

One-way Analysis of Variance (ANOVA)

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Research paper

Alcohol and driving ability

Thirty-six people took part in an experiment to discover the effects of alcohol on drinking ability. They were randomly assigned to three conditions: placebo (no alcohol), low alcohol and high alcohol. The non-alcoholic drink looked and tasted exactly the same as the other drink. Participants were weighed and given the appropriate amount of drink. After half an hour of drinking, participants drove in a simulator for ten minutes, and the number of errors made was automatically registered by the computer.

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Research paper

- Results:
"A one-way ANOVA revealed a significant effect of the amount of alcohol on the error rate ($F(2,33) = 9.91$; $p = 0.001$)."

- One-way ANOVA??????
- $F(2,33) = 9.91$; $p = 0.001$????

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SPSS output

		Degrees of Freedom	ANOVA			P-value
SCORE	Sum of Squares	df	Mean Square	F	Sig.	
Between Groups	97.556	2	48.778	7.133	0.003	
Within Groups	225.667	33	6.838			
Total	323.222	35				

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Learning objectives

- Principles of ANOVA
- Read research papers
- Read SPSS's printouts

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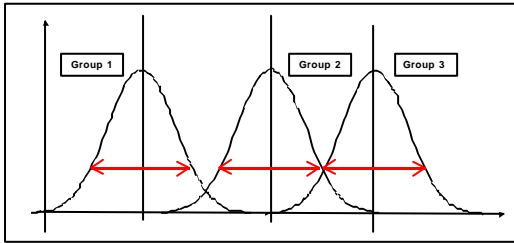
ANOVA

- Null Hypothesis:
The means of **all** groups are equal.
- Experiment:
Alcohol has no influence on driving ability
- Between-groups variance vs. Within-groups variance

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Within-groups variance



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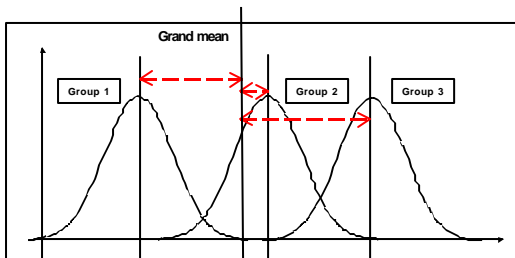
Within-groups variance

- Sources:
 - Individual differences
 - Experimental error
- Alternative Names: within, error

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Between-groups variance



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Between-groups variance

- Sources:
 - Treatment effects
 - Individual differences
 - Experimental error
- Alternative Names: treatment; between; systematic

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F-statistic

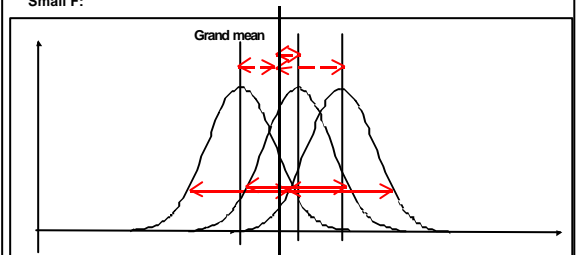
- Broadly:
F is the ratio between
Between-groups variance
and
Within-groups variance
- The larger F the more likely to reject the null hypothesis

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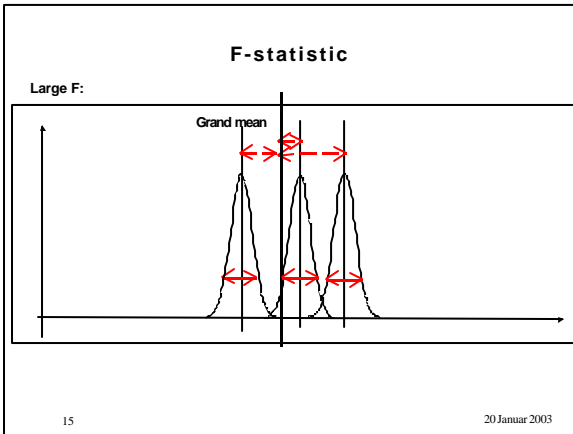
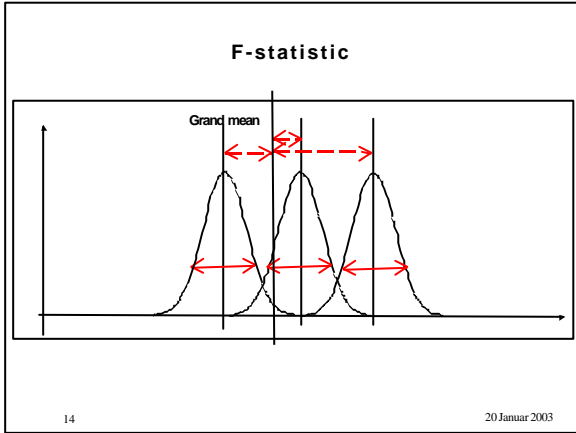
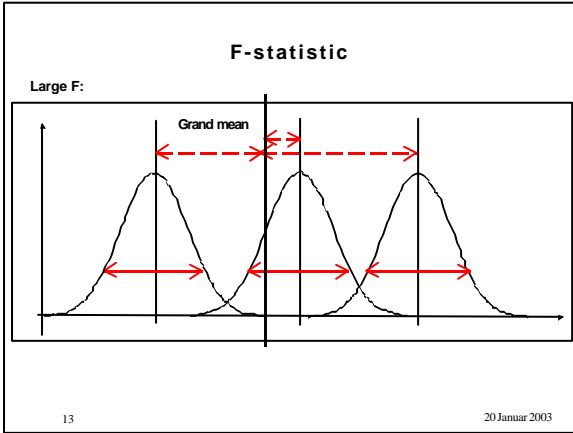
F-statistic

Small F:



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F-statistic

- P-value given by
F-distribution: $F(df_{\text{between}}, df_{\text{within}})$
- Degrees of Freedom:
 - $df_{\text{between}} = \text{groups} - 1$
 - $df_{\text{within}} = \text{participants} - \text{groups}$

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F-statistic

- **Important:**
Rejection of null hypothesis means at least one of the means is different from at least one other mean, **but we do not know** exactly which means are different from which other means!

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Research Paper

F-statistic p-value

- $F(2,33) = 9.91$ $p = 0.001$

Degrees of freedom

- One-way
= one factor
= one independent variable

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SPSS output

ANOVA					
SCORE	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	97.556	2	48.778	7.133	0.003
Within Groups	225.667	33	6.838		
Total	323.222	35			

p-value

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One-way Analysis of Variance Part 2

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Research paper

Alcohol and driving ability

Twelve people took part in an experiment to discover the effects of alcohol on drinking ability. The experiment included three conditions: placebo (no alcohol), low alcohol and high alcohol. The non-alcoholic drink looked and tasted exactly the same as the other drink. Participants were weighted and given the appropriate amount of drink. After half an hour of drinking, participants drove in a simulator for ten minutes, and the number of errors made was automatically registered by the computer. Each participant performed the task in all three conditions.

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Research paper

- **Results:**
"A repeated-measures ANOVA revealed a significant effect of the amount of alcohol on the error rate ($F(2,22) = 10.83; p = 0.001$)."
- **Repeated-measure????**
- **12 participants**
- **$F(2,22) = 10.83; p = 0.001$**

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Repeated-measures ANOVA

Between groups	Degrees of freedom	~ Variance	p-value
Tests of Within-Subjects Effects			
Measure: MEASURE_1	Type III Sum of Squares	df	Mean Square
Source			F
ALCOHOL	145.167	2	72.583
Sphericity Assumed	145.167	1.833	79.194
Greenhouse-Geisser	145.167	2.000	72.583
Huynh-Feldt	145.167	1.000	145.167
Lower-bound	147.500	22	6.705
Error(ALCOHOL)	147.500	20.164	7.315
Sphericity Assumed	147.500	22.000	6.705
Greenhouse-Geisser	147.500	11.000	13.409
Huynh-Feldt			
Lower-bound			

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Learning objectives

- Principles of repeated-measures ANOVA
- Read research papers
- Read SPSS's printouts

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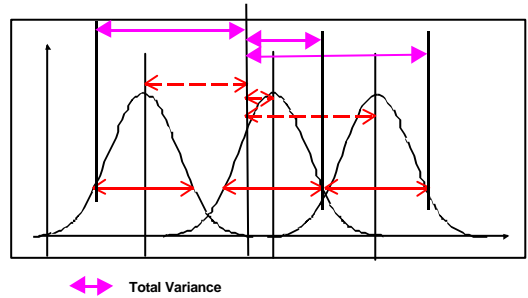
Two experimental designs

- **Between-participants design:** Experimental design in which different participants serve under the different treatment levels
- **Within-participants design:** Experimental designs in which each participants receives all levels if at least one independent variable

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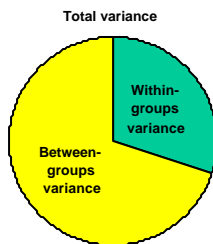
Total variance (between participants)



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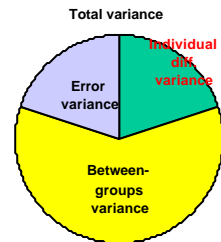
Partitioning variance (between participants)



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Partitioning variance



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F-statistic

- Broadly:
F is the ratio between Between-groups variance and Error variance (Within variance **without individual differences**)
- P-value given by F-distribution: $F(df_{\text{between}}, df_{\text{error}})$

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Degrees of freedom

- $df_{\text{Total}} = \text{participants} * \text{groups} - 1$
- $df_{\text{individual_differences}} = \text{participants} - 1$
- $df_{\text{within}} = df_{\text{Total}} - df_{\text{individual_differences}}$
- $df_{\text{between}} = \text{groups} - 1$
- $df_{\text{error}} = df_{\text{within}} - df_{\text{between}}$

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Repeated-measures ANOVA

Tests of Within-Subjects Effects

Measure: MEASURE_1						
Source		Type III Sum of Squares	df	Mean Square	Sig.	
ALCOHOL	Sphericity Assumed	145.167	2	72.583	10.826	.001
	Greenhouse-Geisser	145.167	1.833	79.194	10.826	.001
	Huynh-Feldt	145.167	2.000	72.583	10.826	.001
	Lower-bound	145.167	1.000	145.167	10.826	.007
Error(ALCOHOL)	Sphericity Assumed	147.500	22	6.705		
	Greenhouse-Geisser	147.500	20.164	7.315		
	Huynh-Feldt	147.500	22.000	6.705		
	Lower-bound	147.500	11.000	13.409		

Error variance (without individual differences)

Report
Greenhouse-Geisser

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Advantages

- Avoidance of variability from participant to participant
- Require fewer participants than between-participant designs

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Disadvantage

- Order effects or carry-over (practice) effects

➤ Counterbalancing for avoidance

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Counterbalancing

- An arrangement of treatment conditions design to balance practice effects
- Example:
 - Participant: Placebo; Low Alcohol; High Alcohol
 - Participant: Placebo; High Alcohol; Low Alcohol
 - Participant: Low Alcohol; Placebo; High Alcohol
 - Participant: High Alcohol; Placebo; Low Alcohol
 - Participant: Low Alcohol; High Alcohol; Placebo
 - Participant: High Alcohol; Low Alcohol; Placebo
 - Participant: like first participant

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