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PSYC214: Statistics
Lecture 2 – One factor between-participants ANOVA – Part I

Michaelmas Term,
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One factor between-participants ANOVA

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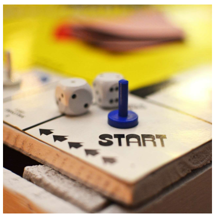
Agenda/Content for Lecture 2

- Introduction to analysis of variance (ANOVA)
- Introduction to one factor between-participants design
- Sources of variability in data
- Calculating within-group and between-group variances
- Degrees of Freedom
- Producing the F-statistic



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Introduction to analysis of variance

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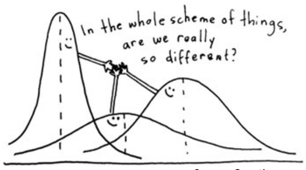
Why conduct an analysis of variance?

- Compares means and variance
- Allows analysis of group differences for more than two groups
- Several means without inflating Type I error rate



Source: Questionpro

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Dissertation!

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ANOVA is a good weapon of choice!

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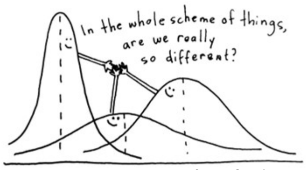
What do you need for a one factor between participants ANOVA?

- Three or more separate groups
- ONE categorical independent variable (i.e., one factor)
- One continuous dependent variable (outcome measure)



Source: Questionpro

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Sources of variability in data

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1. Treatment effects
2. Individual differences
3. Random (residual) errors

Within-group variability?

Between-group variability?

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Sources of variability in data

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1. **Treatment effects**
2. Individual differences
3. Random (residual) errors

Within-group variability?

Between-group variability?

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Treatment effects

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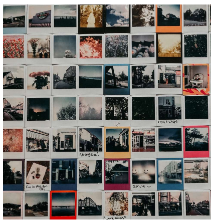
- The effects of the independent variable
- This is what we want!
- We want people who are treated differently because of our intervention to behave differently



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Sources of variability in data

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1. Treatment effects
2. Individual differences
3. Random (residual) errors

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Individual differences

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- Some individuals may be more proficient in memory recall
- Maybe some individuals have experience of similar tasks
- Some may have ignored instructions or had lower attention spans / motivation
- A control group can employ their own strategy, increasing the variability

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Sources of variability in data

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1. Treatment effects
2. Individual differences
3. Random (residual) errors

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Random (residual) errors

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- Ideally a participant would have a ‘true level’ at which they perform, which can always be measured accurately

1. Varying external conditions – e.g., temperature, time of day
2. State of participant (e.g. tired?)
3. Experimenter’s ability to measure accurately…

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…Experimenter effects

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- Experimenters need to minimise these, so not to obscure the treatment effect
- Spread data away from the true means – i.e., increase variability and standard errors
- Reduce confidence in our estimates and a randomly plucked sample

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Within- and between- group variability

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Within-group variability
The extent to which participants within a single group or population differ, despite receiving the same treatment

Within-group variability?

Between-group variability
The extent to which overall groups differ from one another (hopefully because of our treatment)

Between-group variability?

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Within- and between- group variability

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High between-group variability
No within group-variability

	Group A	Group B	Group C
	10	20	30
	10	20	30
	10	20	30
	10	20	30
	10	20	30
Mean	10	20	30
S	0	0	0

No between-group variability
High within-group variability

	Group A	Group B	Group C
	10	15	5
	25	20	25
	30	30	25
	35	40	45
	50	45	50
Mean	30	30	30
S	14.6	12.8	18.0

Moderate between-group variability
Moderate within-group variability

	Group A	Group B	Group C
	10	10	20
	10	20	20
	10	20	30
	20	20	30
	20	30	30
Mean	14	20	26
S	5.5	7.1	5.5

Tables adapted from Roberts and Russo (1999)

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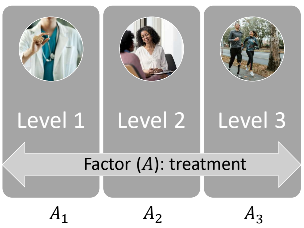
Introduction to analysis of variance

Factors and levels (Example 1)

- Factor: **treatment**
- 3 levels
  - Medication
  - Counselling
  - Exercise



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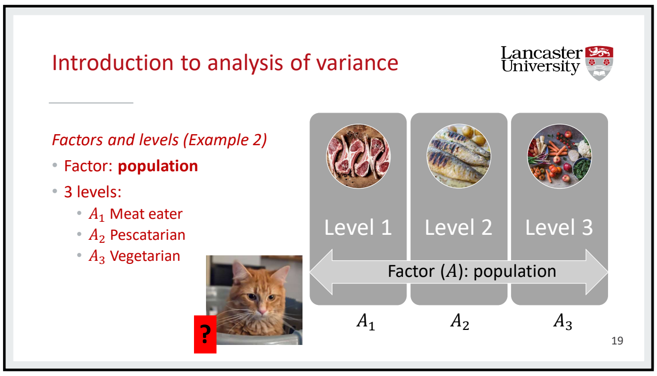
Introduction to analysis of variance
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Factors and levels (Example 2)
Factor: population
3 levels:
A_1 Meat eater
A_2 Pescatarian
A_3 Vegetarian
?
Level 1
Level 2
Level 3
Factor (A): population
A_1
A_2
A_3
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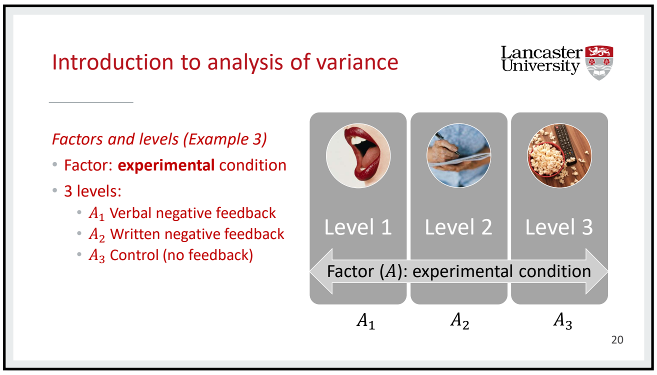
Introduction to analysis of variance
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Factors and levels (Example 3)
Factor: experimental condition
3 levels:
A_1 Verbal negative feedback
A_2 Written negative feedback
A_3 Control (no feedback)
Level 1
Level 2
Level 3
Factor (A): experimental condition
A_1
A_2
A_3
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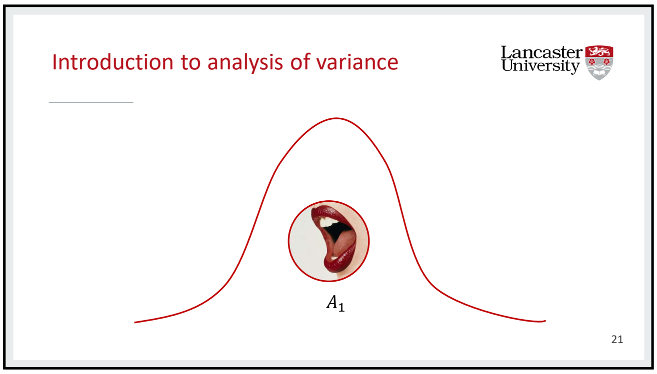
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A_1
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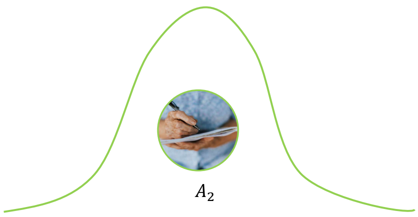

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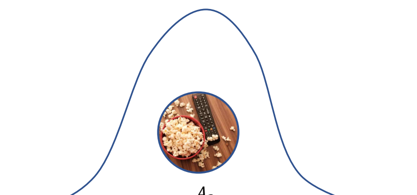

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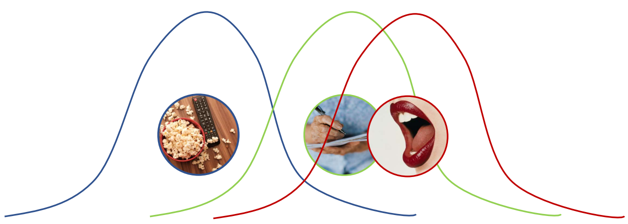

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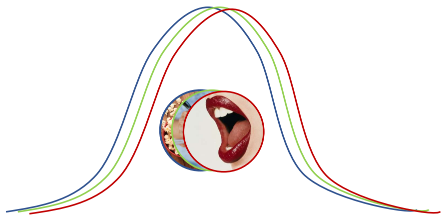

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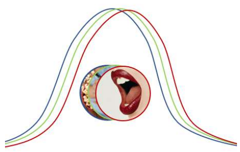
Testing for differences

- H_0 the Null Hypothesis
  - Under H0, the samples come from the <u>same</u> population
  - $\mu_1 = \mu_2 = \mu_3$ [No difference in the population means]
  - Experimental effect = 0
  - All differences are due to individual differences + random (residual) errors



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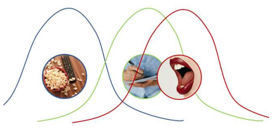
Testing for differences



- H_1 the Experimental Hypothesis
  - Under H_1, the samples come from the <u>different</u> populations.
  - $\mu_1 \neq \mu_2 \neq \mu_3$ [Population means are different]
  - Experimental effect $\neq 0$
  - Differences are due to individual differences, random (residual) errors <u>AND</u> the experimental effect

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Introduction to analysis of variance

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$$F = \frac{\text{between-group variance}}{\text{within-group variance}}$$

$$F = \frac{\text{Signal}}{\text{Noise}}$$

$$F = \frac{\text{Signal}}{\text{Noise}}$$

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The F ratio

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$$F = \frac{\text{between-group variance}}{\text{within-group variance}}$$

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The F ratio

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$$F = \frac{\text{between-group variance}}{\text{within-group variance}}$$

$$F = \frac{\text{treatment effects + individual differences + random (residual) errors}}{\text{individual differences + random (residual) errors}}$$

individual differences + random (residual) errors (numerator) → experimental error

individual differences + random (residual) errors (denominator) → experimental error

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The F ratio

$$F = \frac{\text{between-group variance}}{\text{within-group variance}}$$

$$F = \frac{\text{treatment effects + individual differences + random (residual) errors}}{\text{individual differences + random (residual) errors}}$$

$$F = \frac{\text{treatment effects + experimental error}}{\text{experimental error}}$$

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Introduction to analysis of variance

$$F = \frac{\text{Signal}}{\text{Noise}}$$

$$F = \frac{\text{Signal}}{\text{Noise}}$$

The more treatment effects are standing out away from experimental error – i.e., the larger the signal is from the noise, the larger in magnitude the F value. The larger the F, the less likely that differences in scores are caused by chance.

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Calculating between-group variance

$$F = \frac{\text{between-group variance}}{\text{within-group variance}}$$

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Mean (Ā)

A_1 scores	A_2 scores	A_3 scores
3	2	5
2	4	4
4	5	6
5	4	4
4	3	4
3	1	5
2	2	3
1	3	2
1	4	6

$$\overline{X} = \frac{\sum X}{N}$$

Total set of scores

Mean

Number of scores

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Mean ($\bar{A}$)

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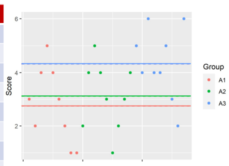
A_1 scores	A_2 scores	A_3 scores
3	2	5
2	4	4
4	5	6
5	4	4
4	3	4
3	1	5
2	2	3
1	3	2
1	4	6
$\bar{A}_1$= 2.78	$\bar{A}_2$= 3.11	$\bar{A}_3$= 4.33



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Grand Mean ($\bar{Y}$)

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A_1 scores	A_2 scores	A_3 scores
3	2	5
2	4	4
4	5	6
5	4	4
4	3	4
3	1	5
2	2	3
1	3	2
1	4	6
$\bar{A}_1$ = 2.78	$\bar{A}_2$ = 3.11	$\bar{A}_3$ = 4.33

$$\bar{Y} = \frac{\bar{A}_1 + \bar{A}_2 + \bar{A}_3 + \ldots \bar{A}_k}{k}$$

$\bar{Y}$ = *The grand mean of averages*

k = *number of levels*

$$\bar{Y} = \frac{2.78 + 3.11 + 4.33}{3}$$

$\bar{Y}$ = 3.41

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Grand Mean ($\bar{Y}$)

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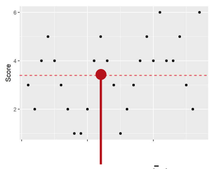
A_1 scores	A_2 scores	A_3 scores	
3	2	5	
2	4	4	
4	5	6	
5	4	4	
4	3	4	
3	1	5	
2	2	3	
1	3	2	
1	4	6	
$\bar{A}_1$= 2.78	$\bar{A}_2$= 3.11	$\bar{A}_3$= 4.33	$\bar{Y}$ = 3.41



Grand mean ($\bar{Y}$)

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Total between-group variance

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$$total\ between\ group\ variance = \frac{N_{A1}(\bar{A}_1 - \bar{Y})^2 + N_{A2}(\bar{A}_2 - \bar{Y})^2 + N_{A3}(\bar{A}_3 - \bar{Y})^2\ (and\ so\ on)}{total\ between\ group\ degrees\ of\ freedom}$$

A_1 scores	A_2 scores	A_3 scores	
3	2	5	
2	4	4	
4	5	6	
5	4	4	
4	3	4	
3	1	5	
2	2	3	
1	3	2	
1	4	6	
$\bar{A}_1$ = 2.78	$\bar{A}_2$ = 3.11	$\bar{A}_3$ = 4.33	$\bar{Y}$ = 3.41

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Total between-group variance

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$$total\ between\ group\ variance = \frac{N_{A1}(\bar{A}_1 - \bar{Y})^2 + N_{A2}(\bar{A}_2 - \bar{Y})^2 + N_{A3}(\bar{A}_3 - \bar{Y})^2\ (and\ so\ on)}{total\ between\ group\ degrees\ of\ freedom}$$

A_1 scores	A_2 scores	A_3 scores	
3	2	5	
2	4	4	
4	5	6	
5	4	4	
4	3	4	
3	1	5	
2	2	3	
1	3	2	
1	4	6	
$\bar{A}_1$ = 2.78	$\bar{A}_2$ = 3.11	$\bar{A}_3$ = 4.33	$\bar{Y}$ = 3.41

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Total between-group variance

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$$total\ between\ group\ variance = \frac{N_{A1}(\bar{A}_1 - \bar{Y})^2 + N_{A2}(\bar{A}_2 - \bar{Y})^2 + N_{A3}(\bar{A}_3 - \bar{Y})^2\ (and\ so\ on)}{total\ between\ group\ degrees\ of\ freedom}$$

A_1 scores	A_2 scores	A_3 scores	
3	2	5	
2	4	4	
4	5	6	
5	4	4	
4	3	4	
3	1	5	
2	2	3	
1	3	2	
1	4	6	
$\bar{A}_1$ = 2.78	$\bar{A}_2$ = 3.11	$\bar{A}_3$ = 4.33	$\bar{Y}$ = 3.41

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Total between-group variance

$$total\ between\ group\ variance = \frac{N_{A1}(\bar{A}_1 - \bar{Y})^2 + N_{A2}(\bar{A}_2 - \bar{Y})^2 + N_{A3}(\bar{A}_3 - \bar{Y})^2\ (and\ so\ on)}{total\ between\ group\ degrees\ of\ freedom}$$

N_{A1} = Number of scores for A_1 = 9

N_{A2} = Number of scores for A_2 = 9

N_{A3} = Number of scores for A_3 = 9

A_1 scores	A_2 scores	A_3 scores	
3	2	5	
2	4	4	
4	5	6	
5	4	4	
4	3	4	
3	1	5	
2	2	3	
1	3	2	
1	4	6	
$\bar{A}_1$ = 2.78	$\bar{A}_2$ = 3.11	$\bar{A}_3$ = 4.33	$\bar{Y}$ = 3.41

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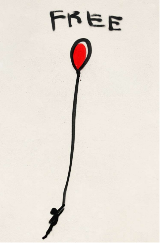
Degrees of freedom

Between-groups degrees of freedom

- The total number of levels minus one
- For example, in our experiment we have three levels [verbal feedback, written feedback, control]
- The between-groups degree of freedom is there 3 levels – 1 = 2
- Between-groups df = 2



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Total between-group variance

$$total\ between\ group\ variance = \frac{9(2.78 - 3.41)^2 + 9(3.11 - 3.41)^2 + 9(4.33 - 3.41)^2}{2}$$

N_{A1} = Number of scores for A_1 = 9

N_{A2} = Number of scores for A_2 = 9

N_{A3} = Number of scores for A_3 = 9

A_1 scores	A_2 scores	A_3 scores	
3	2	5	
2	4	4	
4	5	6	
5	4	4	
4	3	4	
3	1	5	
2	2	3	
1	3	2	
1	4	6	
$\bar{A}_1$ = 2.78	$\bar{A}_2$ = 3.11	$\bar{A}_3$ = 4.33	$\bar{Y}$ = 3.41

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Total between-group variance

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$$total\ between\ group\ variance = \frac{9(-0.63)^2 + 9(-0.30)^2 + 9(0.92)^2}{2}$$

N_{A1} = Number of scores for A_1 = 9

N_{A2} = Number of scores for A_2 = 9

N_{A3} = Number of scores for A_3 = 9

A_1 scores	A_2 scores	A_3 scores	
3	2	5	
2	4	4	
4	5	6	
5	4	4	
4	3	4	
3	1	5	
2	2	3	
1	3	2	
1	4	6	
$\bar{A}_1$ = 2.78	$\bar{A}_2$ = 3.11	$\bar{A}_3$ = 4.33	$\bar{Y}$ = 3.41

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Total between-group variance

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$$total\ between\ group\ variance = \frac{9(0.40) + 9(0.09) + 9(0.85)}{2}$$

N_{A1} = Number of scores for A_1 = 9

N_{A2} = Number of scores for A_2 = 9

N_{A3} = Number of scores for A_3 = 9

A_1 scores	A_2 scores	A_3 scores	
3	2	5	
2	4	4	
4	5	6	
5	4	4	
4	3	4	
3	1	5	
2	2	3	
1	3	2	
1	4	6	
$\bar{A}_1$ = 2.78	$\bar{A}_2$ = 3.11	$\bar{A}_3$ = 4.33	$\bar{Y}$ = 3.41

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Total between-group variance

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$$total\ between\ group\ variance = \frac{3.60 + 0.81 + 7.65}{2} = 6.037 \text{ (with rounding)}$$

A_1 scores	A_2 scores	A_3 scores	
3	2	5	
2	4	4	
4	5	6	
5	4	4	
4	3	4	
3	1	5	
2	2	3	
1	3	2	
1	4	6	
$\bar{A}_1$ = 2.78	$\bar{A}_2$ = 3.11	$\bar{A}_3$ = 4.33	$\bar{Y}$ = 3.41

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Calculating between-group variance

$$F = \frac{\text{between-group variance}}{\text{within-group variance}}$$

$$F = \frac{6.037}{\text{within-group variance}}$$

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Up to now…

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$$F = \frac{\text{between-group variance}}{\text{within-group variance}}$$

$$F = \frac{6.037}{\text{within-group variance}}$$

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Calculating within-group variance

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$$F = \frac{\text{between-group variance}}{\text{within-group variance}}$$

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Total within-group variance

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$$total\ within\ group\ variance = \frac{SS\ level\ A_1 + SS\ level\ A_2 + SS\ level\ A_3 (and\ so\ on)}{total\ within\ group\ degrees\ of\ freedom}$$

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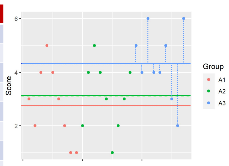
Mean

A_1 scores	A_2 scores	A_3 scores
3	2	5
2	4	4
4	5	6
5	4	4
4	3	4
3	1	5
2	2	3
1	3	2
1	4	6
$\bar{A}_1$= 2.78	$\bar{A}_2$= 3.11	$\bar{A}_3$= 4.33



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Total within-group variance

$$total\ within\ group\ variance = \frac{SS\ level\ A_1 + SS\ level\ A_2 + SS\ level\ A_3 (and\ so\ on)}{total\ within\ group\ degrees\ of\ freedom}$$

$SS\ level\ A_1 = Sums\ of\ squares\ for\ level\ 1$

$SS\ level\ A_2 = Sums\ of\ squares\ for\ level\ 2$

$SS\ level\ A_3 = Sums\ of\ squares\ for\ level\ 3$

A_1 scores	A_2 scores	A_3 scores	
3	2	5	
2	4	4	
4	5	6	
5	4	4	
4	3	4	
3	1	5	
2	2	3	
1	3	2	
1	4	6	
$\bar{A}_1$= 2.78	$\bar{A}_2$= 3.11	$\bar{A}_3$= 4.33	$\bar{Y}$ = 3.41

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Total within-group variance

$$total\ within\ group\ variance = \frac{\sum(A_1 - \bar{A}_1)^2 + (A_2 - \bar{A}_2)^2 + (A_3 - \bar{A}_3)^2 + \ (and\ so\ on)}{total\ within\ group\ degrees\ of\ freedom}$$

A_1 scores	A_2 scores	A_3 scores	
3	2	5	
2	4	4	
4	5	6	
5	4	4	
4	3	4	
3	1	5	
2	2	3	
1	3	2	
1	4	6	
$\bar{A}_1$= 2.78	$\bar{A}_2$= 3.11	$\bar{A}_3$= 4.33	$\bar{Y}$ = 3.41

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Total within-group variance

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$$total\ within\ group\ variance = \frac{\sum(A_1 - 2.78)^2 + (A_2 - 3.11)^2 + (A_3 - 4.33)^2 + \ (and\ so\ on)}{total\ within\ group\ degrees\ of\ freedom}$$

A_1 scores	A_2 scores	A_3 scores	
3	2	5	
2	4	4	
4	5	6	
5	4	4	
4	3	4	
3	1	5	
2	2	3	
1	3	2	
1	4	6	
$\bar{A}_1$ = 2.78	$\bar{A}_2$ = 3.11	$\bar{A}_3$ = 4.33	$\bar{Y}$ = 3.41

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Degrees of freedom

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Within-groups degrees of freedom

- For within-groups degrees of freedom, we add up the number of participants for each level – 1
- Mathematically this is expressed as:

$= (N_{A1} - 1) + (N_{A2} - 1) + (N_{A3} - 1)$

$= (9 - 1) + (9 - 1) + (9 - 1)$

$= 24$

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Total within-group variance

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$$total\ within\ group\ variance = \frac{\sum(A_1 - 2.75)^2 + (A_2 - 3.11)^2 + (A_3 - 4.33)^2}{24}$$

A_1 scores	A_2 scores	A_3 scores	
3	2	5	
2	4	4	
4	5	6	
5	4	4	
4	3	4	
3	1	5	
2	2	3	
1	3	2	
1	4	6	
$\bar{A}_1$ = 2.78	$\bar{A}_2$ = 3.11	$\bar{A}_3$ = 4.33	$\bar{Y}$ = 3.41

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Total within-group variance

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$$total\ within\ group\ variance = \frac{42.444}{24} = 1.769 \text{ (with rounding)}$$

A_1 scores	A_2 scores	A_3 scores	
3	2	5	
2	4	4	
4	5	6	
5	4	4	
4	3	4	
3	1	5	
2	2	3	
1	3	2	
1	4	6	
$\bar{A}_1$= 2.78	$\bar{A}_2$= 3.11	$\bar{A}_3$= 4.33	$\bar{Y}$ = 3.41

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The F ratio

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$$F = \frac{\text{between-group variance}}{\text{within-group variance}}$$

$$F = \frac{6.037}{1.769}$$

F = 3.414

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ν_2 \ ν_1	1	2	3	4	5	6	7	8	9	10	12	15	20	24	30	40	60	120	∞
1	161	200	216	225	230	234	237	239	241	242	244	246	248	249	250	251	252	253	254
2	18.5	19.0	19.2	19.2	19.3	19.3	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.5	19.5	19.5	19.5	19.5	19.5
3	10.1	9.55	9.28	9.12	9.01	8.94	8.89	8.85	8.81	8.79	8.74	8.70	8.66	8.64	8.62	8.59	8.57	8.55	8.53
4	7.71	6.94	6.59	6.39	6.26	6.16	6.09	6.04	6.00	5.96	5.91	5.86	5.80	5.77	5.75	5.72	5.69	5.66	5.63
5	6.61	5.79	5.41	5.19	5.05	4.95	4.88	4.82	4.77	4.74	4.68	4.62	4.56	4.53	4.50	4.46	4.43	4.40	4.37
6	5.99	5.14	4.76	4.53	4.39	4.28	4.21	4.15	4.10	4.06	4.00	3.94	3.87	3.84	3.81	3.77	3.74	3.70	3.67
7	5.59	4.74	4.35	4.12	3.97	3.87	3.79	3.73	3.68	3.64	3.57	3.51	3.44	3.41	3.38	3.34	3.30	3.27	3.23
8	5.32	4.46	4.07	3.84	3.69	3.58	3.50	3.44	3.39	3.35	3.28	3.22	3.15	3.12	3.08	3.04	3.01	2.97	2.93
9	5.12	4.26	3.86	3.63	3.48	3.37	3.29	3.23	3.18	3.14	3.07	3.01	2.94	2.90	2.86	2.83	2.79	2.75	2.71
10	4.96	4.10	3.71	3.48	3.33	3.22	3.14	3.07	3.02	2.98	2.91	2.85	2.77	2.74	2.70	2.66	2.62	2.58	2.54
11	4.84	3.98	3.59	3.36	3.20	3.09	3.01	2.95	2.90	2.85	2.79	2.72	2.65	2.61	2.57	2.53	2.49	2.45	2.40
12	4.75	3.89	3.49	3.26	3.11	3.00	2.91	2.85	2.80	2.75	2.69	2.62	2.54	2.51	2.47	2.43	2.38	2.34	2.30
13	4.67	3.81	3.41	3.18	3.03	2.92	2.83	2.77	2.71	2.67	2.60	2.53	2.46	2.42	2.38	2.34	2.30	2.25	2.21
14	4.60	3.74	3.34	3.11	2.96	2.85	2.76	2.70	2.65	2.60	2.53	2.46	2.39	2.35	2.31	2.27	2.22	2.18	2.13
15	4.54	3.68	3.29	3.06	2.90	2.79	2.71	2.64	2.59	2.54	2.48	2.40	2.33	2.29	2.25	2.20	2.16	2.11	2.07
16	4.49	3.63	3.24	3.01	2.85	2.74	2.66	2.59	2.54	2.49	2.42	2.35	2.28	2.24	2.19	2.15	2.11	2.06	2.01
17	4.45	3.59	3.20	2.96	2.81	2.70	2.61	2.55	2.49	2.45	2.38	2.31	2.23	2.19	2.15	2.10	2.06	2.01	1.96
18	4.41	3.55	3.16	2.93	2.77	2.66	2.58	2.51	2.46	2.41	2.34	2.27	2.19	2.15	2.11	2.06	2.02	1.97	1.92
19	4.38	3.52	3.13	2.90	2.74	2.63	2.54	2.48	2.42	2.38	2.31	2.23	2.16	2.11	2.07	2.03	1.98	1.93	1.88
20	4.35	3.49	3.10	2.87	2.71	2.60	2.51	2.45	2.39	2.35	2.28	2.20	2.12	2.08	2.04	1.99	1.95	1.90	1.84
21	4.32	3.47	3.07	2.84	2.68	2.57	2.49	2.42	2.37	2.32	2.25	2.18	2.10	2.05	2.01	1.96	1.92	1.87	1.81
22	4.30	3.44	3.05	2.82	2.66	2.55	2.46	2.40	2.34	2.30	2.23	2.15	2.07	2.03	1.98	1.94	1.89	1.84	1.78
23	4.28	3.42	3.03	2.80	2.64	2.53	2.44	2.37	2.32	2.27	2.20	2.13	2.05	2.01	1.96	1.91	1.86	1.81	1.76
24	4.26	3.40	3.01	2.78	2.62	2.51	2.42	2.36	2.30	2.25	2.18	2.11	2.03	1.98	1.94	1.89	1.84	1.79	1.73
25	4.24	3.39	2.99	2.76	2.60	2.49	2.40	2.34	2.28	2.24	2.16	2.09	2.01	1.96	1.92	1.87	1.82	1.77	1.71
26	4.23	3.37	2.98	2.74	2.59	2.47	2.39	2.32	2.27	2.22	2.15	2.07	1.99	1.95	1.90	1.85	1.80	1.75	1.69
27	4.21	3.35	2.96	2.73	2.57	2.46	2.37	2.31	2.25	2.20	2.13	2.06	1.97	1.93	1.88	1.84	1.79	1.73	1.67
28	4.20	3.34	2.95	2.71	2.56	2.45	2.36	2.29	2.24	2.19	2.12	2.04	1.96	1.91	1.87	1.82	1.77	1.71	1.65
29	4.18	3.33	2.93	2.70	2.55	2.43	2.35	2.28	2.22	2.18	2.10	2.03	1.94	1.90	1.85	1.81	1.75	1.70	1.64
30	4.17	3.32	2.92	2.69	2.53	2.42	2.33	2.27	2.21	2.16	2.09	2.01	1.93	1.89	1.84	1.79	1.74	1.68	1.62
40	4.08	3.23	2.84	2.61	2.45	2.34	2.25	2.18	2.12	2.08	2.00	1.92	1.84	1.79	1.74	1.69	1.64	1.58	1.51
60	4.00	3.15	2.76	2.53	2.37	2.25	2.17	2.10	2.04	1.99	1.92	1.84	1.75	1.70	1.65	1.59	1.53	1.47	1.39
120	3.92	3.07	2.68	2.45	2.29	2.18	2.09	2.02	1.96	1.91	1.83	1.75	1.66	1.61	1.55	1.50	1.43	1.35	1.25
∞	3.84	3.00	2.60	2.37	2.21	2.10	2.01	1.94	1.88	1.83	1.75	1.67	1.57	1.52	1.46	1.39	1.32	1.22	1.00

Source: E. S. Pearson and H. O. Hartley, *Biometrika Tables for Statisticians*, Vol. 2 (1972), Table 5, page 178, by permission.

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The F ratio

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$F = \frac{\text{between-group variance}}{\text{within-group variance}}$

$F = \frac{6.037}{1.769}$

$F = 3.414$, $p = 0.05$, A statistically significant test result ($P \le 0.05$)

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Lecture 2 – One factor between-participants ANOVA

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Review of lecture 2

- What is Analysis of Variance
- What is a one-factor between-participants design
- Sources of variability in data
- Calculated within-group and between-group variances
- Degrees of Freedom
- Produced the F-statistic

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Check you understand today's lecture – repeat any parts of the lecture you need to.

Don't forget to ask any questions using the Discussion Forum on **Moodle**!

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