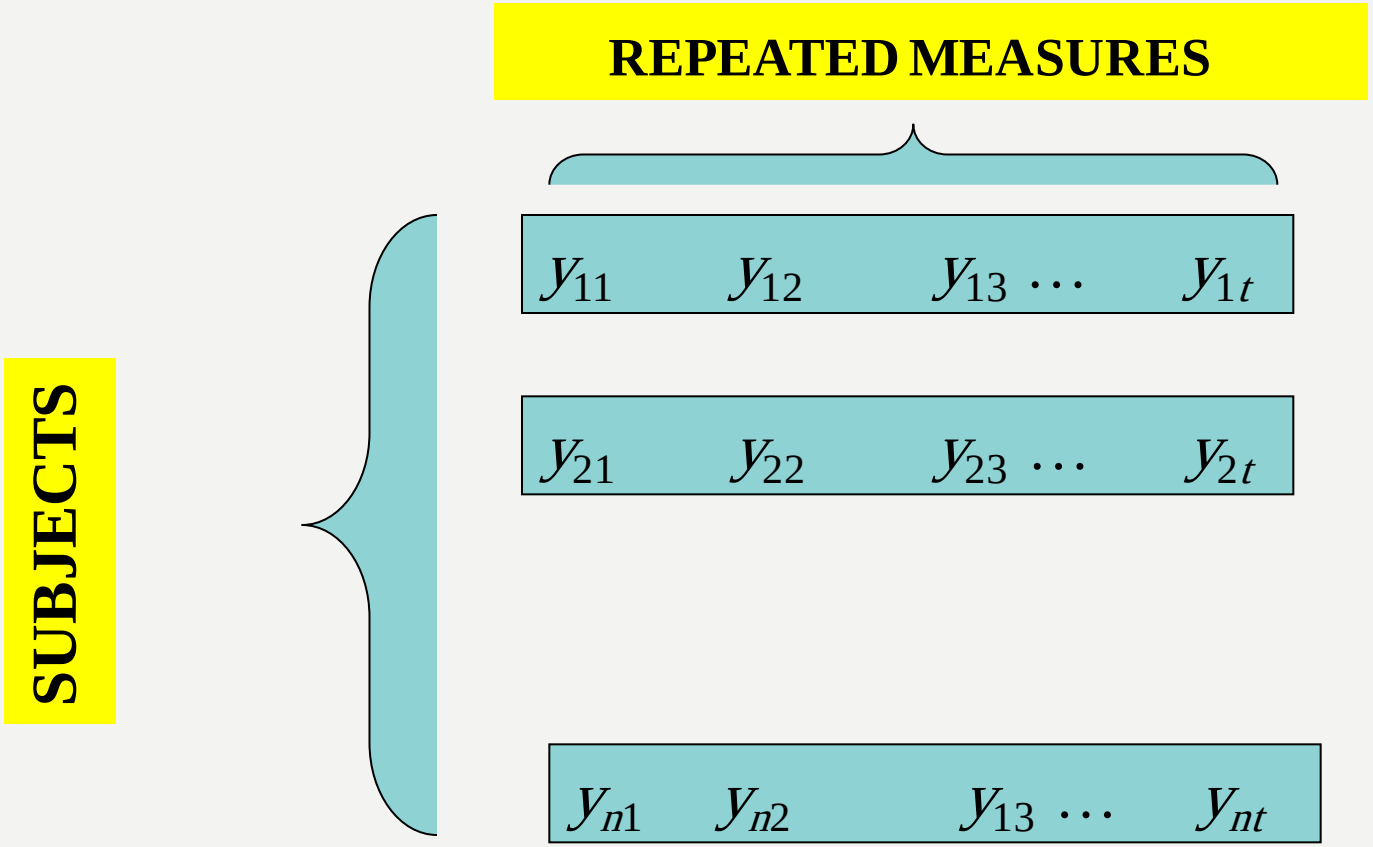
Between Subjects ANOVA
Data points in each group are unrelated

Group A	Group B	Group C
5	4	3
6	2	7
9	4	3
2	5	4
9	3	2

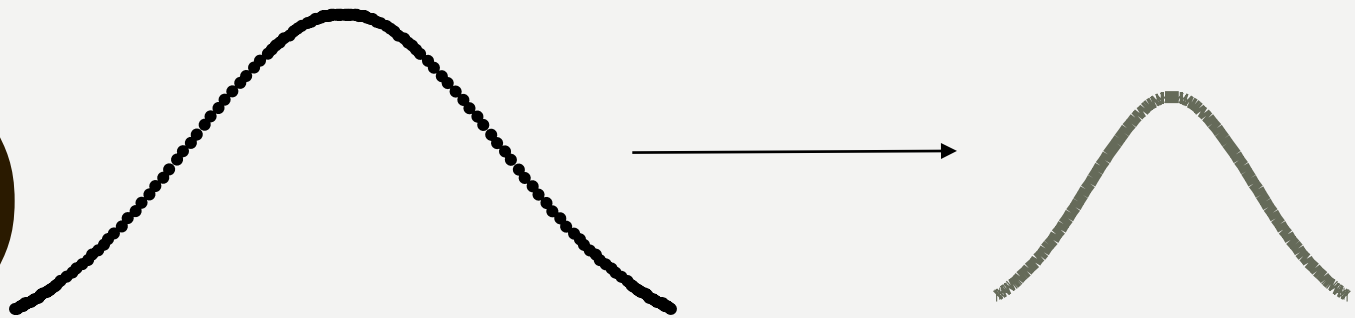
Repeated Measures ANOVA
Data points in each group are related

Time A	Time B	Time C
1	2	4
5	5	9
7	8	6
3	5	8
2	2	4

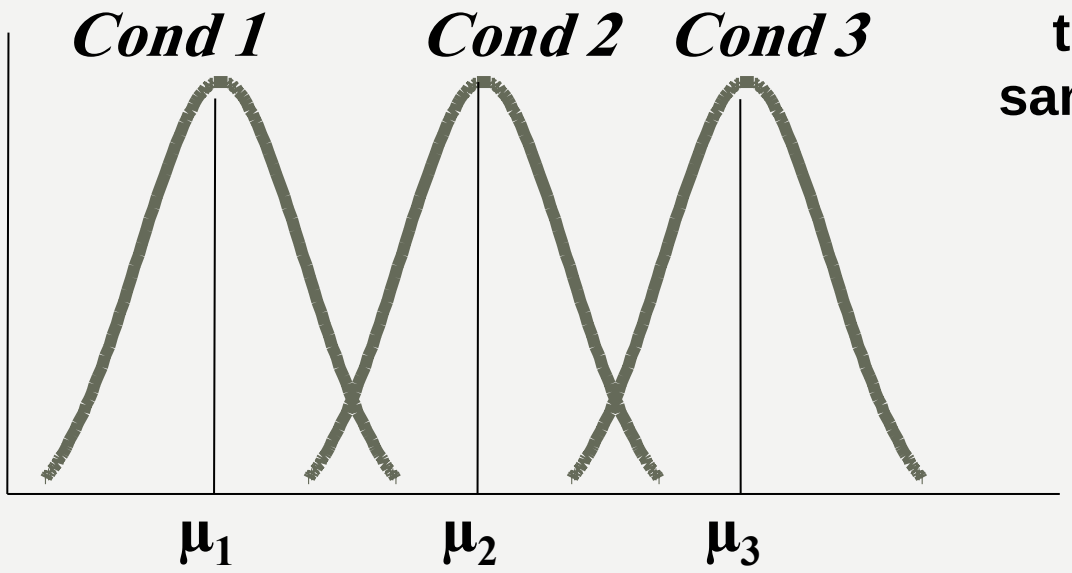
- **THE ANOVA MODEL FOR A SIMPLE REPEATED MEASURES DESIGN:**



Population → draw one sample



Manipulate the sample



measure effect of IV on a DV

ASSUMPTIONS…

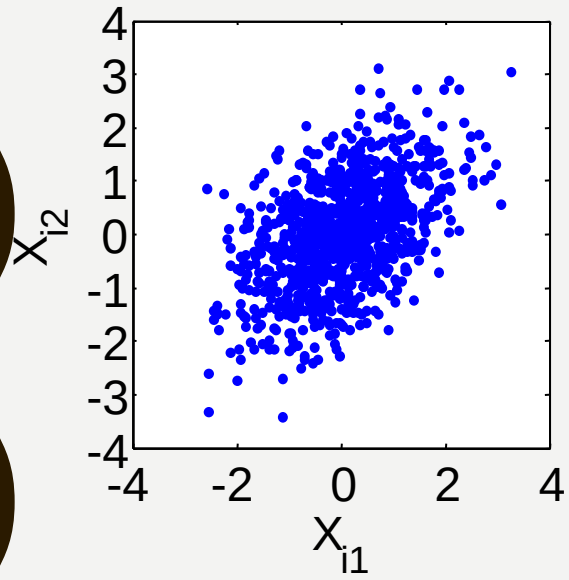
Data in each group should be…

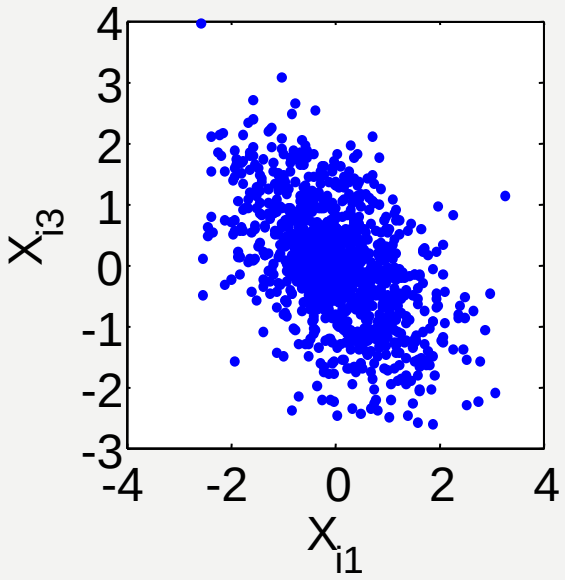
- **Interval scale**
- **Normally distributed**
  - Histograms, box plots
- **Homogeneity of variance**
  - Variance within each condition should be roughly equal
- **RM require complete data for all subjects, i.e. no missing observations for any subjects.**

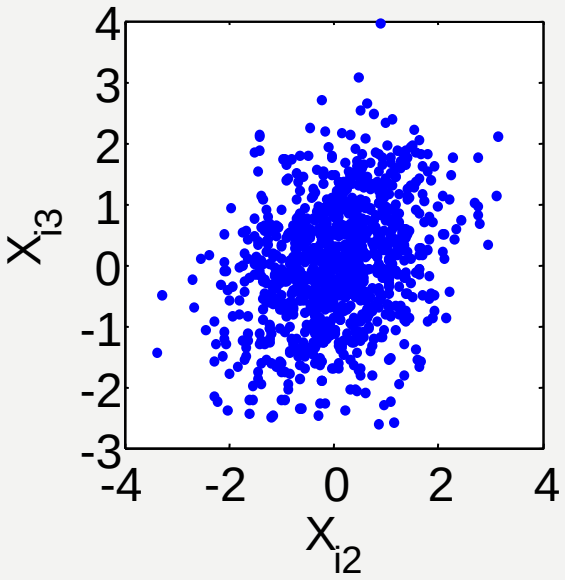
SPHERICITY

- **Sphericity** is the property that the degree of interaction (covariance) between any two different levels of the independent variable is the same.
- **Sphericity** is critical for RM ANOVA because the error term is the average of the pairwise interactions.
- Violations generally lead to inflated F statistics (and hence inflated Type I error).

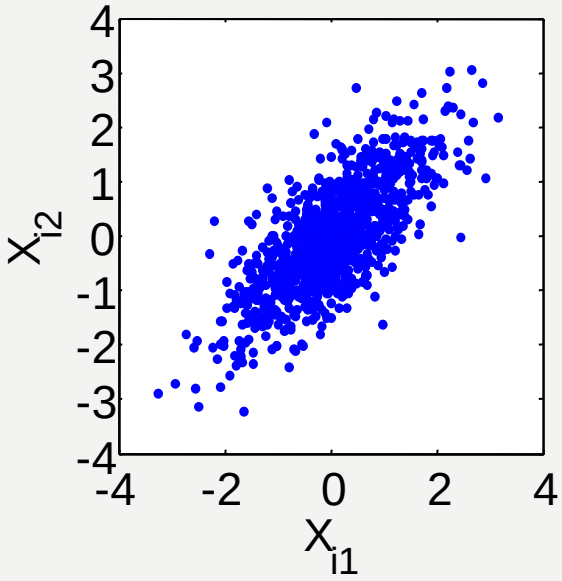
SPHERICITY DOES NOT HOLD

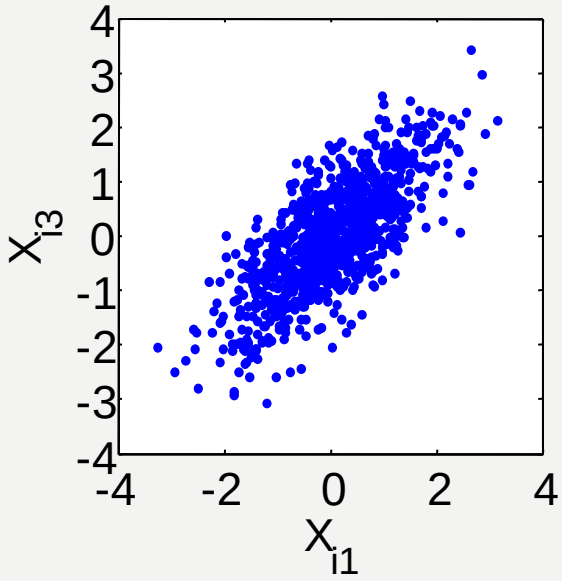


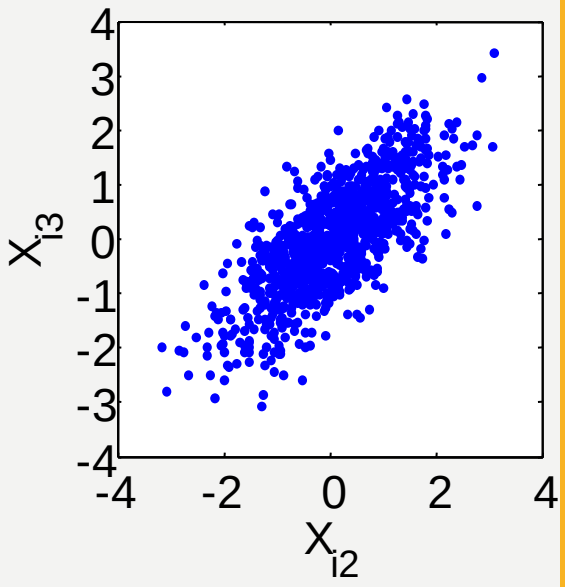




SPHERICITY DOES HOLD







- ***SO THE SPHERICITY MEAN THAT:***

  - Variance of the differences between conditions is the same.
    - $\text{Variance}_{t1\text{-}t2} \approx \text{Variance}_{t1\text{-}t3} \approx \text{Variance}_{t2\text{-}t3}$

  - Correlation between pairs of groups is the same.
    - $\text{Corr}_{t1\text{-}t2} \approx \text{Corr}_{t1\text{-}t3} \approx \text{Corr}_{t2\text{-}t3}$

  This assumption can be tested using Mauchly's Sphericity Test.

TESTING SPHERICITY

- **Mauchly's Test**
  - If $p > .05$, assume equality of variances.

- If p < .05, then the data fails to meet the assumption of sphericity.

Need to use one of the correction factors
E.g. Greenhouse-Geisser
A more conservative test, using different dfs

Mauchly's Test of Sphericity[b]

Measure:MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig	Epsilon[a]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
factor1	.077	44.681	9	.000	.414	.448	.250

Which estimate do you use?

Remember!: If the Epsilon estimates <.75, use Greenhouse-Geisser (GG);

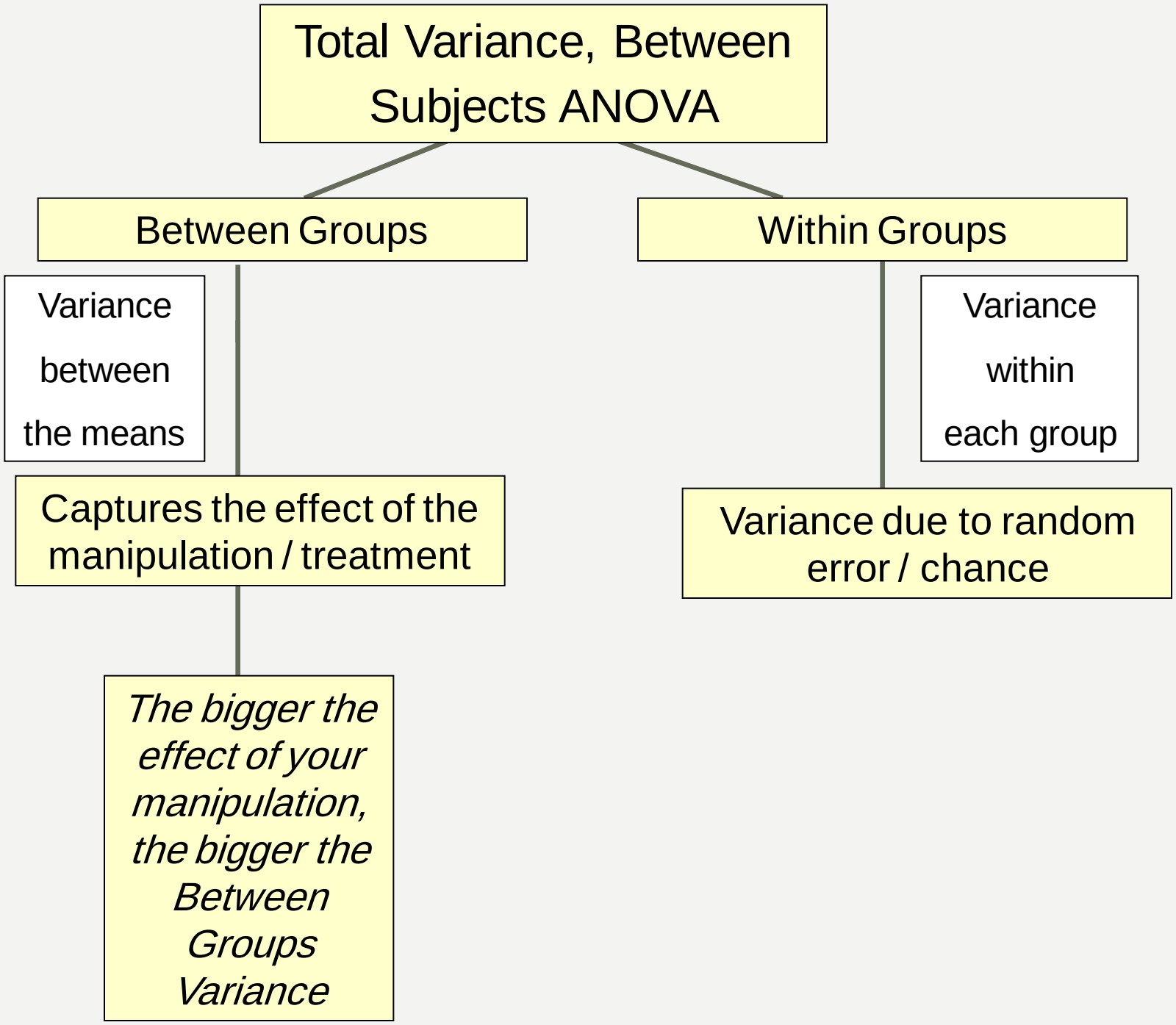
If the Epsilon estimates > .75, use Huynh-Feldt (HF).

CORRELATION ACROSS TIME POINTS

	Time 1	Time 2	Time 3	Time 4
Time 1	1.00000	0.94035	-0.14150	0.28445
Time 2	0.94035	1.00000	-0.02819	0.26921
Time 3	-0.14150	-0.02819	1.00000	0.27844
Time 4	0.28445	0.26921	0.27844	1.00000

Time 1 and Time 2 are highly positively correlated, but Time 1 and Time 3 are *negatively* correlated!

Thus for this example we might conclude that the conditions for compound symmetry are NOT met.


Total Variance, Between Subjects ANOVA
Between Groups
Within Groups
Variance between the means
Variance within each group
Captures the effect of the manipulation / treatment
Variance due to random error / chance
The bigger the effect of your manipulation, the bigger the Between Groups Variance

NOW WE HAVE FOUR KINDS OF VARIANCE

- **TOTAL VARIANCE**
  - SS_{total}
  - $\sum (x_{ij} - \text{Grand Mean})^2$
- **Variance due to the manipulation**
  - $SS_{treatment}$
  - $n\sum (\text{Group mean}_j - \text{Grand Mean})^2$

- **Variance due to individual differences between participants**
  - $SS_{participants}$
  - No. of conditions $\sum$ (Participant mean - Grand Mean $)^2$
- **Variance due to random error**
  - $SS_{random\ error} = SS_{total} - SS_{treatment} - SS_{participants}$

F Ratio

Compares the variance due to the treatment / manipulation to the variance due to random error / chance

$$\frac{MS_{\text{between groups}}}{MS_{\text{within groups}}}$$

$$\frac{\text{Between Groups Variance}}{\text{Within Groups Variance}}$$

$$\frac{\text{Treatment Effect + Differences due to chance / error}}{\text{Differences due to chance / error}}$$

If the treatment / manipulation has an effect, then…

$$MS_{\text{between groups}} > MS_{\text{within groups}}$$

$$F > 1$$

Repeated measures (no grouping factor, one repeated measures factor (time))

Source	SS	df	MS	F
Between Subject	SS_{Subject}	n - 1	MS_{Subject}	$MS_{\text{Time}} / MS_{\text{Error}}$
Time	SS_{Time}	t - 1	MS_{Time}	
Between Subject Error	SS_{Error}	(n - 1)(t - 1)	MS_{Error}	

EXAMPLE:

	Condition / Treatment		
Person	1	2	3
1	2	4	7
2	10	12	13
3	22	29	30
4	30	31	34

	Condition / Treatment			
Person	1	2	3	
1	2	4	7	
2	10	12	13	
3	22	29	30	
4	30	31	34	
Mean	16	19	21	18.67

$SS_{treatment}$: no. of people in each condition ∑ (Treatment Mean - Grand Mean)^2

$$4 \sum(16 - 18.67)^2 + (19 - 18.67)^2 + (21 - 18.67)^2$$

Condition / Treatment

Person	1	2	3	Mean per person
1	2	4	7	4.33
2	10	12	13	11.67
3	22	29	30	27
4	30	31	34	31.67
Mean	16	19	21	18.67

$SS_{participants}$: no. of conditions $\sum$ (Participant Mean - Grand Mean)2

$$3 \sum(4.33 - 18.67)^2 + (11.67 - 18.67)^2 + \ldots + (31.67 - 18.67)^2$$

	Condition / Treatment			
Person	1	2	3	Mean per person
1	2	4	7	4.33
2	10	12	13	11.67
3	22	29	30	27
4	30	31	34	31.67
Mean	16	19	21	18.67

$$SS_{\text{random error}} = SS_{\text{total}} - SS_{\text{treatment}} - SS_{\text{participants}}$$

ANOVA TABLE

Source of variation	SS	df	MS	F	p
Between participants (individual differences)	$K \sum (\text{Participant Mean} - \text{Grand Mean})^2$	$n - 1$			
Treatment	$n \sum (\text{Treatment mean}_j - \text{Grand Mean})^2$	$K - 1$	SS_T / df_T	$\frac{MS_{Treatment}}{MS_{error}}$	Prob. of observing F-value when H_o is true
Random Error	$SS_{total} - SS_{treatment} - SS_{participants}$	$(n-1)x(k-1)$	SS_e / df_e		
Total	$\sum (x_{ij} - \text{Grand Mean})^2$	$N - 1$			

N = Total no. of observations, n = no. of people in each condition, K = no. of conditions

EXAMPLE (1)

- In the following study the experimenter was interested in how the level of a certain enzyme changed in cardiac patients after open heart surgery:

For n = 15 cardiac surgical patients, the enzyme was measured:

- **Immediately after surgery (Day 0),**
- **One day (Day 1),**
- **Two days (Day 2) and**
- **One week (Day 7) after surgery.**