# Advanced Experimental Design

Topic 8

Chapter 14: Repeated Measures Analysis of Variance

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## Overview

- Basic idea, different forms of repeated measures
- Partialling out between subjects effects
- Simple repeated measures ANOVA
  - structural model
- New assumptions
  - Sphericity & equality of covariance matrices
- Mixed model (adding a between subjects factor)
- SPSS example(s)

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## Repeated measures ANOVA

- Similar to switch from independent samples t to paired samples t-test
- Basic design consists of the same subject being measured on all levels of DV
  - different conditions
  - measures taken over time
- Advantage: reduces the overall variability within subjects; allows removal of subject differences from the error term

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## Different forms of repeated measures

- Time – same measurement at multiple points in time
- Different conditions
- Different versions of the same measuring device
- Matched triads or larger groups

- Potential biases
  - Practice effects
  - Fatigue
  - Confounding effects

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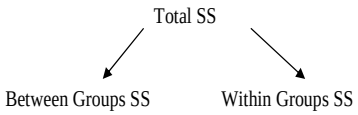
## Partitioning Variability - Oneway

- In oneway ANOVA, between groups and within groups

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## Partitioning Variability – Repeated Measures

- In Repeated Measures ANOVA
- Between subjects SS
- Within subjects variability
  - between treatments variance
  - error variance - individual variability in impact of treatment
- Repeated measure over more than two levels
- Hypothesis test focuses on change over time (or across treatments)

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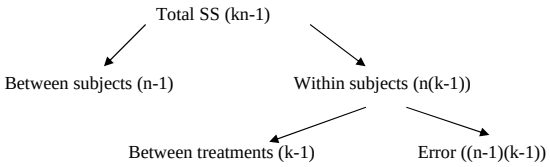
## Partitioning Variability – Repeated Measures

- SS divided into between subjects and within subjects, which is then divided further

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## Partialling out subject effects

- each subjects contribution to the overall variability is placed on a common footing
- Howell Table 14.1, Pg. 441
- Each subject's scores expressed as deviations from their overall mean score

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## Partialling out subject effects

| | Treatment | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Subject | 1 | 2 | 3 | Mean | Sub | 1 | 2 | 3 | M |
| 1 | 2 | 4 | 7 | 4.33 | 1 | -2.33 | -0.33 | 2.67 | 0.00 |
| 2 | 10 | 12 | 13 | 11.67 | 2 | -1.67 | 0.33 | 1.33 | 0.00 |
| 3 | 22 | 29 | 30 | 27.00 | 3 | -5.00 | 2.00 | 3.00 | 0.00 |
| 4 | 30 | 31 | 34 | 31.67 | 4 | -1.67 | -0.67 | 2.33 | 0.00 |
| Mean | 16 | 19 | 21 | 18.67 | M | -2.67 | 0.33 | 2.33 | 0.00 |

| | | | |
|---|---|---|---|
| **Original** | **12.44** | **13.14** | **13.04** |
| **Deviations** | **1.59** | **1.19** | **0.72** |

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## Structural model for repeated measures ANOVA

- Represents each individual score for each treatment in terms of the model parameters
- Used to derive expected mean squares for the different portions of the total variance
- F ratios that we will use to evaluate our null hypothesis

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## Structural model

$$X_{ij} = \mu + \pi_i + \tau_j + \pi\tau_{ij} + e_{ij}$$

- μ = grand mean
- $\pi_i$ = a constant associated with the $i^{th}$ person
- $\tau_j$ = a constant associated with the $j^{th}$ treatment
- $\pi\tau_{ij}$ = the subject by treatment interaction
- $e_{ij}$ = the experimental error for the $i^{th}$ person under the $j^{th}$ treatment

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## Assumptions

- Compound symmetry of the covariance matrix
- covariance matrix = unstandardized correlation matrix
  - Variances on the diagonal, off diagonal elements are covariances between variables

$$\Sigma = population$$

$$\hat{\Sigma} = estimate$$

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## Covariance

- Crossproducts of deviations from the mean
- Dividing by product of sd's turns into a correlation coefficient

$$COV_{XY} = \frac{\sum (X - \bar{X})(Y - \bar{Y})}{N - 1}$$

$$or \frac{\sum XY - \frac{\Sigma X \Sigma Y}{N}}{N - 1} \qquad r = \frac{COV_{xy}}{S_x S_y}$$

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## Compound symmetry/Sphericity

- Compound symmetry: variances all about the same; covariances all about the same
  - variances and covariances do not need to be similar
- Sphericity: less restrictive condition, which can be present in the absence of compound symmetry
- repeated-measures ANOVA equivalent of the homogeneity of variances assumption
- SPSS provides Mauchley's test of Sphericity
- Run example from Table 14.3 in text in SPSS

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## Mixed model

- add a grouping factor
- a little more complicated
- partitioning the variance in our DV
- in both major partitions, the S's within groups term represents the "error" or residual term

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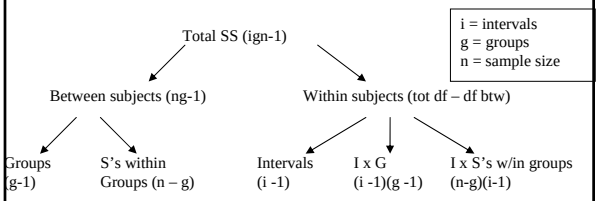
## Partitioning Variability – mixed model, 1 between and 1 within

- Three hypothesis tests
  - group, interval, interval x group




i = intervals
g = groups
n = sample size

Adapted from Howell (2007) pg 451

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## Another assumption

- equality of covariance matrices across groups
- interrelationships among intervals of the DV do not differ across groups
- SPSS provides us with Box's test of the equality of covariance matrices
- Mixed model example in SPSS, Table 14.4 data from text

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