Analysis of Variance (ANOVA)

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What Is H_0 Meaning?

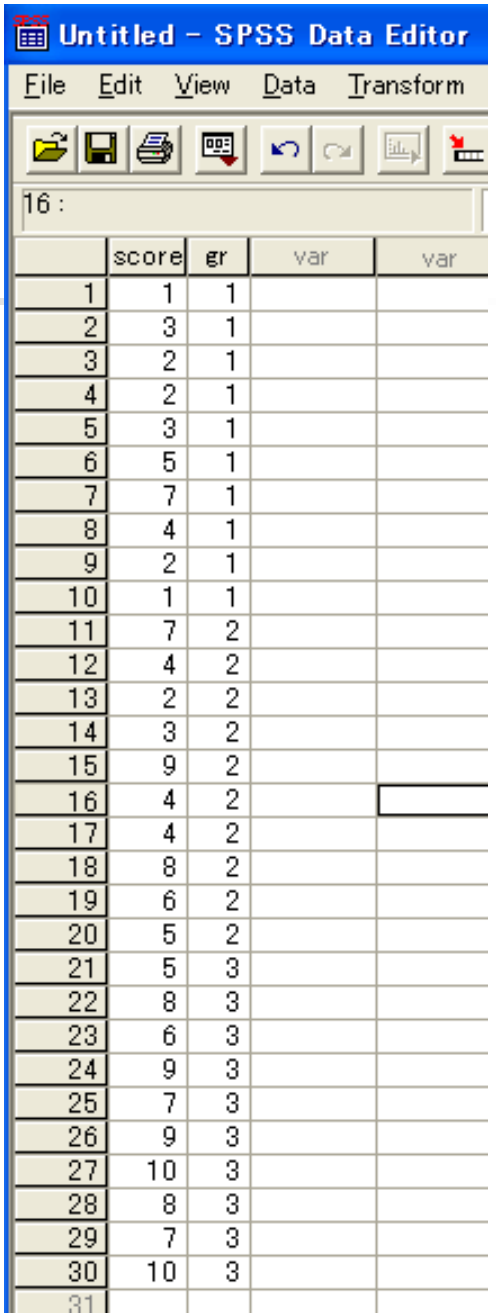
- H_0: $\bar{x}_1 = \bar{x}_2 = \bar{x}_3$
- Even if H_0 is rejected, it does not automatically mean $x_1 < x_2$ or $x_2 < x_3$
- To prove the difference between specific two variables, post-hoc tests will be used.
  - Scheffé test: most stringent
  - Bonferroni: α is divided by the number of tests.
  - Tukey's Honestly Significant Difference (HSD): numbers of cases must be the same

Differentiate Within-subject from Between-subject Data

- Within-subject data
  - Longitudinally (repeatedly) collected data
  - Multiple items in a questionnaire
- Between-subject
  - Different groups of subjects
    - Demographic data: Gender, age group…
    - Study vs control groups

Data Format

control	APN phone	APN ph + visits
1	7	5
3	4	8
2	2	6
2	3	9
3	9	7
5	4	9
7	4	10
4	8	8
2	6	7
1	5	10
$\bar{x}$ = 3.0	$\bar{x}$ = 5.2	$\bar{x}$ = 7.9
sd = 1.89	sd = 2.25	sd = 1.66



Data Format

- In SPSS or Excel
  - Within-subject data are put in parallel → You have to define the group to conduct the analysis
  - Between-subject data are put in tandem

Nation	HiB	HiY	HiR
1	10	6	19
1	12	11	16
1	9	8	19
1	10	9	19
2	8	7	20
2	10	7	20
2	8	9	16
2	9	9	19
3	8	15	9
3	7	19	6
3	11	14	6
3	7	18	8

Select Post-hoc Test

When three or more options are

- Within-subject
  - Sidak is often selected
- Between-subject
  - Tukey is one of the most frequently used post-hoc test

Sphericity

- If within-subject data has three or more options, sphericity might be a problem.
  - When “test of homogeneity of variances” is significant, 3 Steps will be taken:
  - (1) sphericity supposed
  - (2) lowest, and
  - (3) Greenhouse-Geisser’s modification

Interaction

	Male	Female	
Young	5	10	15
Old	10	5	15
	15	15	

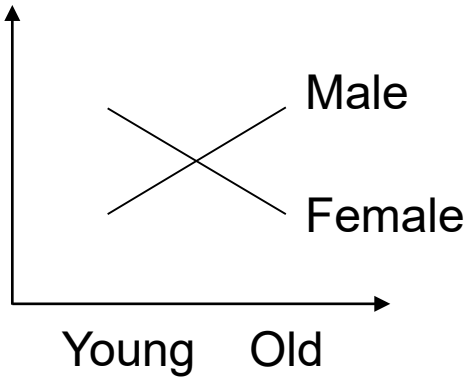
Main effect for Age

Main effect for Sex

H_0: $\mu_{young} = \mu_{old}$
H_1: H_0 is false

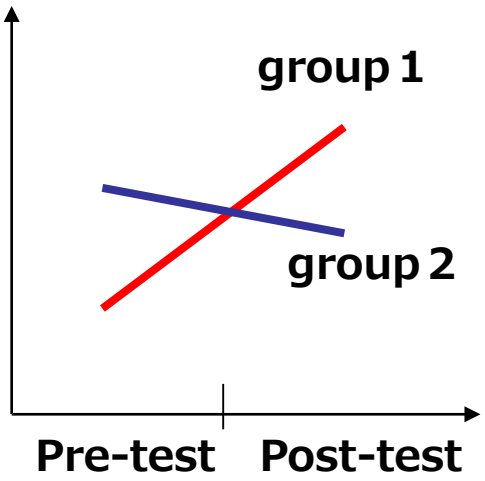
H_0: $\mu_{male} = \mu_{female}$
H_1: H_0 is false

H_0: There is no interaction
H_1: H_0 is false

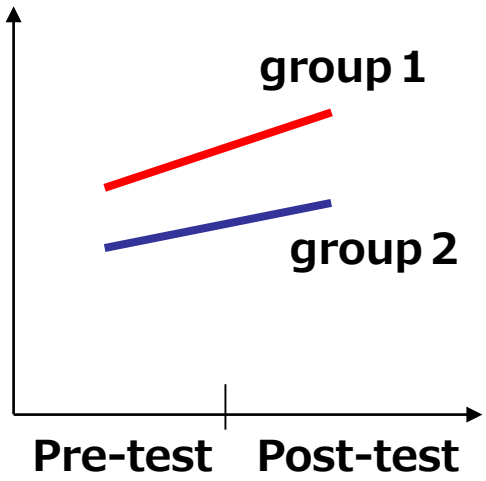


2way, 3way ANOVA

- More than one factors are compared simultaneously.
- Both within-subject and between subject data are combined for one analysis.
- Interaction is another issue for 2way ANOVA or more.



With interaction



Without interaction

検定・分析の種類別の代表的な効果量の指標と大きさの目安

使用される検定（分析）	対象と注意	効果量の指標	効果量の目安 小 (Small)	中 (Medium)	大 (Large)
相関分析		r	.10	.30	.50
重回帰分析		R^2	.02	.13	.26
		f^2	.02	.15	.35
t 検定（t-test）	r と d は対応ありの場合は注意	r	.10	.30	.50
		d	.20	.50	.80
一元配置分散分析 (One-way ANOVA)	全体の検定	η^2	.01	.06	.14
		partial η^2	-	-	-
		ω^2	.01	.09	.25
		f	.10	.25	.40
	多重比較	r	.10	.30	.50
		d	.20	.50	.80
二元配置分散分析 (Two-way ANOVA) 多元配置分散分析* (Multi-way ANOVA) *三元配置以上の分散分析	主効果	η^2	.01	.06	.14
		partial η^2	-	-	-
		ω^2	.01	.09	.25
	交互作用	η^2	.01	.06	.14
		partial η^2	-	-	-
		ω^2	.01	.09	.25
	多重比較	r	.10	.30	.50
		d	.20	.50	.80

水本，竹内．研究論文における効果量の報告のために．英語教育研究 31, 57-66, 2008

Exercise 1

- Open 2wayANOVA.xlsx
- Seek for the relationship (1) age (2) # of delivery and (3) sex of the baby (1 male, 0 female)

対馬栄輝．SPSSで学ぶ医療系データ解析：分析内容の理解と手順解説、バランスのとれた医療統計入門．pp166-174

Exercise 2

- Open repANOVA.xlsx
- 23 young subjects measured height in 3 consecutive years.
- Are they growing?
- Change in the data format might be needed.

対馬栄輝．SPSSで学ぶ医療系データ解析：分析内容の理解と手順解説、バランスのとれた医療統計入門．pp182-188

Exercise 3

- Open water learning.xlsx
- 9 divers participated in the experiments of learning words in 8 conditions
  - 1st digit: reproduction–1, reaffirmation–2
    - Reproduction: recall what was experienced as it was
    - Reaffirmation: confirm that what is being questioned is what was experienced.
  - 2nd digit: learning on the ground–1, in the water–2
  - 3rd digit: testing on the ground–1, in the water–2

山内光哉．心理・教育のための分散分析と多重比較－エクセル・SPSS解説付き．pp199-212

Exercise 4

- Open MixedANOVA.xlsx
- 12 workers from 3 countries (Japan – 1, Korea – 2, US – 3) participated in the physical exercise.
- Conditions
  - Color lighting: blue, red and yellow
  - Temperature: high, normal and low

竹原卓真．SPSSのススメ(2) 3 要因の分散分析をすべてカバー．pp198-302