

Research Design and Analysis

Lecture 3: Mixed-design ANOVA

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Aims:

- Continuation of multifactorial designs
- Mixed design ANOVA (within AND between IV's)
- Unplanned (*post-hoc*) tests

ANOVA

- Many different types of ANOVA
 - One-way between/within
 - Two-way between/within
 - Three-way between/within
 - Etc etc...
 - Mixed design

Mixed-design ANOVA

- Combines within-subjects variables and between-subjects variables in one analysis
- 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

Focus on Mixed-Design ANOVA

- Let's use a specific example and look at it in detail
 - (this will also be similar to the example you will be working on during workshops next week...)

Research question 1: the effect of subject of study (psychology and art) on end of year grades (DV).

- IV = between-subjects (2 levels; students either study psychology OR they study art)
- We find that scores were higher for psychology students

Focus on Mixed-Design ANOVA

- What other factors do we need to consider?
- Could other things other than **JUST** subject studied have an influence on end of year grades?
- What about the **year of study** itself?
- How can we deal with this as a possible influencing factor?

Focus on Mixed-Design ANOVA

- We now need to consider exploring **multiple factors** and also **mixed design**
- Need to include more than one IV
- Investigate possible '**interaction**' between IV's
- Still looking at the effect on one DV (end of year grades)

New Study

- IV 1: Subject studied (psychology or art)
- IV 2: Year of study (year one, two, or three)
- DV: End of year grade
- This is a '**multifactorial**' design, and also a **mixed-design ANOVA**

ANOVA – Multifactorial Design

- ANOVA allows us to investigate the effect of more than one IV
 - E.g., examine the effect of subject studied at university and year of study on end of year grades
 - Here we have **TWO IVs**: (1) subject of study and (2) year of study
 - **ONE DV**: end of year grades
- ANOVA can handle any number of IV's, but more than about 4 are rarely used... **Why?**

Research Question 2

The effect of subject and year of study on

end of year grades

Two categorical
IV's

One continuous
DV

ANOVA – Main effects and interactions recap

- ANOVA produces **main effects** and an **interaction effect**
 - This allows us to investigate how multiple IV's combine (or interact) to affect the DV, as well as each IV in isolation.
- Using the previous example...
 - Psychology students may have better end of year grades than art students; students in year three may have better grades than students in year one
 - OR** – we may see an interaction:
 - Psychology students have better grades in year three while art students score higher in year one.

Describing ANOVA's

- There are **THREE** things that you need to specify when describing the specific type of ANOVA you are using:
 - How many **factors** are involved
2
 - How many **levels** there are of each factor
2 and 3
 - Whether each factor is a **within-** or **between-**subject factor
One within-, one between-

Describing ANOVA's

- So, we have TWO IV's:
 - We need to combine the conditions of each of these
 - One IV is *between subjects* and has two levels, and the other is *within-subjects* and has three levels
 - Subject: *Psychology or Art*
 - Year of study: *Year one, Year two, or Year three*

Describing ANOVA's

This gives us a **2 x 3 design**

BUT also a **mixed-design** as we have one between-subjects and one within-subjects factor

To test all combinations, we need **6 conditions**

Study Design

A 2 x 3 mixed-design ANOVA
– table of conditions

	Year One	Year Two	Year Three
Psychology	Condition 1	Condition 2	Condition 3
Art	Condition 4	Condition 5	Condition 6

Study Design

Sample mean scores for the study

	Year One	Year Two	Year Three	Means
Psychology	66.45	68.20	69.40	68.02
Art	54.00	55.10	58.00	55.70
Means	60.23	61.65	63.70	

Main effects and interactions

- In exactly the same way as the two-way between-subjects ANOVA we looked at last week, we need to assess the **main effects** as well as the **interaction effect** between our two IV's
- The interaction effect that we are interested in here is a two-way interaction

Year × Subject

(you will notice when you run your analysis that this is shown as Year*Subject)

SPSS Output



1. Descriptive stats

Descriptive Statistics				
	Subject	Mean	Std. Deviation	N
Year1	Psychology	66.4500	7.98996	20
	Art	54.0000	9.13063	20
	Total	60.2250	10.55750	40
Year2	Psychology	68.2000	7.22277	20
	Art	55.1000	8.62615	20
	Total	61.6500	10.27955	40
Year3	Psychology	69.4000	8.22320	20
	Art	58.0000	8.35401	20
	Total	63.7000	10.01332	40

SPSS Output



2. Assumptions

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

Box's Test of Equality of Covariance Matrices^a

Box's M	12.768
F	1.945
df1	6
df2	10462.189
Sig.	.070

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

a. Design: Intercept + Subject Within Subjects Design: Year

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SPSS Output



2. Assumptions

Mauchly's Test of Sphericity^a

Measure: MEASURE_1						Epsilon ^b		
Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Greenhouse-Geisser	Huynh-Feldt	Lower-bound	
Year	.930	2.690	2	.260	.934	1.000	.500	

The assumption being tested is that the correlation between all the variables is roughly the same. The sig value here should ideally be bigger than 0.05 (i.e., **NOT** significant).

If it is significant then the 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.

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SPSS Output



2. Assumptions

Levene's Test of Equality of Error Variances^a

	F	df1	df2	Sig.
Year1	.195	1	38	.661
Year2	1.325	1	38	.257
Year3	.007	1	38	.932

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

a. Design: Intercept + Subject Within Subjects Design: Year

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

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SPSS Output



3. Interaction

Measure: MEASURE_1

Tests of Within-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Year	244.117	2	122.058	22.783	.000	.375
Greenhouse-Geisser	244.117	1.869	130.618	22.783	.000	.375
Huynh-Feldt	244.117	2.000	122.058	22.783	.000	.375
Lower-bound	244.117	1.000	244.117	22.783	.000	.375
Year * Subject	14.717	2	7.358	1.373	.259	.035
Greenhouse-Geisser	14.717	1.869	7.874	1.373	.259	.035
Huynh-Feldt	14.717	2.000	7.358	1.373	.259	.035
Lower-bound	14.717	1.000	14.717	1.373	.249	.035
Error(Year)	407.167	76	5.357			
Greenhouse-Geisser	407.167	71.019	5.733			
Huynh-Feldt	407.167	76.000	5.357			
Lower-bound	407.167	38.000	10.715			

a. Computed using alpha = .05

No significant interaction!

Be careful when reading the columns
The last column 'Partial eta squared' shows the estimate of the effect size

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SPSS Output



4. Main effects

Measure: MEASURE_1

Tests of Within-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Year	244.117	2	122.058	22.783	.000	.375
Greenhouse-Geisser	244.117	1.869	130.618	22.783	.000	.375
Huynh-Feldt	244.117	2.000	122.058	22.783	.000	.375
Lower-bound	244.117	1.000	244.117	22.783	.000	.375
Year * Subject	14.717	2	7.358	1.373	.259	.035
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Lower-bound	407.167	38.000	10.715			

a. Computed using alpha = .05

Significant main effect of Year

Be careful when reading the columns
The last column 'Partial eta squared' shows the estimate of the effect size

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SPSS Output



4. Main effects

Measure: MEASURE_1

Transformed Variable: Average

Tests of Between-Subjects Effects

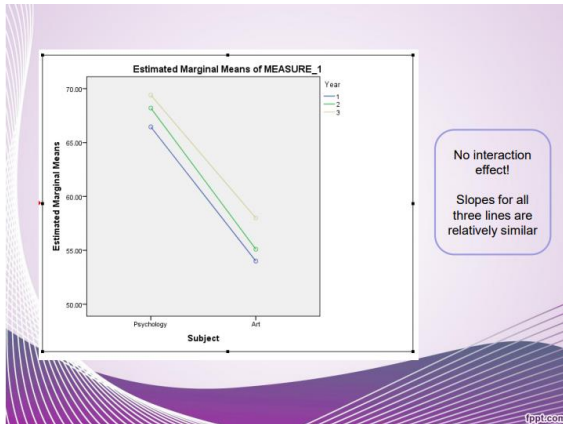
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	459174.408	1	459174.408	7356.145	.000	.984
Subject	4551.008	1	4551.008	23.352	.000	.381
Error	7405.583	38	194.884			

a. Computed using alpha = .05

Significant main effect of Subject

Be careful when reading the columns
The last column 'Partial eta squared' shows the estimate of the effect size

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Reverting back slightly...

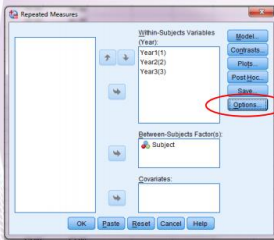
- We have noted a significant main effect of our IV 'year' on end of year grades
 - This was our within-subjects IV with three levels
- What the sig. main effect **does not** tell us is between which two years this differences lies between...



Exploring significant main effects when there are more than two levels

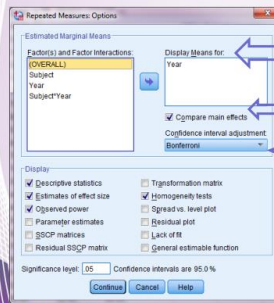
- Are you expecting differences at the start of your study?
 - Planned comparisons
- Are you wanting to explore non-hypothesised differences?
 - Post-hoc comparisons for between-subjects factors (e.g., Tukey, Scheffe)
 - Comparing main effects for within-subjects factors (e.g., Bonferroni)

Comparing main effects



- Our IV with more than two levels was a within-subjects factor, therefore we are looking to **compare main effects**
- Use SPSS to perform **Pairwise Comparisons**

Comparing main effects



- Move the variable of interest into the 'Display means for' box.
- Tick the 'Compare main effects' box.
- Change 'Confidence interval adjustment' to 'Bonferroni'.

SPSS Output



5. (if needed) pairwise comparisons

Measure: MEASURE_1

		Pairwise Comparisons				
		Mean Difference (I-J)	Std. Error	Sig. ^a	95% Confidence Interval for Difference ^b	
					Lower Bound	Upper Bound
1	2	-.142 ^a	.463	.012	-.2584	-.0266
	3	-.347 ^a	.505	.000	-.4739	-.2211
2	1	1.425 ^a	.463	.012	.266	2.584
	3	-.205 ^a	.579	.003	-.3499	-.0601
3	1	3.475 ^a	.505	.000	2.211	4.739
	2	2.050 ^a	.579	.003	.601	3.499

Based on estimated marginal means

^a The mean difference is significant at the .05 level.

^b Adjustment for multiple comparisons: Bonferroni.

The sig. values in this table show us that there is a significant difference in end of year grades between years 1 and 2, years 1 and 2, AND years 2 and 3.

Reporting these results...

- ANOVA will analyse:
 - Main effects
 - Interaction effects
 - Main stats for each analysis:
 - F-value, degrees of freedom (df), and p-value (Sig.)
 - Need 2 values for the df: one from the row of your IV and one from the 'error' row of output
 - Sig. value < 0.05 is significant

Reporting these results...

A very basic results section... remember to start with your descriptives before this!!

A 2 x 3 mixed-design ANOVA was carried out to explore the effect of subject of study and year of study on end of year grades in university students. There was no significant interaction between subject (psychology or art) and year (1, 2 or 3), $F(2, 76) = 1.37, p = .25$. There was a significant main effect of both subject studied [$F(1, 38) = 23.35, p < .001$] and year of study [$F(2, 26) = 22.78, p < .001$]. Pairwise comparisons indicate that there was a significant difference in end of year grades between year 1 and 2 ($p < .05$), year 2 and 3 ($p < .001$), and year 1 and 3 ($p < .005$).

Things to remember with ANOVA

- The main values needed for your ANOVA write-up are the F , df's, and sig. values, but you **MUST** check other tables from the output (depending on the type of ANOVA) to ensure your data has not violated any assumptions and that you are reading the values you need from the correct rows.

Good practice for using SPSS

- Always double check your data
- If you don't need decimal places then change them in the variable view to 0 (this looks cleaner)
- Remember your assumptions!
- 'estimates of effect size' will tell you the proportion of total variance accounted for by the factor (ANOVA) – get into the habit of selecting this.

Any Questions?
