Mixed factorial ANOVA

Introduction to Statistics
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Example

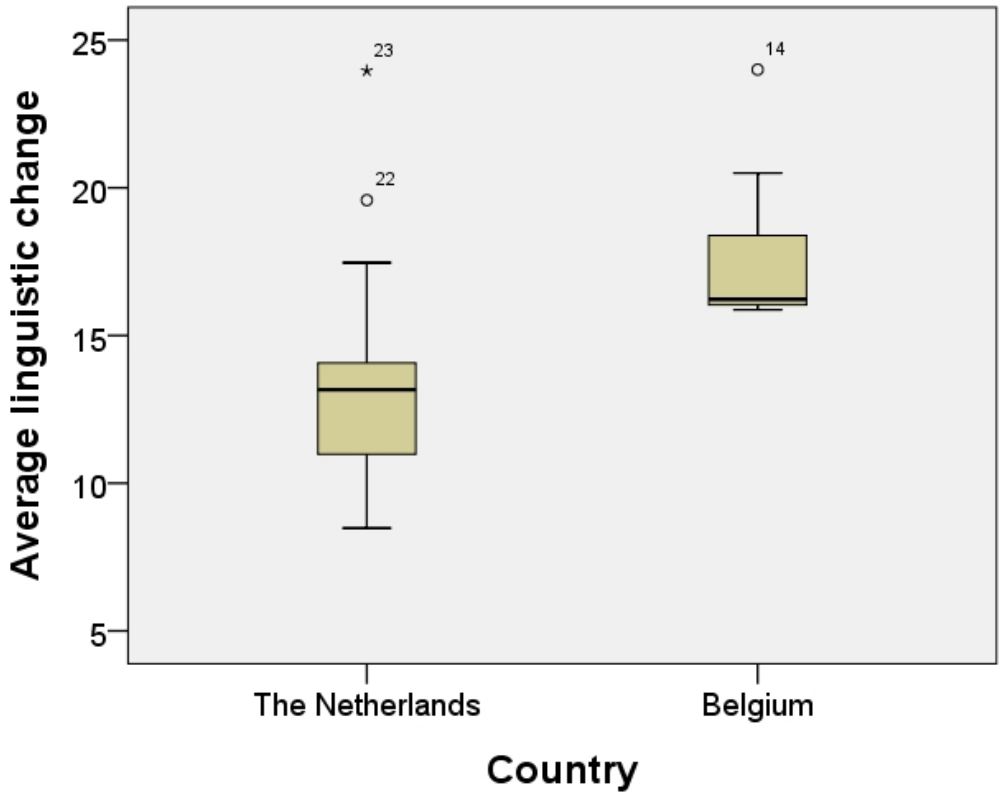
- Previous example: we study the change of 25 local dialects in the Netherlands and Flanders.
- For each locations we consider the change in lexis, morphology and sound components.
- The observational units (the 25 locations) can be divided 18 Netherlandic and seven Flemish locations.
- Three questions:
  - Do Netherlandic and Flemish dialect change measurements differ? (between-subjects).
  - Do the three linguistic levels differ? (within-subjects, we answered this question earlier).
  - Does there exist an interaction between $country$ and $linguistic\ level$?
- These questions can be answered by using a mixed factorial ANOVA.

Mixed factorial ANOVA

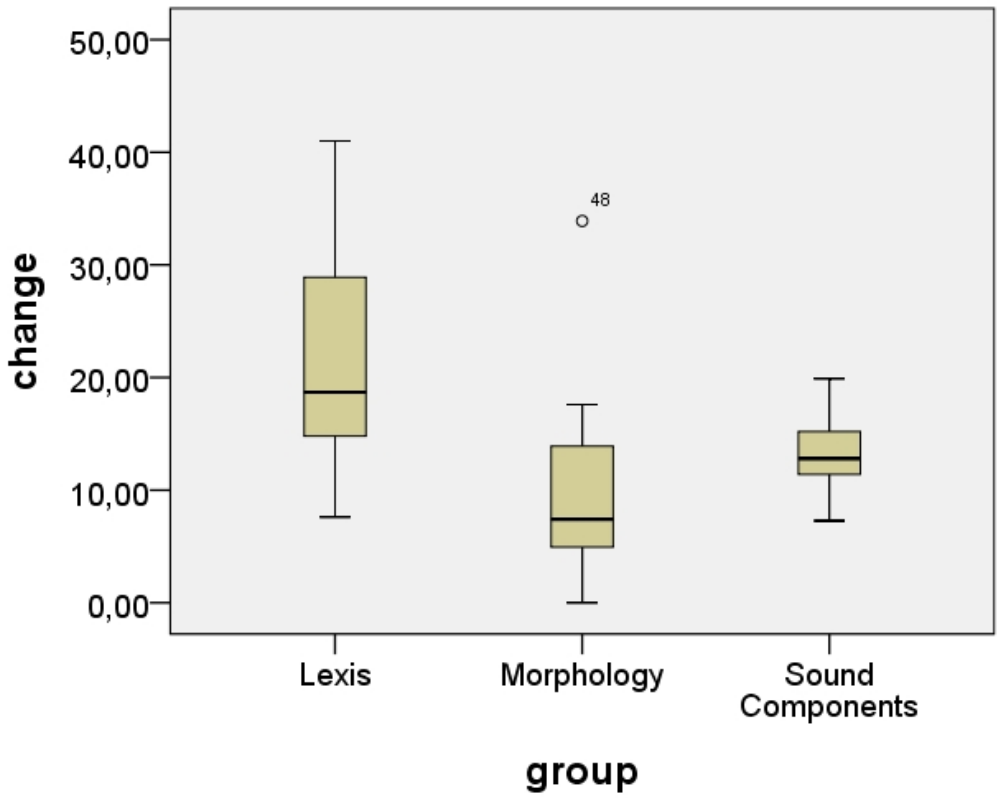
- **Mixed model** means: a model with between-subjects factors **and** within-subjects factors.
- **Between subjects factor**: a factor which divides the observational units in groups.
- In our example: the factor $country$ divides locations in a Netherlandic and Flemish group.
- **Within subjects factor**: a factor which divides the measurements per subject in groups (i.e. repeated measurements).
- In our example: the factor $linguistic\ level$ causes a distinction between a lexical measurement, a morphological measurement and a measurement in the sound components.

Mixed factorial ANOVA

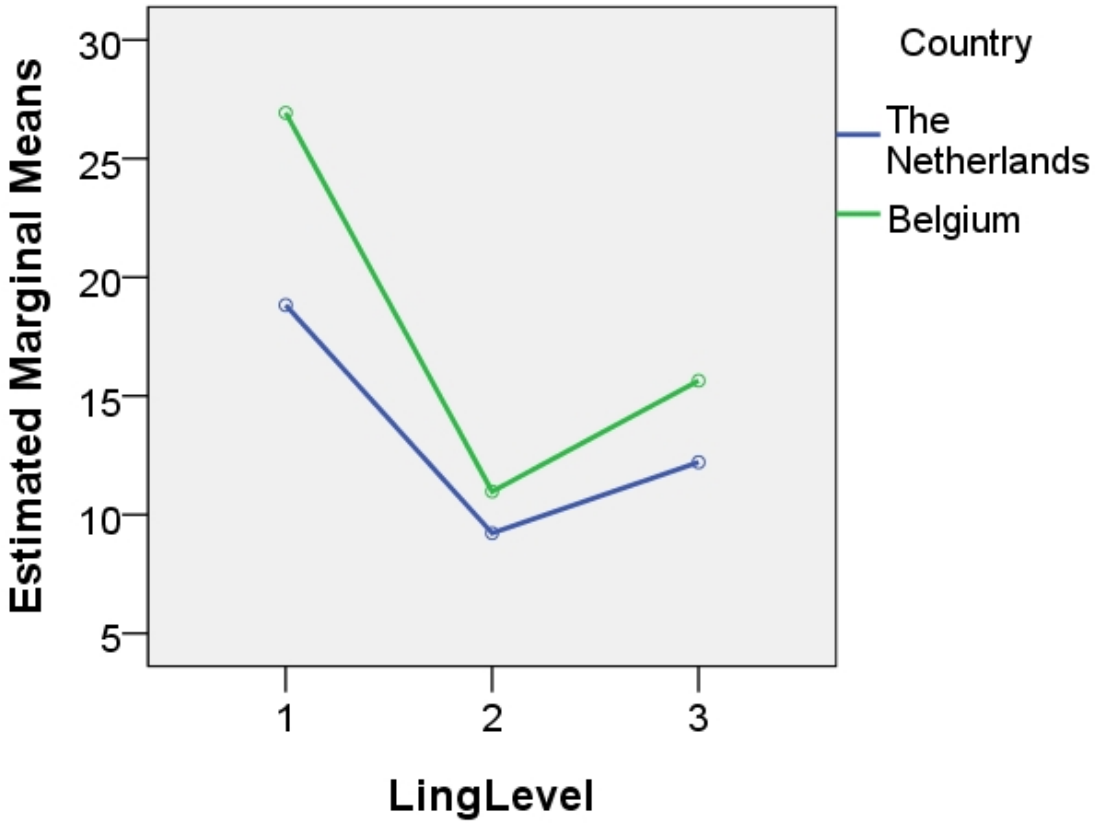
- Mixed ANOVA models are available for both continuous normal distributed dependent variables and (for example) dichotomous dependent variables (variables which can take two values only).
- Mixed ANOVA models can deal with missing data to some extent, especially when data are randomly lacking.



First question: is there a difference between the two countries? We expect that dialects in Flanders have changed more strongly than in the Netherlands.



Second question: do the three linguistic levels (lexis, morphology and sound components) differ? We expect that change at the lexical level is stronger than at the morphological level and the level of the sound components.



Third question: is there an interaction between *country* and *linguistic level*? The graph suggests that the difference between countries varies per linguistic level.

Assumptions

- Normality:
  the scores for each group (3 linguistic levels $\times$ 2 countries $=$ 6 groups) should be normally distributed. Use normal quantile plots and the Shapiro-Wilk test.
- Homogeneity of variance:
  the groups (in our case six groups) should have the same variance. Use Levene's test and Hartley's test.
- Sphericity:
  homogeneity of variances of pairwise differences between levels of the within-subjects factor. We have three groups (3 linguistic levels) and therefore three pairs. Use Mauchly's Test.

Mauchly's Test of Sphericity[b]

Measure:LingChange

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[a]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
LingLevel	,611	10,821	2	,004	,720	,789	,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 + Country
Within Subjects Design: LingLevel

The Mauchly's Test of Sphericity gives a p value (Sig.) which is smaller than 0.05. Therefore we may not assume that the assumption of sphericity is met.

Tests of Within-Subjects Effects

Measure:LingChange

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
LingLevel	Sphericity Assumed	1734,915	2	867,458	19,371	,000	,457
	Greenhouse-Geisser	1734,915	1,440	1204,480	19,371	,000	,457
	Huynh-Feldt	1734,915	1,577	1099,809	19,371	,000	,457
	Lower-bound	1734,915	1,000	1734,915	19,371	,000	,457
LingLevel * Country	Sphericity Assumed	108,968	2	54,484	1,217	,306	,050
	Greenhouse-Geisser	108,968	1,440	75,652	1,217	,297	,050
	Huynh-Feldt	108,968	1,577	69,078	1,217	,300	,050
	Lower-bound	108,968	1,000	108,968	1,217	,281	,050
Error(LingLevel)	Sphericity Assumed	2059,938	46	44,781			
	Greenhouse-Geisser	2059,938	33,129	62,180			
	Huynh-Feldt	2059,938	36,282	56,776			
	Lower-bound	2059,938	23,000	89,563			

Since we obtained a significant result with the *Mauchly's Test of Sphericity*, we use the **Greenhouse-Geisser conversative F test**.

Results

- The Partial Eta Squared of LingLevel (linguistic level) is 0.457. About 46% of the variance in the measurements is explained by the distinction in three linguistic levels.
- The measurements of dialect change for each of the three linguistic levels differ significantly at the 5% level: $F(1.440, 33.129) = 19.371$, $p < 0.001$, $R^2 = 0.457$.
- De Partial Eta Squared of LingLevel * Country (interaction between linguistic level and country) is small: 0.050 or 5%.
- There is not an interaction between *linguistic level* and *country*: $F(1.440, 33.129) = 1.217$, $p = 0.217$, $R^2 = 0.050$.

Tests of Between-Subjects Effects

Measure:LingChange
Transformed Variable:Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	14782,830	1	14782,830	360,763	,000	,940
Country	296,587	1	296,587	7,238	,013	,239
Error	942,461	23	40,977			

- The Partial Eta Squared of $Country$ is 0.239. About 24% of the variance in the measurements of dialect change is explained by the distiniction between the Netherlands and Flanders.
- The measurements of dialect change in the Netherlands and Flanders differ significantly at the 5% level: $F(1, 23) = 7.238$, $p = 0.013$, $R^2 = 0.239$.

Pairwise Comparisons

Measure:LingChange

(I) LingLevel	(J) LingLevel	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
					Lower Bound	Upper Bound
1	2	12,781*	2,667	,000	5,894	19,669
	3	8,954*	1,932	,000	3,965	13,942
2	1	-12,781*	2,667	,000	-19,669	-5,894
	3	-3,827	1,575	,070	-7,893	,238
3	1	-8,954*	1,932	,000	-13,942	-3,965
	2	3,827	1,575	,070	-,238	7,893

Based on estimated marginal means

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

a. Adjustment for multiple comparisons: Bonferroni.

Multiple comparisons on the basis of the Bonferroni correction. 1 = lexis, 2 = morphology, 3 = sound components. Note that morphology and sound components do not differ significantly.