

RESEARCH DESIGN AND ANALYSIS

Lecture 3: Multi-factorial Designs
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Terms to remember

- **FACTORS:**
 - These are your Independent Variables (IVs)
- **LEVELS OF FACTORS:**
 - Similar to conditions
- **BETWEEN-SUBJECTS FACTOR:**
 - Factors whose levels vary between participants
 - Each participant only experiences one level of a factor (e.g., male/female)
- **WITHIN-SUBJECTS FACTOR:**
 - Factors whose various levels vary within a participant
 - Each participant experiences all levels of the factor (e.g., testing mood at 9am, 12pm and 3pm)

Factors in experiments and studies

- Often we are looking to ask a far more complex question
- Sometimes we want 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...
- Or whether a variable effects the DV **in light of another variable**...
- Or even the **interaction between TWO OR MORE variables** and how they effect the DV

ANOVA recap

• So, if we run an experiment where we include more than 2 groups, more than 2 conditions, or involves more than one IV, then the Analysis of Variance (ANOVA) statistical procedure is used to analyse the data.

• WHY??



ANOVA Assumptions

• ANOVA is a *parametric test*, therefore the following conditions must be met in order to use it:

1. DV must be continuous (interval or ratio data)
2. IV must consist of more than two categorical, independent groups
3. Data must be normally distributed
4. There is homogeneity of variance (or sphericity)
5. For independent group designs, independent random samples must have been taken from each population

ANOVA Recap

• Human performance varies both between individuals and within the same individual

• If the variance between conditions is larger than the variance within conditions, then 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.

ANOVA Recap

• ANOVA compares the **VARIANCE** (variability in scores) between the different groups (believe to be due to the IV) to the variability within each of the groups (believed to be due to chance)

• If there are differences between groups, the between group variance will be **larger** than the within group variance

• Calculated as the *F ratio*

Larger F value = more variability between groups caused by the IV

The F-Ratio

• Put simply, the F-ratio looks at whether variances are due to our manipulation of the IV, or whether it is due to another nuisance factor (also known as the error variance)

Today...

• **Multi-factorial ANOVA design**

• More than one IV

• We will look at a two-way between-subjects ANOVA

Example...

- We are interested in exploring two types of teaching strategies (A & B) on learning
- DV = reading test scores
- IV: Teaching strategy A & B (2 conditions)

Example..

- Between participants design (half of pupils in strategy A, half in strategy B)
- Results show that scores are higher for the students in strategy B

Teaching example

- What else do you think we could consider?
- Could original level of reading ability of children have an effect on their reading scores?
- How can we deal with this as a possible influencing factor?

Exploring multiple factors

- We want to look at more than one IV
- And we are interested in the **INTERACTION** between these
- Still looking at the effect on one DV (reading score)

Exploring multiple factors

IV ₁	IV ₂	DV
Teaching strategy	Original ability	Reading score after teaching
A or B	High or low	

This is a **multifactorial** design

Describing ANOVA's

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

Both between-subjects

Describing ANOVA's

- So, we have TWO IV's:
- We need to combine the conditions of each of these
- Both IV's have two levels
 - Teaching strategy: A or B
 - Original ability: High or Low

Describing ANOVA's

- This gives us a **2 x 2 design**
- As both IV's are between-subjects, we call this a **two-way between-subjects ANOVA**
- To test all combinations, we need **4 conditions**

Multi-factorial Designs

- 2 x 2 table of conditions (4 conditions)

	Strategy A	Strategy B
Low ability	Condition 1	Condition 2
High ability	Condition 3	Condition 4

Multi-factorial Designs

• Sample mean scores for the study:

	Strategy A	Strategy B	Means
Low ability	2	7	4.5
High ability	8	8	8
Means	5	7.5	

Main effects and Interactions

• The first thing we can do here is assess the effect of each factor on their own

• We call this the **main effect**: this is used to describe the independent effect of each factor (IV).

• E.g., in this study, **2 main effects** would be reported:

- Main effect of teaching strategy
- Main effect of original ability

Main effects

• 'Main effects' are effects of **ONE IV ALONE**

• Where is the effect of 'ability' shown in the scores below?

	Strategy A	Strategy B	Means
Low ability	2	7	4.5
High ability	8	8	8
Means	5	7.5	

Main effects

- Where is the effect of 'teaching strategy' shown in the scores below?

	Strategy A	Strategy B	Means
Low ability	2	7	4.5
High ability	8	8	8
Means	5	7.5	

Main effects

- The analysis can show us whether these 'main effects' are significant
- Effects of each IV in isolation on the DV score
- Looking whether there is a significant difference between conditions
 - (e.g., is the difference between A and B significant for teaching strategy?)

Interaction effects

- BUT: the point was to examine how the **TWO** IV's may influence the DV **together**
- So, we analyse any possible 'interaction' between IV's
 - Combination of IV's in effecting the DV
 - Differences dependent on conditions of both IV's

Main effects

- Compare the means for one **level/condition** with the mean of the other **level(s)/condition(s)** of that factor
 - In the same way as an experiment with only one IV
 - You would have more than one main effect

Interactions

- Assess the combined effect of the factors (all the IV's)

Interactions

- The interaction effect that we are interested in here is a **two-way interaction**

Teaching strategy x ability

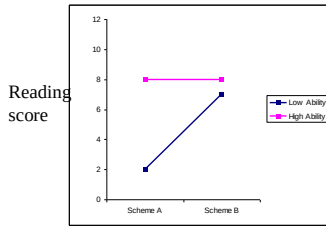
*(you will notice when you run your analysis that this is shown as strategy*ability)*

Multi-factorial Designs

- How do the two IV's interact?
- What is the effect of **strategy** only for the **LOW** ability group?

	Strategy A	Strategy B	Means
Low ability	2	7	4.5
High ability	8	8	8
Means	5	7.5	

Using graphs to show interactions



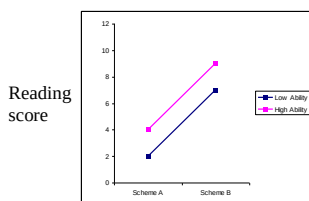
This graph shows an interaction – but how?

Effect of strategy IV (higher scores for B) but effect shown only for one ability (IV) group

Using graphs to show interactions

- The key to interpreting these graphs is to assess the relative slope of the lines
- Same/similar slope = likely **no interaction**
- Very different slopes indicates that there **may be an interaction** between the IV's

Using graphs to show interactions



No Interaction

Main effects of strategy IV and ability IV

QUESTIONS?

Possible ANOVA designs

- **One-way within-subjects ANOVA:**
 - Has 1 factor (IV) with multiple levels
 - Each participant takes part in all conditions
- **One-way between-subjects ANOVA:**
 - Has 1 factor (IV) with multiple levels
 - Different participants take part in each of the different conditions

Possible ANOVA designs

- **Two-way within-subjects ANOVA:**
 - Has 2 factors (IV's) with multiple levels
 - Each participant takes part in each possible combination of the 2 factors
- **Two-way between-subjects ANOVA:**
 - Has 2 factors (IV's) with multiple levels
 - Different participants take part in each of the different combinations of factors and conditions

Mixed-Design ANOVA

- Can also use a **mixed design**
 - A between-subjects IV
 - A within-subjects IV
 - Both included together in one analysis
- A very common structure for studies in psychology

Reporting ANOVA statistics

- ANOVA will analyse:
 - Main effects
 - Interaction effects
- Main stats for each analysis:
 - F-value, degrees of freedom, p-value (sig.)
- All showing whether (or not) there are significant differences (and to what degree) between the means in each grouping of data

Interpretation of ANOVA Output

Rule number 1: USE YOUR STATS BOOK!!!

- Nothing can explain the steps to interpretations like a stats book; this is the only way you will understand if for yourself!
- Tells you exactly how to run the analysis, what to interpret and how to report it
- Just make sure you are aware exactly what type of ANOVA analysis you are running based on your experimental design!

Note 1:

- With the ANOVA output, although the main values you will need for writing up the results are the F , df , and sig values, you still need to check other tables from the output (depending on the type of ANOVA) in order to ensure there have been no violations and to ensure you have read the values you need from the correct rows.

**Interpretation of ANOVA
Output: Between-subjects**

- Report descriptives
- Check Levene's test for equality of error variances
 - Needs to be GREATER THAN 0.05
- Report interaction effect(s)
- Report main effects
- Report effect sizes
- Report post-hoc tests (if needed)

Note 2:

- There are **always** two values for the degrees of freedom (df) with ANOVA:
 - The value from the row of your IV will provide you with the first df
 - The value from the top 'error' row will provide you with the second df

DF1 explanation...

Number of cell means that are free to vary to get to a given grand mean

- NB: marginal means with 2+ way ANOVA

E.g., one-way BS ANOVA with 3 levels

$$Df = \text{levels} - 1 = 2$$

	1	2	3	Grand mean
Mean	4	6	8	6

DF1 explanation...

- Two-way between-subjects designs
- Marginal means and grand means come into play

- Easy way to calculate...

- $(\text{Factor 1 levels} - 1) \times (\text{Factor 2 levels} - 1) = DF1$

- E.g., 2 x 2 design:
- $(2 - 1) \times (2 - 1) = 1$

- So $DF1$ would be 1.

DF1 (between-subjects only)

- E.g., 2 x 2 design:

- $(2 - 1) \times (2 - 1) = 1$

- So $DF1$ would be 1.

- E.g., 2 x 3 design:

- $(2 - 1) \times (3 - 1) = 2$

- So $DF1$ would be 2

DF2 explanation... (between-sub)

DF2 is about how the single observations in the cells relate to the cell means...

Total number of observations in all cell(s) MINUS the DFs lost because the cell means are set

- So, minus the number of cell means or groups/conditions

DF2 explanation... (between-sub)

Easy way to calculate...

$$DF2 = n - k$$

Where n = participants (or total observations)

And k = df's lost (or no* of conditions/groups)

If we had 30 participants, and a 2x2 design therefore has 4 cells, then DF2 would be $30 - 4 = 26$

- SPSS will always provide you with DF1 and DF2 for any ANOVA analysis that you conduct (DF2 labelled as (error))

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
colour						
Sphericity Assumed	336.467	2	168.233	4.725	.022	.344
Greenhouse-Geisser	336.467	1.517	221.761	4.725	.035	.344
Huynh-Feldt	336.467	1.760	191.133	4.725	.028	.344
Lower-bound	336.467	1.000	336.467	4.725	.058	.344
Error(colour)						
Sphericity Assumed	640.867	18	35.604			
Greenhouse-Geisser	640.867	13.655	46.932			
Huynh-Feldt	640.867	15.843	40.450			
Lower-bound	640.867	9.000	71.207			

ANY QUESTIONS?

Workshops today

- Two-way between-subjects ANOVA analysis
- Interpreting and reporting main and interaction effects
- Ethics information and group work
