One-way Analysis of Variance (ANOVA)

Within-subjects designs

Konstantinos I. Bougioukas, MSc, PhD

School of Psychology
Faculty of Philosophy
Aristotle University of Thessaloniki

Έλεγχος υποθέσεων-Βήματα

1. Καθορίζεται η **μηδενική υπόθεση H0 (=)** και **εναλλακτική υπόθεση H1 (≠) .**

2. Ορίζεται το **επίπεδο σημαντικότητας** α (συνήθως α=0.05).

3. Επιλέγεται μια κατάλληλη **στατιστική δοκιμασία** και υπολογίζεται η τιμή του στατιστικού με βάση τα δεδομένα του δείγματος.

4. Σύγκριση της **πιθανότητας p** να έχουμε την συγκεκριμένη τιμή του στατιστικού (ή κάτι πιο ακραίο) θεωρώντας ότι ισχύει η Ho, με το **επίπεδο σημαντικότητας α** (0.05). Στατιστικά σημαντικό αποτέλεσμα ($p < 0.05$).

5. **Ερμηνεία** αποτελεσμάτων.

One-way within-subjects ANOVA

ANOVA: Y = numeric variable → **Dependent**

X = categorical (factor) variable (>2 levels) → **Independent**

Each subject is exposed to all levels of the independent variable.

NOTE: If categorical variable has only 2 related samples: paired t-test

EXAMPLE

A study investigated the effect of a drug on symptom intensity in a specific disease, assessing eight patients before (two pre-test baseline measures) and after treatment (three post-test measures). The primary question is whether the mean symptom intensity score changed over time.

Y: Symptom intensity in a specific disease (0-12)

X: Follow-up time (five time points: 1 month and 1 week before treatment, 1 week, 1 month, 1 year after treatment)

One-way within-subjects ANOVA: hypotheses

H_0: The means of all the **related** groups are equal ($\mu_1 = \mu_2 = \mu_3 = \mu_4 = \mu_5$).

H_1: At least one mean differs from the other

- doesn't say how or which ones differ.
- Can follow up with "post-hoc tests"

Assumptions of one-way within-subjects ANOVA

- **Within-subjects design** (each participant is exposed to all levels of the independent variable)

- **Normality:** The outcome variable (symptom intensity in our example) must be normally distributed in each group (here five time points: 2 baseline and 3 after treatment measurements).

  Check this by looking at histograms, Q-Q plots, and Shapiro-Wilk test:

  If $P>0.05$ then normal distribution

  If $P<0.05$ then non-normal distribution

- **Sphericity assumption:** The variances of the differences between all possible pairs of within-subject conditions are equal.

  Check sphericity with the Mauchly's sphericity test

  If $P>0.05$ then ANOVA

  If $P<0.05$ then ANOVA with corrected df (Greenhouse-Geisser (GGe), or Huynh-Feldt (HFe))

DATA

Factor levels	Follow-up time					Sum
	1 month before	1 week before	1 week afterr	1 month after	1 year after	
S1	12	[illegible]	[illegible]	5	5	41
S2	9	[illegible]	[illegible]	6	5	35
S3	9	[illegible]	[illegible]	5	6	35
S4	8	[illegible]	[illegible]	4	4	28
S5	8	[illegible]	[illegible]	4	5	32
S6	9	10	8	6	7	40
S7	12	10	7	5	4	38
S8	6	7	5	7	5	30
Sum	73	72	51	42	41	
Mean	9.13	9.00	6.38	5.25	5.13	

symptom intensity scores

DATA

Factor levels	1 month before	1 week before	1 week afterr	1 month after	1 year after	Sum
S1	12	12	7	5	5	41
S2	9	10	5	6	5	35
S3	9	8	7	5	6	35
S4	8	6	6	4	4	28
S5	8	9	6	4	5	32
S6	9	10	8	6	7	40
S7	12	10	7	5	4	38
S8	6	7	5	7	5	30
Sum	73	72	51	42	41	
Mean	9.13	9.00	6.38	5.25	5.13	

Between subjects (residuals)

DATA

Factor levels	1 month before	1 week before	1 week afterr	1 month after	1 year after	Sum
S1	12	12	7	5	5	41
S2	9	10	5	6	5	35
S3	9	8	7	5	6	35
S4	8	6	6	4	4	28
S5	8	9	6	4	5	32
S6	9	10	8	6	7	40
S7	12	10	7	5	4	38
S8	6	7	5	7	5	30
Sum	73	72	51	42	41	
Mean	9.13	9.00	6.38	5.25	5.13	

Within subjects: time

Treatment effect

DATA

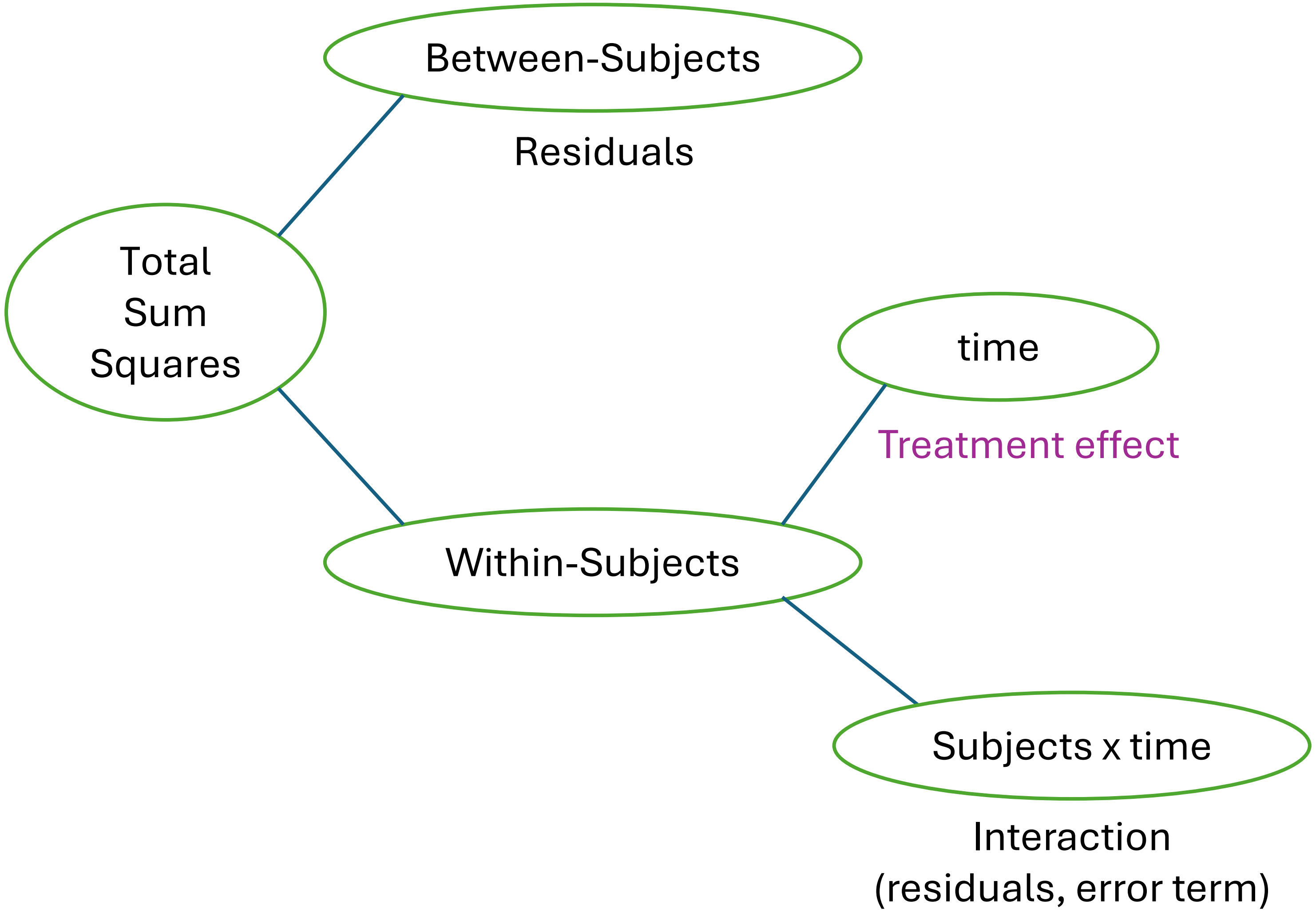
Factor levels	1 month before	1 week before	1 week after	1 month after	1 year after	Sum
S1	12	12	7	5	5	41
S2	9	10	5	6	5	35
S3	9	8	7	5	6	35
S4	8	6	6	4	4	28
S5	8	9	6	4	5	32
S6	9	10	8	6	7	40
S7	12	10	7	5	4	38
S8	6	7	5	7	5	30
Sum	73	72	51	42	41	
Mean	9.13	9.00	6.38	5.25	5.13	

Within subjects: subjects x time

Interaction
(residuals, error term)

One-way within- subjects ANOVA

Partitioning the total variance into its sources



Repeated ANOVA table

Within Subjects Effects

	Sphericity Correction	Sum of Squares	df	Mean Square	F	p	η^2	η^2_p
time	Greenhouse-Geisser	123.850	1.951	63.483	18.624	< .001	0.616	0.727
Residual	Greenhouse-Geisser	46.550	13.657	3.409				

Note. Type 3 Sums of Squares

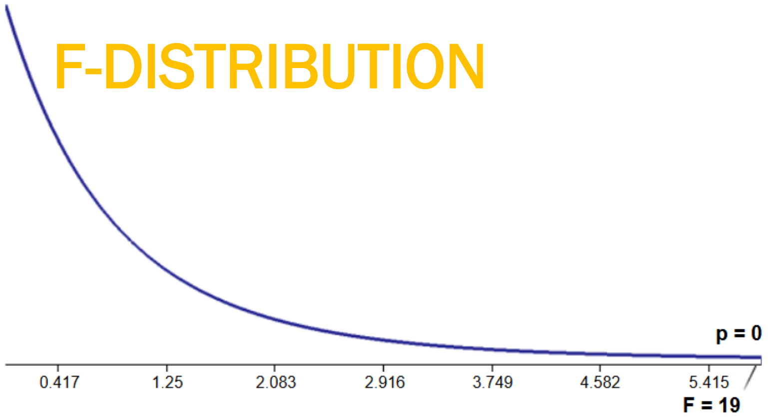
[3]

Between Subjects Effects

	Sum of Squares	df	Mean Square	F	p	η^2	η^2_p
Residual	30.575	7	4.368				

Note. Type 3 Sums of Squares

F-DISTRIBUTION



Post hoc Tests

- Bonferroni Procedure
- Tukey’s Test
- Scheffe
- Holm