

MSc Applied Social and Health Psychology

Applied Research, Ethics, and Analysis (AREA)

Analysis of Variance (ANOVA)

Dr Kate Williams

Essential Reading

- Brace, N., Kemp, R., & Snelgar, R. *SPSS for Psychologists*
- Pallant, J. *SPSS Survival Manual*
- Coolican, H. *Research methods and statistics in psychology.*

Analysis of Variance (ANOVA)

- Basic Terms:
- Factors: These are the Independent Variables (IVs)
- Levels of factors: Similar to conditions
- Between-subject factor: Factors where levels vary between Ps (each P only experiences 1 level of a factor).
- Within-subject factors: Factors whose various levels vary within a P (each P will experience 2 or more levels of a factor).

Analysis of Variance (ANOVA)

- Often we want to ask quite complex question.
- We may need to examine more than two groups.
- We may want to examine which of a number of variables **has the greatest influence** over a given outcome?
- How does a variable/factor **effect the DV** in light of another variable/factor?
- What is the **interaction** of two (or more) variables/factors **in their effect on DV**?

Analysis of Variance (ANOVA)

- Why use ANOVA? 4 main reasons:
 1. It can handle more than 2 groups.
 2. It can handle more than 2 conditions.
 3. It can handle more than 1 IV.
 4. It shows us interactions between IVs.

ANOVA

- ANOVA can handle data from studies involving more than 2 groups/conditions:
 - E.g., A researcher wants to examine psychological distress of patients over three different time points: 1 month, 5 months, & 10 months.
 - If there were only 2 conditions e.g., 1 month vs. 10 months, we would conduct a t-test.
 - But because there are more than two conditions we would need to conduct an ANOVA.

ANOVA

IV
Patient distress over time

```
graph TD; IV["IV  
Patient distress over time"] --- C1["Condition 1  
Time: 1 month"]; IV --- C2["Condition 2  
Time: 5 months"]; IV --- C3["Condition 3  
Time: 10 months"];
```

Condition 1

Time: 1
month

Condition 2

Time: 5
months

Condition 3

Time: 10
months

Why not just do lots of t-tests?....



Analysis of Variance (ANOVA)

- Too many multiple comparisons = increased likelihood of Type 1 error
- Type 1 error more possible by chance
 - Accept a difference as significant ($p < 0.05$) in error
- ANOVA corrects for this problem:
 - More stringent test of significance than t-test

ANOVA

- ANOVA allows us to investigate the effect of more than one Independent variable (IV)
 - E.g., examine the effect of a gender and age on remembering a list of words.
 - Here there are 2 IVs: (1) Gender and (2) Age
 - One DV: Memory for the list of words
- ANOVA can handle any number of IVs (but more than about 4 are rarely used)

ANOVA

IV 1
Gender

Male

Female

IV 2
Age

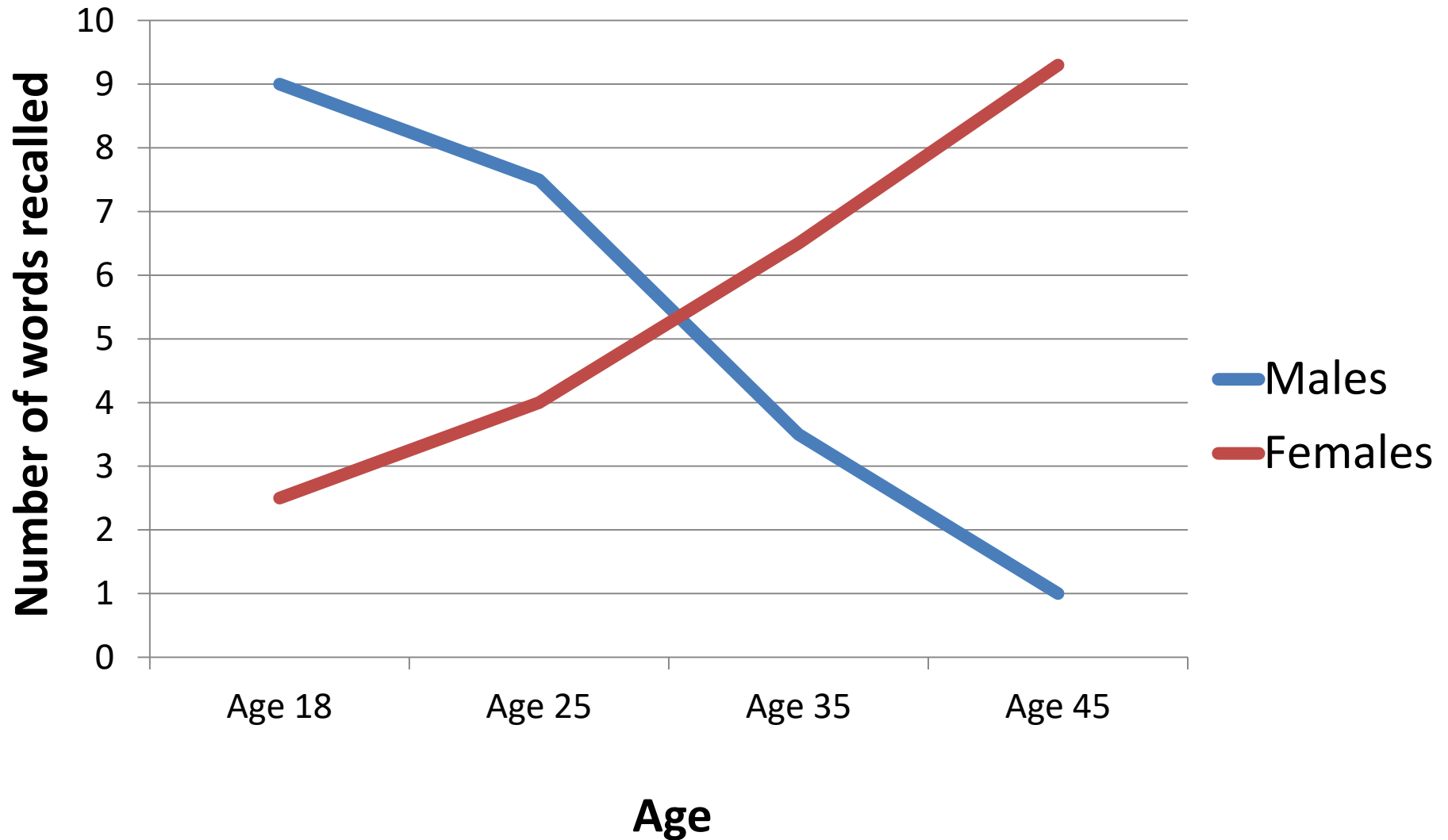
18-35

36-53

ANOVA – Interactions

- Allows us to investigate how multiple IVs combine (or interact) to affect the DV.
 - E.g., consider previous example: Effects of gender and age on memory score.
 - Males may remember more than females; older Ps may remember more than younger Ps.
 - OR we may see an interaction:
 - Male performance may decline with age while female performance may improve with age.

Interactions in ANOVA



Analysis of Variance (ANOVA)

- ANOVA is a parametric test so the following conditions must be met in order to use it:
 1. The DV comprises of interval or ratio data.
 2. Data is from a normally distributed population.
 3. There is homogeneity of variance (population variances are all equal).
 4. For independent group design, independent random sample must be taken from each population

Analysis of Variance (ANOVA)

- Human performance varies both between individuals and within the same individual.
- If variance **between** conditions is larger than variance **within** conditions, we can say that the IV is having a larger effect on scores than individual differences are.
- So ANOVA needs to calculate both types of variances.

Analysis of Variance (ANOVA)

- ANOVA compares the between-group variation to the random variation (within group variation) within each group.
- If there are differences between groups, the between group variance will be larger than the within group variance
- Calculated as the *F ratio*

The F-Ratio

- To put it another way:
- The F-ratio looks at whether variances are due to our manipulation of the IV or from other nuisance factors (also known as the error variance).

Possible ANOVA Designs

- **One-way within:** 1 factor (IV) with multiple levels (conditions) – Each P takes part in all conditions.
- **One-way between:** 1 factor (IV) with multiple levels (conditions) – Different Ps take part in each of the different conditions.
- **Two-way within:** 2 factors (IVs) with multiple levels (conditions) – Each P takes part in each possible combination of the 2 factors.
- **Two-way between:** 2 factors (IV) with multiple levels (conditions) – Different Ps take part in each of the different combination of factors and conditions.

Mixed ANOVA Designs

- A between (unrelated) independent variable
- A within (related) independent variable
 - Included together in one analysis
- A very common structure for studies
- Requires (at the minimum):
 - One categorical between-subjects IV (2 or more levels)
 - One categorical within-subjects IV (2 or more levels)
 - One continuous DV
- Can involve more than 2 IVs
- IVs can include more than 2 levels/conditions.

Possible ANOVA Designs

- ANOVA can handle any number of IVs
 - So you could have a three-way, four-way, etc.
- Great for applied research because in the real world there are often many factors that have an influence on an outcome.
- But this ability to measure many IVs all at once comes at a price – the complication of attempting to interpret multiple interactions.

Let's look at an example in detail...

- Effect of a coping intervention on Affect
 - IV: Group with 2 levels (Intervention or Control)
 - Between participants design ($\frac{1}{2}$ of the patients receive the intervention, $\frac{1}{2}$ receive usual care)
 - Aim = Examine any differences in Positive Affect (PA) between those who receive the intervention vs. those in the control group.

Intervention example

- What other factors need to be considered?
- Could things other than just the intervention influence reports of positive affect?
- What about levels of positive affect before patients took part in the study?
- How can we deal with this as a possible influencing factor?

Exploring Multiple Factors

- Need to study more than one IV
- Investigate possible ‘interaction’ between IVs
- Still looking at the effect on one DV (positive affect)
- IV1: Group (Intervention or Control)
- IV2: Original positive affect levels (time 1 vs. time 2)
- DV: positive affect scores after study manipulation
- This is a ‘multifactorial’ design

Describing ANOVAs

- You need to specify 3 things:
 1. How many **factors** are involved (IVs)
 2. How many **levels** there are of each factor (IV)
 3. Whether each factor (IV) is a **within-** or **between-**subject factor.

Intervention study:

- Because we have two IVs:
 - Have to combine the conditions of each
 - Both IVs have 2 conditions:
 - Group: Intervention VS. Control (between)
 - Time: One VS. Two (within)
 - This gives us a 2 x 2 mixed design
 - To test all combinations need 4 conditions

Multifactorial designs

- Intervention study:
- 2 x 2 table of conditions (4 conditions)

	Intervention	Control
Time 1 (Pre- study manipulation)	Condition 1	Condition 2
Time 2 (Post study manipulation)	Condition 3	Condition 4

Multifactorial designs

- Sample mean scores for the study:

	Intervention	Control	Means
Time 1 (Pre- study manipulation)	Condition 1	Condition 2	4.5
Time 2 (Post study manipulation)	Condition 3	Condition 4	8
Means	7.5	5	

Main effects and interactions

- We can assess the effect of each factor on their own and the interaction between them.
- **Main effect:** is used to describe the independent effect of a factor (IV).
- E.g., in the intervention study example, **2 main effects** will be reported:
 1. Group: Difference in means between intervention and control
 2. Time: Difference in means between time 1 and time 2

Multifactorial designs

- **‘Main effects’** are effects of one IV alone.
- Where is effect of the ‘time’ IV shown in the scores below?

	Intervention	Control	Means
Time 1 (Pre- study manipulation)	Condition 1	Condition 2	4.5
Time 2 (Post study manipulation)	Condition 3	Condition 4	8
Means	7.5	5	

Multifactorial designs

- **‘Main effects’** are effects of one IV alone.
- Where is effect of the ‘Group’ IV shown in the scores below?

	Intervention	Control	Means
Time 1 (Pre- study manipulation)	Condition 1	Condition 2	4.5
Time 2 (Post study manipulation)	Condition 3	Condition 4	8
Means	7.5	5	

Main effects

- The study can show us the ‘main effects’
 - Effects of each IV in isolation on DV score
 - Is there a significant difference between conditions
- However, the point was to examine how the **TWO** IVs may influence the DV **together**
- Analyse any possible ‘interaction’ between IVs
 - Combination of IVs in effecting the DV
 - Differences dependent on conditions of both IVs

Main effects and Interactions

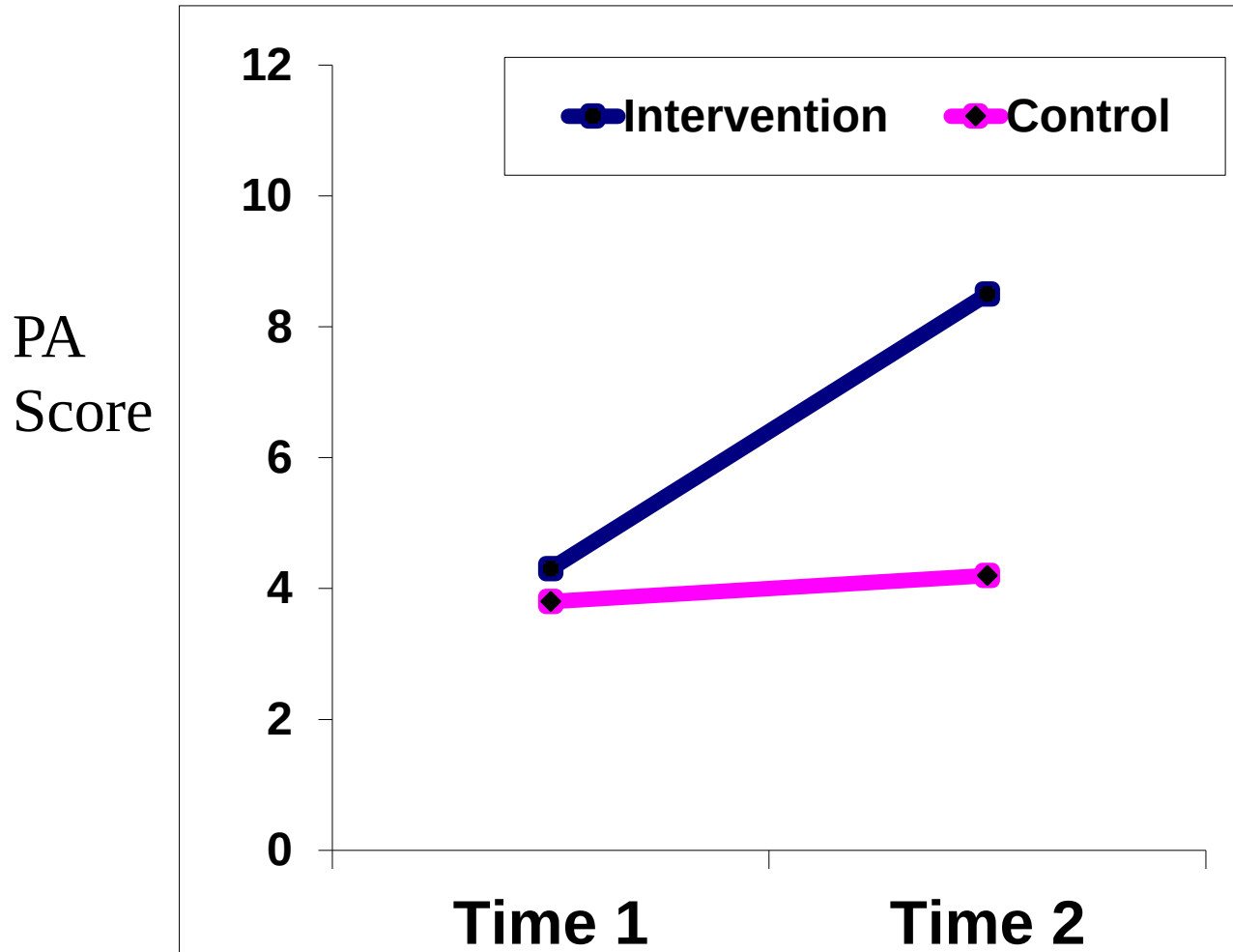
- **Main effects** compare means for one level/condition of a factor with the mean of the other level(s)/condition(s) of that factor.
 - In the same way as in an experiment with only 1 IV.
 - Only this time you would have more than 1 main effect.
- **Interactions**: assess the combined effect of the factors (all the IVs)
- An interaction assessing 2 factors combined is called a two-way interaction. When 3 factors are involved it is a three-way interaction. And so on....

Multifactorial designs

- How do the two IVs interact?

	Intervention	Control	Means
Time 1 (Pre- study manipulation)	Condition 1	Condition 2	4.5
Time 2 (Post study manipulation)	Condition 3	Condition 4	8
Means	7.5	5	

Using graphs to show interactions



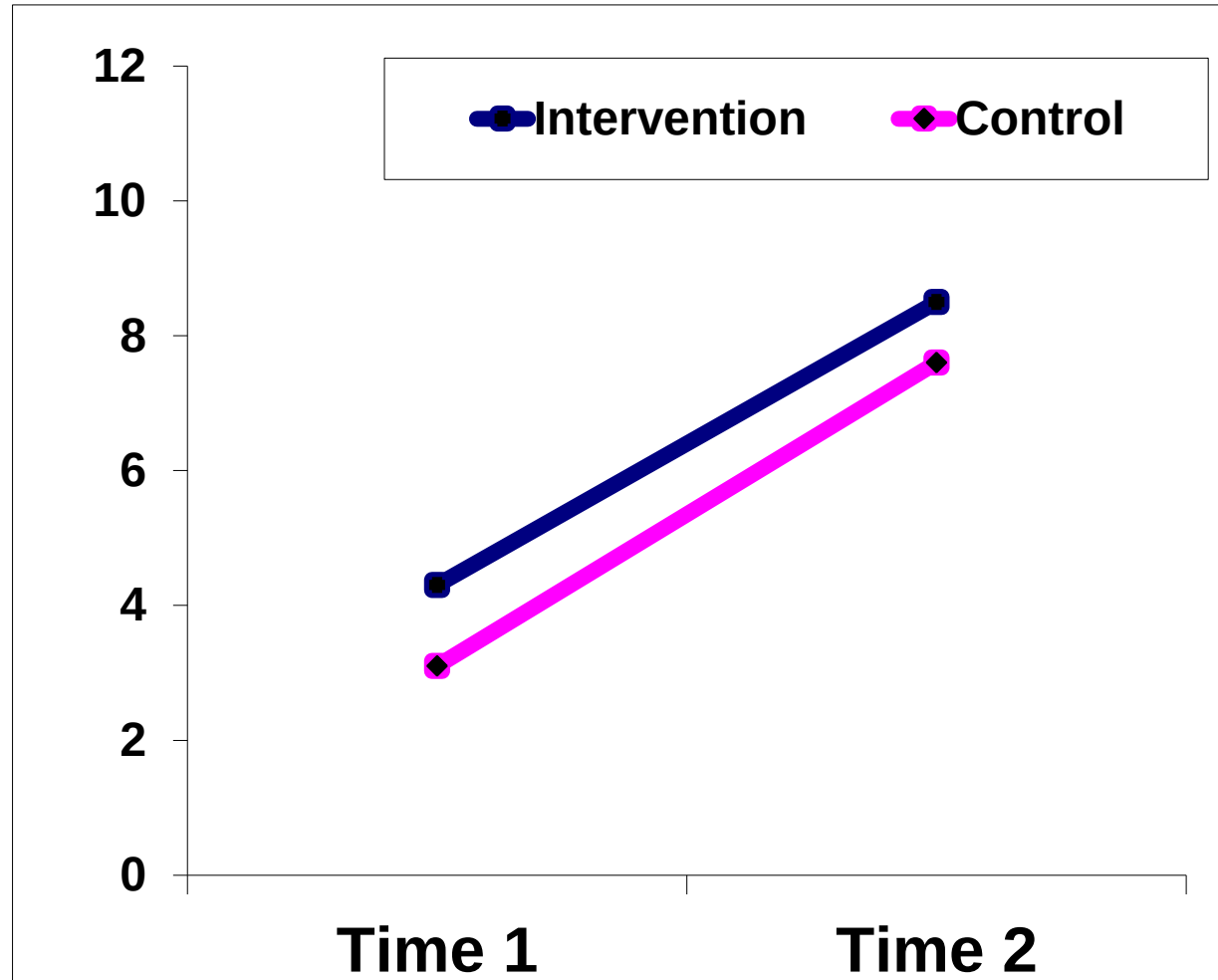
Why
interaction?

Effect of Group
IV (higher
scores for
intervention)
but effect
shown only at
time 2.

Using graphs to show interactions

- Key to interpreting is relative slope of lines
- Same/Similar slope = likely no interaction
- Markedly different slope indicates may be interaction between the IVs

Using graphs to show interactions



No
Interaction

Main effects
of Group
and Time

ANOVA Output

ANOVA will analyse:

- Main effects (effects of one IV in isolation)
- Interactions (combined effects of more than 1 IV)
- Main statistics for each analysis:
 - F-value, degrees of freedom (df), & p-value (sig. value)

ANOVA Output

- F-value equates to the t-value in the t-test
- Need 2 values for the df:
 - The value from the row of your IV and the value from the 'error' row of output.
- Sig. Value $p < 0.05$ is significant
- All show whether (or not) there are **significant differences** (and to what degree) between the means in each grouping of data.

Interpretation of mixed ANOVA Output

- Report descriptives (Means & Standard deviations)
- Check **Box's test of Equality of Covariance Matrices:**
 - Sig value needs to be **above** .001.
- Check **Levene's test of Equality of Error Variances:**
 - Needs to be **greater** than .05
- Check other tables (depending on type of ANOVA) to ensure no violations and ensure to read values from correct rows.
- Report main effects (For each IV)
- Report interaction effects
- Report effect size (Partial Eta Squared)
- Report planned and/or post-hoc tests (if needed)

Mixed ANOVA Practice

- Use the hypothetical SPSS data provided in the workshop materials folder on Moodle to conduct a 2x2 mixed ANOVA.
- Aim: to establish whether there would be any significant differences in positive affect (PA) at time 2 (after the study manipulation) between those in the intervention group and control group.
- Write up the results as you would for a report.

Planned/Post-hoc Comparisons

- Exploring significant main effects when there are more than 2 levels associated with an IV.
- Are you expecting differences at the start of your study?
 - Planned comparisons (*a Prior*)
- Are you wanting to explore non-hypothesised differences?
 - Post-hoc comparisons for between-subject factors (e.g., Tukey, Scheffe, Bonferroni)
 - Comparing main effects for within-subject factors (e.g., Bonferroni Pair-wise comparisons)

Let's look at our Intervention study in further detail to examine **distress** levels...

- Research Question:
 - Is a coping intervention programme more effective than a control condition in reducing distress across **three time** points?
 - 1. Referral, 2. Waiting period, and 3. After diagnosis
- How would you set this study up?
- What would you be comparing? And why?

Intervention Study

- One categorical between-subjects IV (number of levels ?)
- One categorical within-subjects IV (number of levels ?)
- One continuous DV



Intervention Study

- One categorical between-subjects IV (2 or more levels)
 - INTERVENTION GROUP v CONTROL GROUP
- One categorical within-subjects IV (2 or more levels)
 - TIME 1 (referral) v TIME 2 (waiting period) v TIME 3 (after diagnosis)
- One continuous DV
 - Distress scores (measured on validated scale)

Study Design

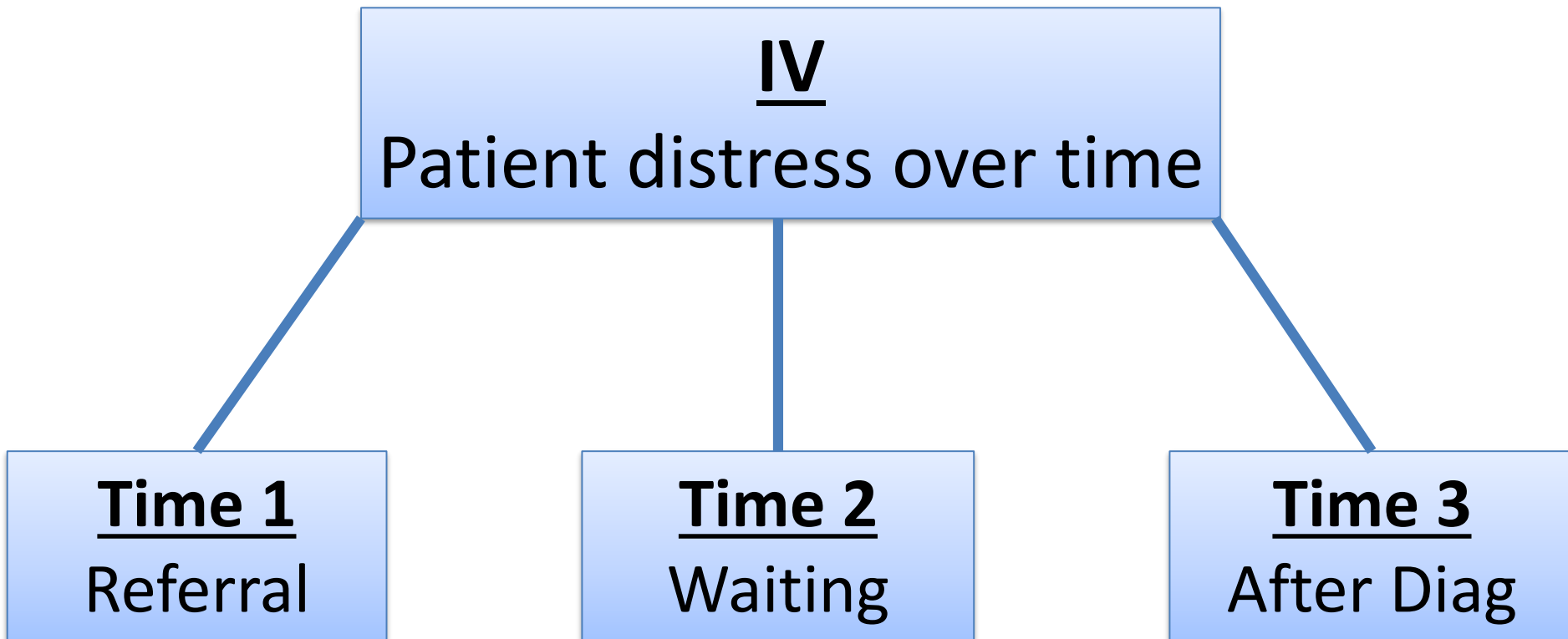
	CONTROL	INTERVENTION
Time 1		
Time 2		
Time 3		

- A 2 x 3 Mixed design ANOVA

Study Design

	CONTROL	INTERVENTION	Total Mean
Time 1	8.21	7.46	15.67
Time 2	6.21	6.30	12.51
Time 3	5.56	6.46	12.02
Total Mean	19.98	20.22	40.2

Time IV has more than 2 levels



Even if the main effect for time is sig, ANOVA does not tell us which means are different from which other means.

E.g., could be a significant difference between T1 & T2 but not between T2 & T3.

SPSS ANOVA Output

Descriptive Statistics

group		Mean	Std. Deviation	N
tot_int1	intervention	7.46	8.681	124
	control	8.21	8.077	137
	Total	7.85	8.361	261
tot_int2	intervention	6.30	7.338	124
	control	6.21	7.049	137
	Total	6.25	7.174	261
tot_int3	intervention	6.46	7.807	124
	control	5.56	6.266	137
	Total	5.99	7.041	261

SPSS Output: Assumptions

Box's Test of Equality of Covariance Matrices^a

Box's M	8.555
F	1.408
df1	6
df2	473190.960
Sig.	.207

Check that the Sig.
value here is bigger
than .001 (i.e., **NOT**
significant) to ensure
that this assumption
has not been violated.

Tests the null
hypothesis that
the observed
covariance
matrices of the
dependent
variables are
equal across
groups.

a. Design:
Intercept + group
Within Subjects
Design: Time

SPSS Output: Assumptions

Mauchly's Test of Sphericity^b

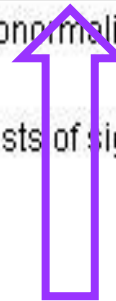
Measure: MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon ^a		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Time	.927	19.536	2	.000	.932	.942	.500

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

b. Design: Intercept + group
Within Subjects Design: Time



Assumption being tested is that correlation between all variables is roughly the same. Sig value here should be bigger than 0.05 (i.e., **NOT** significant). If it is significant then assumption of sphericity is violated and you will need to report values from either the 'Multivariate Tests' box or other rows in the 'Tests of within-subjects effects' box in the output.

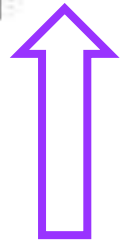
SPSS Output: Assumptions

Levene's Test of Equality of Error Variances^a

	F	df1	df2	Sig.
tot_int1	.013	1	259	.910
tot_int2	.264	1	259	.608
tot_int3	3.297	1	259	.071

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

a. Design: Intercept + group
Within Subjects Design: Time



Check that the Sig. value for **each** condition in this box is bigger than 0.05 (i.e., **NOT** significant). Need to ensure that all are not significant because this tells us that the assumption of homogeneity of variances has not been violated and so we are safe to proceed with our interpretation of the ANOVA.

SPSS Output: Interaction

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Time	Sphericity Assumed	510.938	2	255.469	11.226	.000	.042
	Greenhouse-Geisser	510.938	1.864	274.099	11.226	.000	.042
	Huynh-Feldt	510.938	1.884	271.155	11.226	.000	.042
	Lower-bound	510.938	1.000	510.938	11.226	.001	.042
Time * group	Sphericity Assumed	88.442	2	44.221	1.943	.144	.007
	Greenhouse-Geisser	88.442	1.864	47.446	1.943	.148	.007
	Huynh-Feldt	88.442	1.884	46.937	1.943	.147	.007
	Lower-bound	88.442	1.000	88.442	1.943	.165	.007
Error(Time)	Sphericity Assumed	11788.265	518	22.757			
	Greenhouse-Geisser	11788.265	482.793	24.417			
	Huynh-Feldt	11788.265	488.034	24.155			
	Lower-bound	11788.265	259.000	45.515			

No significant interaction

Be careful when reading the columns

Final column 'Partial Eta Squared' shows estimate of effect size

SPSS Output: Main effects

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Time	Sphericity Assumed	510.938	2	255.469	11.226	.000	.042
	Greenhouse-Geisser	510.938	1.864	274.099	11.226	.000	.042
	Huynh-Feldt	510.938	1.884	271.155	11.226	.000	.042
	Lower-bound	510.938	1.000	510.938	11.226	.001	.042
Time * group	Sphericity Assumed	88.442	2	44.221	1.943	.144	.007
	Greenhouse-Geisser	88.442	1.864	47.446	1.943	.148	.007
	Huynh-Feldt	88.442	1.884	46.937	1.943	.147	.007
	Lower-bound	88.442	1.000	88.442	1.943	.165	.007
Error(Time)	Sphericity Assumed	11788.265	518	22.757			
	Greenhouse-Geisser	11788.265	482.793	24.417			
	Huynh-Feldt	11788.265	488.034	24.155			
	Lower-bound	11788.265	259.000	45.515			

Significant main effect of Time

SPSS Output: Main effects

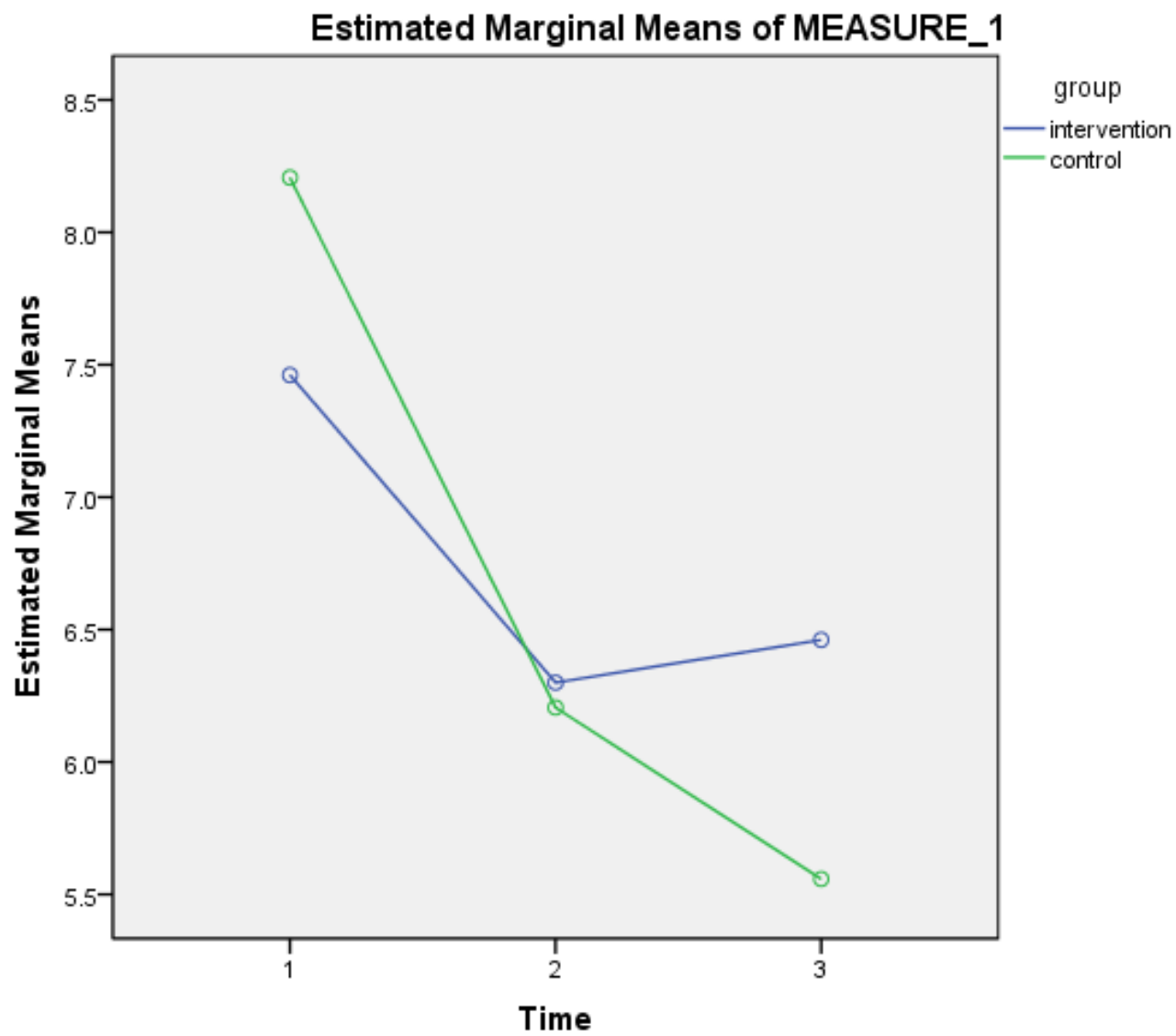
Tests of Between-Subjects Effects

Measure: MEASURE_1
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	35048.299	1	35048.299	278.693	.000	.518
group	1.369	1	1.369	.011	.917	.000
Error	32571.759	259	125.760			

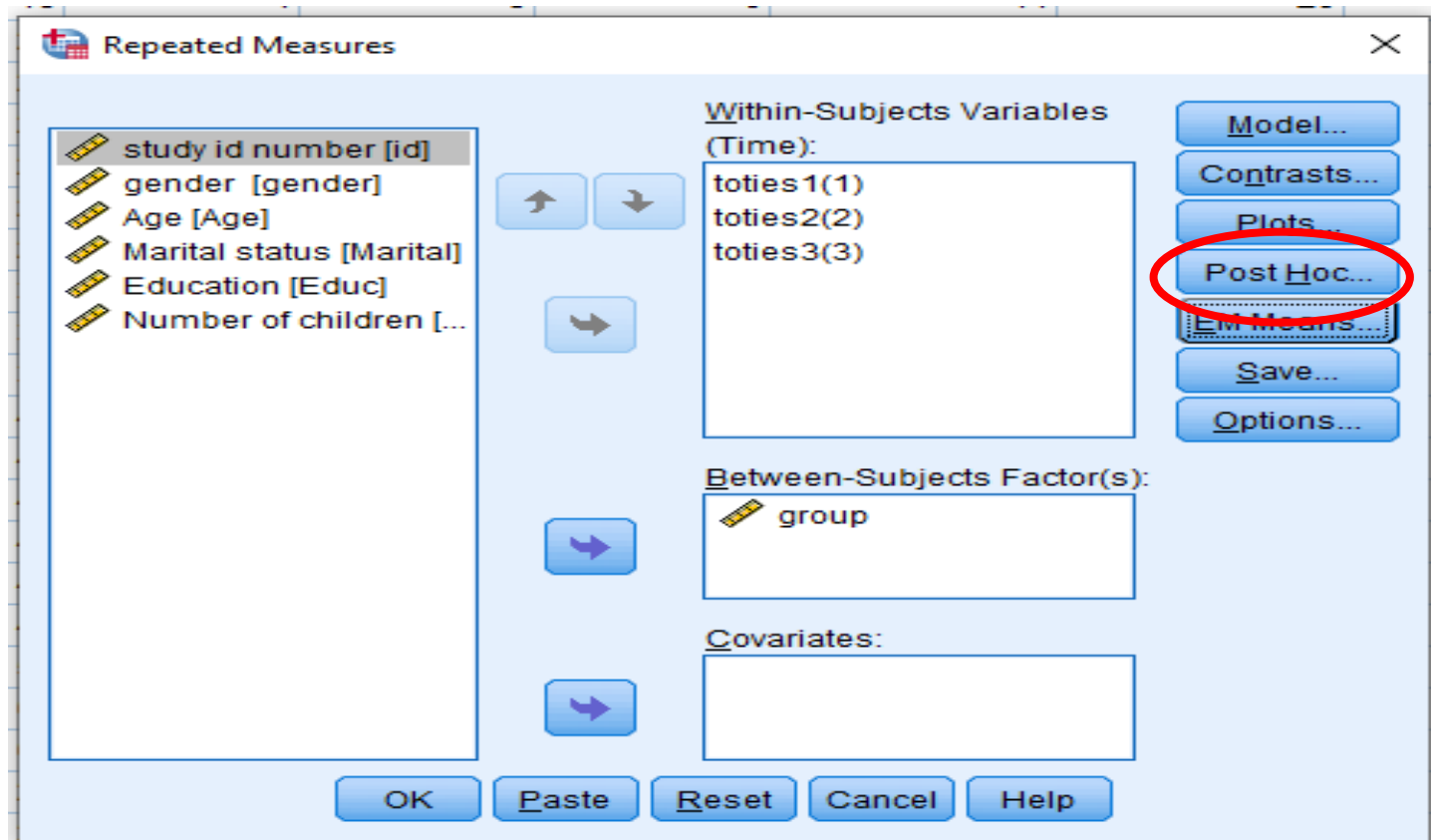
No significant main effect of Group

Plot



Post-hoc comparisons – Between groups

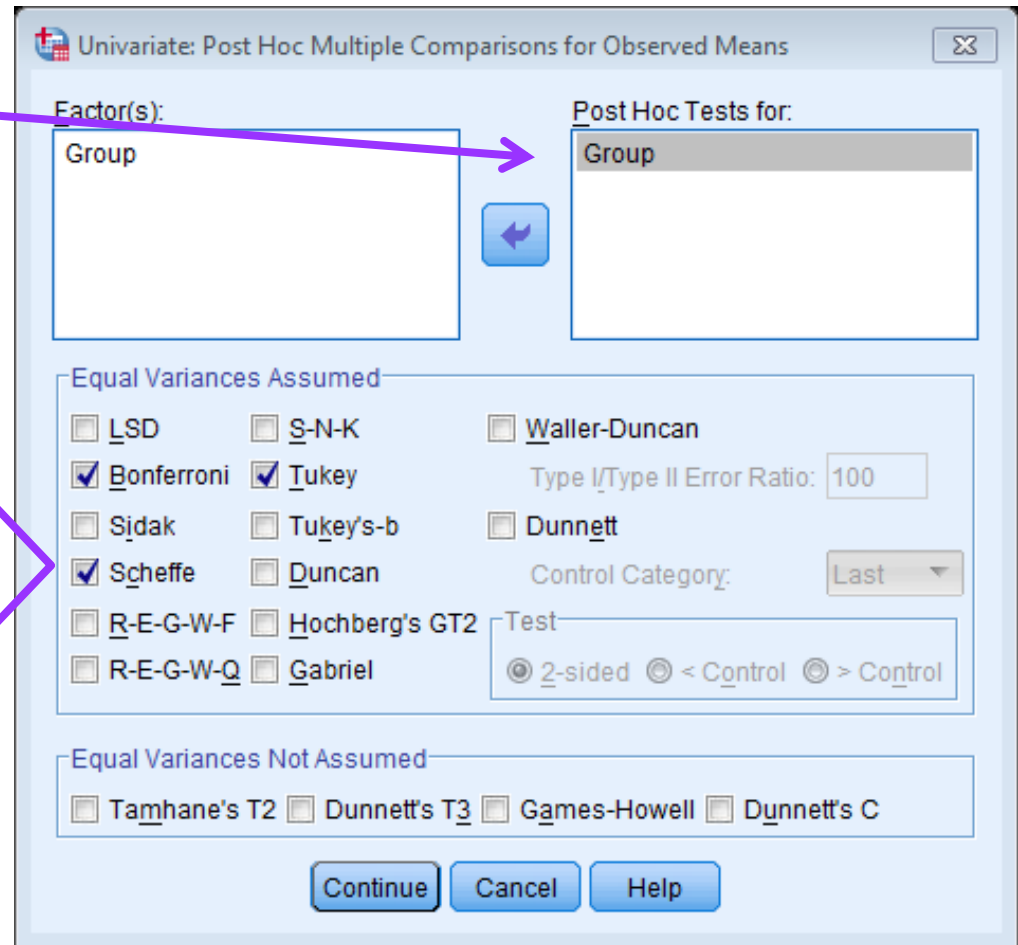
- If you have a significant main effect of a between-subjects factor with more than 2 levels:
 - E.g., 3 groups (Caffeine, Placebo, No caffeine)
 - You can ask SPSS to perform post-hoc tests



Post-hoc comparisons – Between groups

Move the variable
in to the 'Post Hoc
Tests for:' box

Some post-hoc tests are more conservative than others. Depending on the statistics book you read some would recommend using Tukey, while others would recommend Scheffe, and others Bonferroni. I have ticked all of these so you can see the difference in the values they produce.



The image shows the 'Univariate: Post Hoc Multiple Comparisons for Observed Means' dialog box in SPSS. The 'Factor(s):' box contains 'Group'. The 'Post Hoc Tests for:' box also contains 'Group'. A purple arrow points from the 'Factor(s):' box to the 'Post Hoc Tests for:' box. The 'Equal Variances Assumed' section has several tests checked: Bonferroni, Tukey, Scheffe, and Dunnett. The 'Equal Variances Not Assumed' section has Tamhane's T2, Dunnett's T3, Games-Howell, and Dunnett's C checked. The 'Type I/Type II Error Ratio' is set to 100. The 'Control Category' is set to 'Last'. The 'Test' section has '2-sided' selected. The 'Continue', 'Cancel', and 'Help' buttons are at the bottom.

Univariate: Post Hoc Multiple Comparisons for Observed Means

Factor(s):
Group

Post Hoc Tests for:
Group

Equal Variances Assumed

- ☐ LSD
- ☒ Bonferroni
- ☐ Sidak
- ☒ Scheffe
- ☐ R-E-G-W-F
- ☐ R-E-G-W-Q
- ☐ S-N-K
- ☒ Tukey
- ☐ Tukey's-b
- ☐ Duncan
- ☐ Hochberg's GT2
- ☐ Gabriel
- ☐ Waller-Duncan
- ☐ Dunnett

Type I/Type II Error Ratio: 100

Control Category: Last

Test:
☒ 2-sided ☐ < Control ☐ > Control

Equal Variances Not Assumed

- ☒ Tamhane's T2
- ☒ Dunnett's T3
- ☒ Games-Howell
- ☒ Dunnett's C

Continue Cancel Help

SPSS Output: Post-hoc comparisons – Between groups

Multiple Comparisons

Dependent Variable: Errors

	(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Tukey HSD	Caffeine	Placebo	-3.40 [*]	.757	.002	-5.42	-1.38
		No Caffeine	-5.20 [*]	.757	.000	-7.22	-3.18
	Placebo	Caffeine	3.40 [*]	.757	.002	1.38	5.42
		No Caffeine	-1.80	.757	.083	-3.82	.22
	No Caffeine	Caffeine	5.20 [*]	.757	.000	3.18	7.22
Scheffe	Caffeine	Placebo	-3.40 [*]	.757	.003	-5.51	-1.29
		No Caffeine	-5.20 [*]	.757	.000	-7.31	-3.09
	Placebo	Caffeine	3.40 [*]	.757	.003	1.29	5.51
		No Caffeine	-1.80	.757	.099	-3.91	.31
	No Caffeine	Caffeine	5.20 [*]	.757	.000	3.09	7.31
Bonferroni	Caffeine	Placebo	-3.40 [*]	.757	.002	-5.50	-1.30
		No Caffeine	-5.20 [*]	.757	.000	-7.30	-3.10
	Placebo	Caffeine	3.40 [*]	.757	.002	1.30	5.50
		No Caffeine	-1.80	.757	.105	-3.90	.30
	No Caffeine	Caffeine	5.20 [*]	.757	.000	3.10	7.30

Based on observed means.

The error term is Mean Square(Error) = 1.433.

*. The mean difference is significant at the 0.05 level.

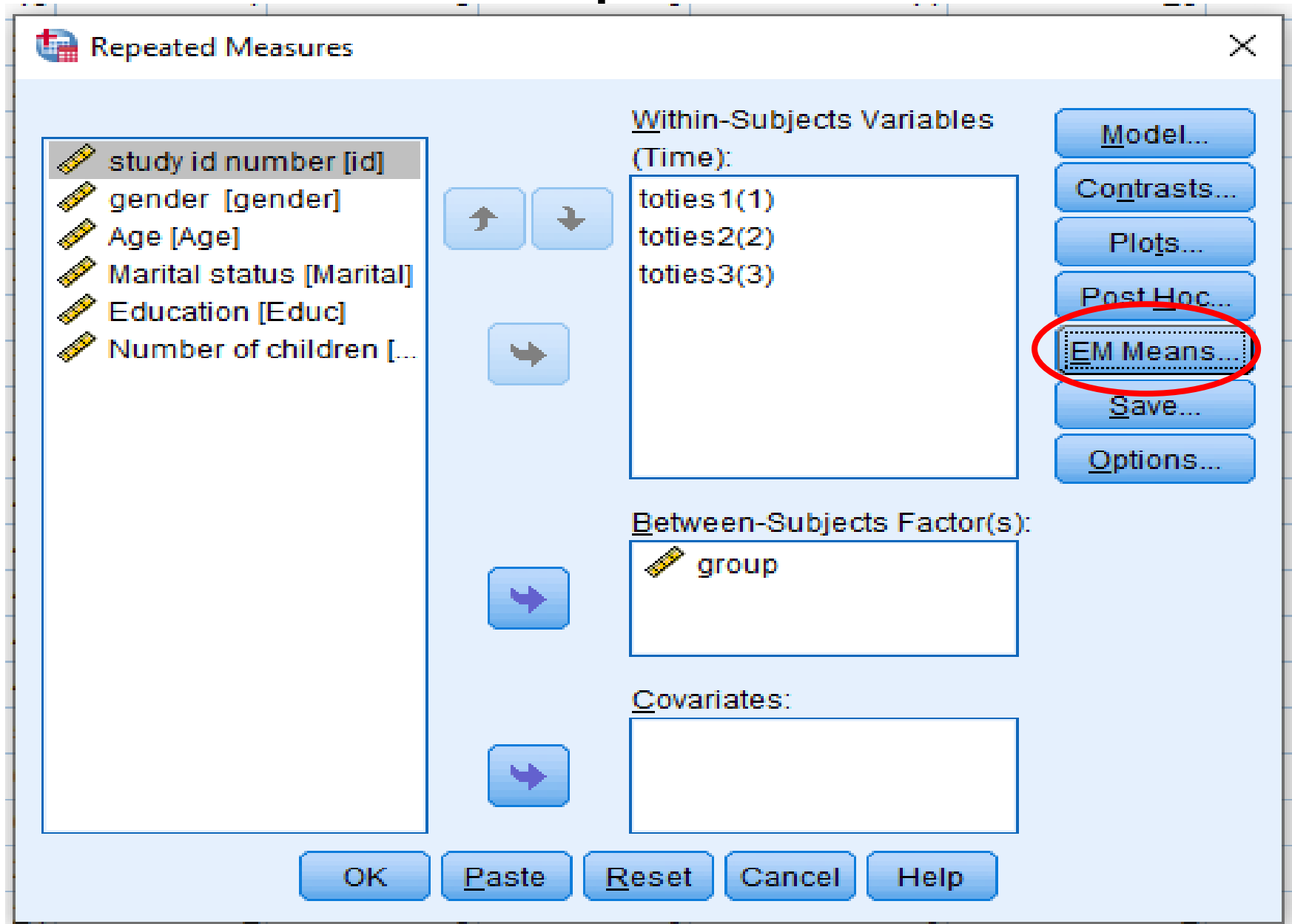
Reporting Between groups post-hoc analyses

- The information you present should include:
 - The type of post-hoc test
 - The mean and Standard Deviation values for each group
 - The Sig value for each comparison.
- E.G., “Employing the Bonferroni post-hoc test, statistically significant differences were found in error rates between the Caffeine (M=4.7; SD=0.2) and No Caffeine (M=1.3; SD=0.1) groups ($p < 0.005$), and between the Caffeine (M=4.7; SD=0.2) and Placebo (M=2.7; SD=1.7) groups ($p < 0.001$). However, there was no statistically significant difference found between the Placebo (M=2.7; SD=1.7) and No caffeine (M=1.3; SD=0.1) groups ($p = 0.1$).”

Comparing significant main effects for within-subject factors

- If you have a significant main effect of a within-subjects factor with more than 2 levels:
 - SPSS can perform Pairwise comparisons
- E.g., In our intervention example there was a significant main effect of time (3 levels)
- Where does the difference lie?
 - Time1 & Time 3? Time2 & Time3? Time1 & Time2? All?

Pairwise Comparisons - Within



The image shows the 'Repeated Measures' dialog box in SPSS. On the left, a list of variables includes 'study id number [id]', 'gender [gender]', 'Age [Age]', 'Marital status [Marital]', 'Education [Educ]', and 'Number of children [...]'. The 'Within-Subjects Variables (Time):' box contains 'toties1(1)', 'toties2(2)', and 'toties3(3)'. The 'Between-Subjects Factor(s):' box contains 'group'. The 'Covariates:' box is empty. On the right, a vertical stack of buttons includes 'Model...', 'Contrasts...', 'Plots...', 'Post Hoc...', 'EM Means...', 'Save...', and 'Options...'. The 'EM Means...' button is circled in red. At the bottom are 'OK', 'Paste', 'Reset', 'Cancel', and 'Help' buttons.

Repeated Measures

study id number [id]
gender [gender]
Age [Age]
Marital status [Marital]
Education [Educ]
Number of children [...]

Within-Subjects Variables (Time):
toties1(1)
toties2(2)
toties3(3)

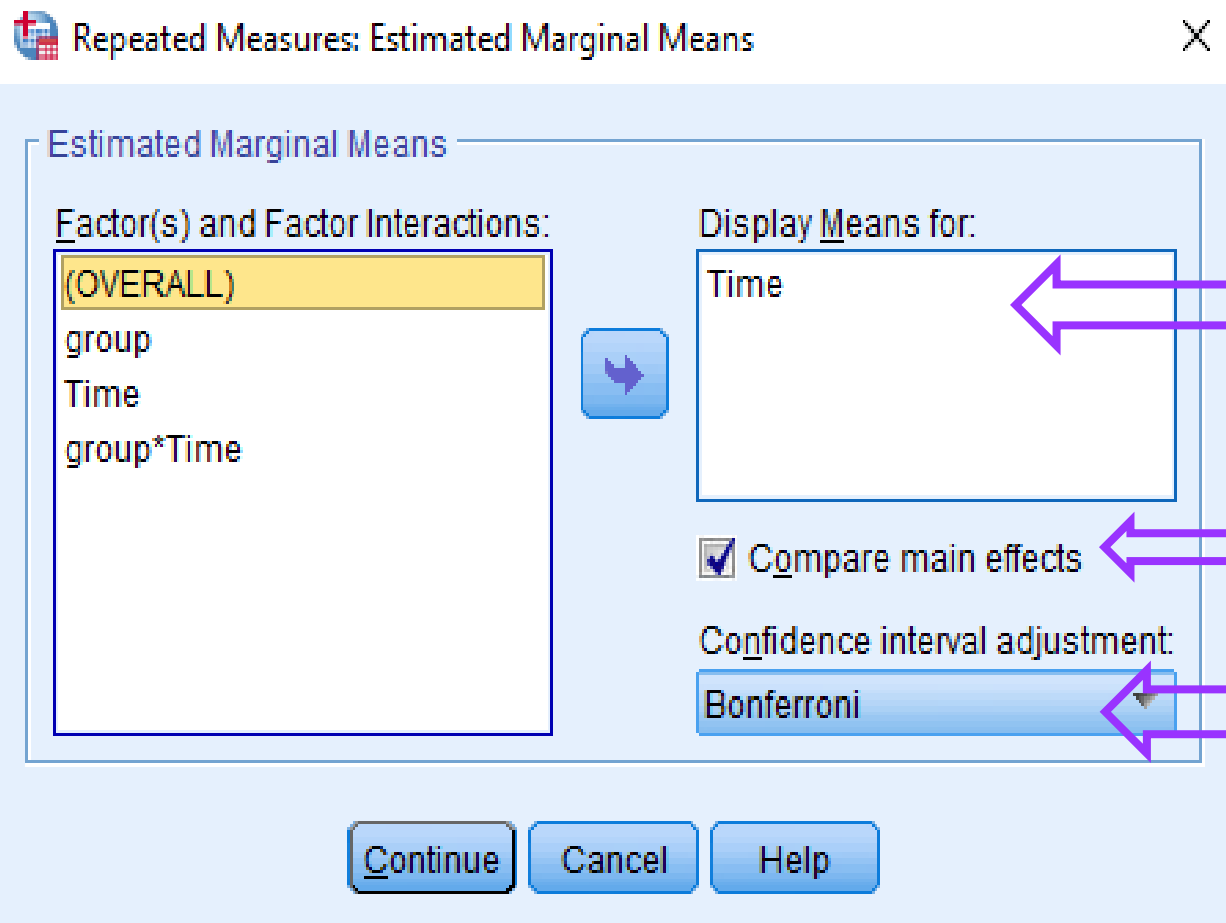
Between-Subjects Factor(s):
group

Covariates:

Model...
Contrasts...
Plots...
Post Hoc...
EM Means...
Save...
Options...

OK Paste Reset Cancel Help

Pairwise Comparisons - Within



Move the variable in to the 'Display Means for' box

Tick 'Compare main effects'

Change 'Confidence interval adjustment' to 'Bonferroni'

Descriptives

Repeated Measures

study id number [id]
gender [gender]
Age [Age]
Marital status [Marital]
Education [Educ]
Number of children [...]

↑ ↓

→

↪

Within-Subjects Variables (Time):

toties1(1)
toties2(2)
toties3(3)

Between-Subjects Factor(s):

group

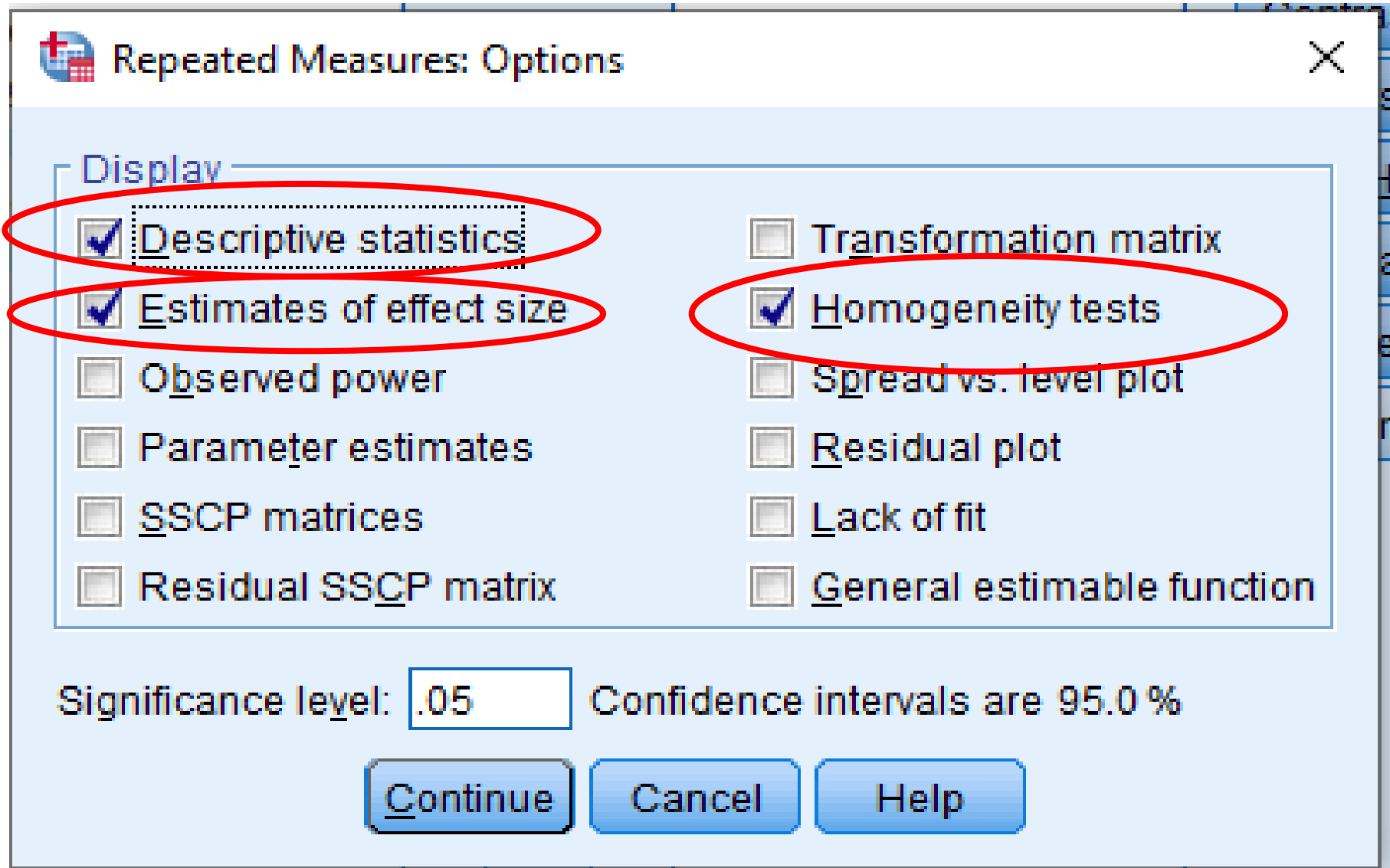
Covariates:

Model...
Contrasts...
Plots...
Post Hoc...
EM Means...
Save...
Options...

OK Paste Reset Cancel Help

Descriptives

Ensure these boxes are ticked



The image shows the 'Repeated Measures: Options' dialog box in SPSS. The 'Display' section contains two columns of options. In the first column, 'Descriptive statistics' and 'Estimates of effect size' are checked and circled in red. In the second column, 'Homogeneity tests' is checked and circled in red. Other options like 'Observed power', 'Parameter estimates', 'SSCP matrices', 'Residual SSCP matrix', 'Transformation matrix', 'Spread vs. level plot', 'Residual plot', 'Lack of fit', and 'General estimable function' are unchecked. At the bottom, the 'Significance level' is set to '.05' and 'Confidence intervals are 95.0 %'. There are 'Continue', 'Cancel', and 'Help' buttons at the bottom.

Repeated Measures: Options

Display

- ☒ Descriptive statistics
- ☒ Estimates of effect size
- ☐ Observed power
- ☐ Parameter estimates
- ☐ SSCP matrices
- ☐ Residual SSCP matrix
- ☐ Transformation matrix
- ☒ Homogeneity tests
- ☐ Spread vs. level plot
- ☐ Residual plot
- ☐ Lack of fit
- ☐ General estimable function

Significance level: .05 Confidence intervals are 95.0 %

Continue Cancel Help

SPSS Output: Pairwise Comparisons

Pairwise Comparisons

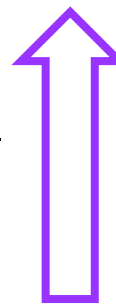
Measure: MEASURE_1

		Mean Difference (I- J)	Std. Error	Sig. ^b	95% Confidence Interval for Difference ^b	
(I) Time	(J) Time				Lower Bound	Upper Bound
1	2	3.900 [*]	.407	.000	2.706	5.094
	3	4.000 [*]	.537	.000	2.423	5.577
2	1	-3.900 [*]	.407	.000	-5.094	-2.706
	3	.100	.379	1.000	-1.011	1.211
3	1	-4.000 [*]	.537	.000	-5.577	-2.423
	2	-.100	.379	1.000	-1.211	1.011

Based on estimated marginal means

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

b. Adjustment for multiple comparisons: Bonferroni.



Reporting Within groups post-hoc analyses

- The information you present should include:
 - The type of post-hoc test
 - The mean and SD values for each group
 - The Sig value for each comparison.

Mixed ANOVA practice – Where an IV has more than 2 levels.

- Using the hypothetical data provided on moodle, conduct a 2x3 mixed ANOVA.
- Aim: to establish whether an intervention programme is more effective than a control condition in reducing distress across **three time** points.
- Write up the results as you would for a report.

Interaction effects in ANOVA

- Experiments involving more than one factor (IV) gives us the main effect of each of the factors but also the possibility of an interaction between the factors.
- Manipulating more than 1 factor means we can see the ways in which a factor *interacts* with another.
- E.g., In the intervention study example there were 2 IVs: Group (Intervention vs. Control) that could interact with the other IV of Time point (1,2,3).

Interaction: Intervention Study

IV1: Group

Intervention

Control

IV2: Time

Time 1
Referral

Time 2
Waiting

Time 3
Diagnose

Interaction effects in ANOVA

- In order to investigate an interaction effect you would need to look at **Simple Effects**.
- A simple effect occurs when there is a significant effect of one level of a factor across the levels of the other factor.
- It can be thought of like separating the whole design of your study in to smaller constituent elements.

Interaction effects in ANOVA

- Simple effects can be investigated with:
 - T-tests
 - Planned Contrasts
 - One-way ANOVA
- **BUT:** Remember the investigation of simple effects must avoid 'capitalising on chance'.
- Think back to how you deal with multiple comparisons!!!

Interaction effects in ANOVA

- You may need to split the sample into groups according to one of your IVs.
- You could do this by using the 'Split File' option in SPSS
 - This allows you to split your sample according to one categorical variable and repeat analyses separately for each group.

Interaction effects in ANOVA

- Say we obtained a significant interaction between Group and Time in the intervention study....
- We might split the SPSS file by Group and look at the effect of Time on distress scores separately for the intervention group only and then run a separate analysis for the effect of Time on distress scores for the Control group only.
- Use your SPSS books to see how splitting a file is done – remember to turn off the split file option when you are finished otherwise all subsequent analysis will be split.

Interaction effects in ANOVA

- Relatively straight forward to interpret an interaction when each of your factors only has 2 levels.
- **BUT:** What if you had a study where one (or more) of the factors (IVs) has more than 2 levels?
- This gets quite tricky and you need to think carefully about what further analyses to do and how to interpret the results.

Interaction effects in ANOVA

- If you are comparing means across levels using t-tests, you **MUST ALWAYS KEEP ONE FACTOR CONSTANT!**
- Say there was a significant interaction between:
 - IV1: Group (2 levels: Intervention or Control)
 - IV2: Time (3 levels: 1, 2, 3).

Interaction effects in ANOVA

- You could compare the means for:
 - Intervention group Time 1 and Time 2;
 - Intervention group Time 2 and Time 3;
 - Intervention group Time 1 and Time 3
 - Control group Time 1 and Time 2;
 - Control group Time 2 and Time 3;
 - Control group Time 1 and Time 3
- **BUT NEVER:** Intervention group Time 1 with Control group Time 3, for example.

Note on follow-up tests

- Think about whether the comparisons are within-subjects or between-subjects
 - This will dictate whether you run Independent samples or Repeated-measures analyses.
- Think about whether you have any interaction effects, as this will dictate on what data you run any follow up analyses.

Mixed ANOVA practice – Interaction where an IV has more than 2 levels.

- Using the hypothetical data provided on moodle, conduct a 2x3 mixed ANOVA to examine the interaction when one of the IVs has more than 2 levels.
- Aim: to examine whether there is an interaction for patient distress levels between Intervention and control groups at three time points.
- Write up the results as you would for a report.

General ANOVA practice Worksheet

Includes:

One-way between

One-way within

Two way between

Mixed