PSYC214: Statistics
Lecture 5 – Interim summary – Part I

Michaelmas Term

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WBA 1 – Q2.

- Young-min is examining the quality of care received by individuals suffering from depression. He compares the services from 10 different NHS clinics around the Lancaster area by asking their respective clients to rate their level of satisfaction on a scale from 1 to 7, 1 being not at all satisfied and 7 being extremely satisfied.

A. Quality of care received

B. Lancaster

C. NHS clinics

D. Individual suffering from depression

E. Satisfaction scores

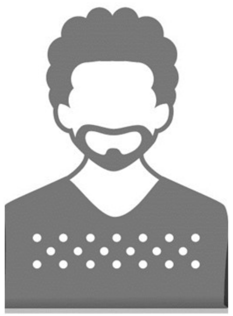
Variables

Independent Variable

- The variable the experimenter manipulates or changes, which may be assumed to have a direct effect (i.e., influences change) on the dependent variable.

Dependent Variable

- The outcome of interest. It is the variable being tested and measured in an experiment. It is 'dependent' on the effect (i.e., influence) of the independent variable.



WBA 1 – Q6.

- Under H0, the Null Hypothesis,

A. There is a significant difference between the conditions/groups

B. The samples come from different populations

C. The samples come from the same population

D. We accept the experimental hypothesis

E. We formulate a research hypothesis

Inferential statistics - Hypotheses

H_0 the Null Hypothesis

- H_0: there is no significant difference between the conditions/groups and the null hypothesis is accepted.
- Under H_0, the samples come from the same population.

H_1 the Experimental Hypothesis

- H_1: there is a significant difference between the conditions/groups and the null hypothesis is rejected.
- Under H_1, the samples come from the different populations.

WBA 1 – Q12.

- Matilda has three independent groups who each receive a different treatment to help them quit smoking – either hypnotherapy, psychotherapy or nicotine patches. To assess statistical differences between groups, Matilda should run:

A. Three independent group t-tests

B. A one-factor within-participant ANOVA

C. A two-factor between-participant ANOVA

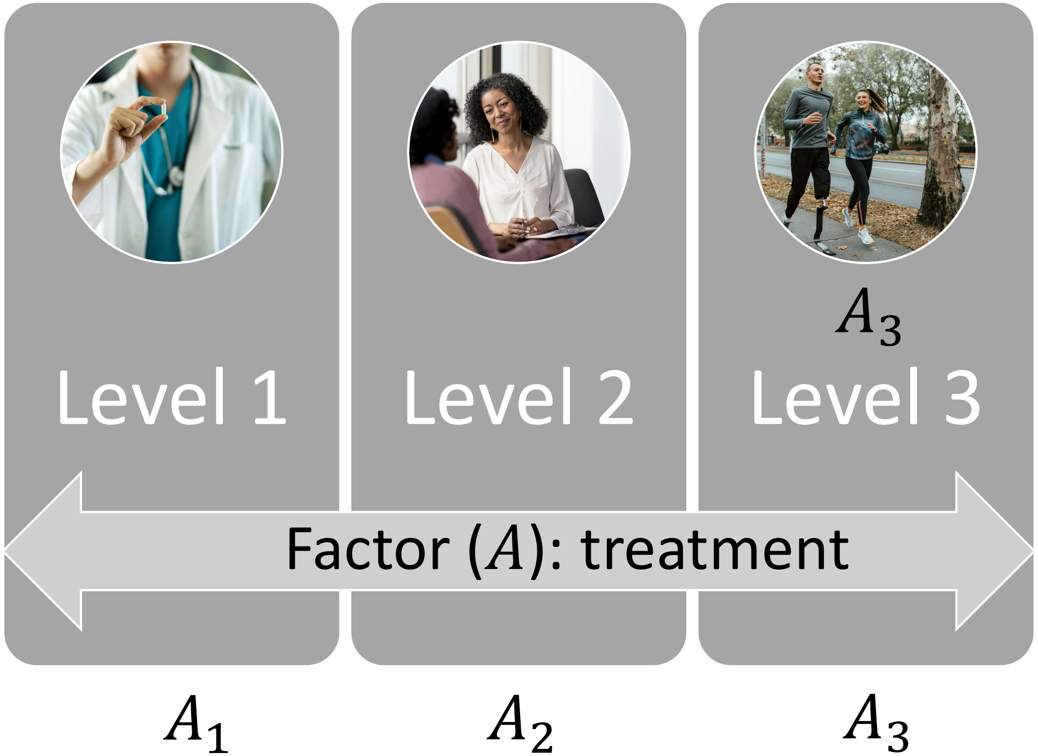
D. A one-factor, between-participant ANOVA

E. A set of descriptive statistics

Introduction to analysis of variance

Factors and levels

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



WBA 1 – Q15.

- The larger the F ratio

A. The larger the noise in a study

B. The smaller the signal in comparison to the noise

C. The larger the signal in comparison to the noise

D. Generally, the less likely your difference between groups will be significant

E. The harder your equation was to calculate

Introduction to analysis of variance

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

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

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

WBA 1 – Q18.

- Which statement about the ANOVA is NOT true

A. It is useful for examining mean differences between three or more groups

B. It provides a greater risk of producing type I errors than a series of T-tests

C. It requires at least one factor

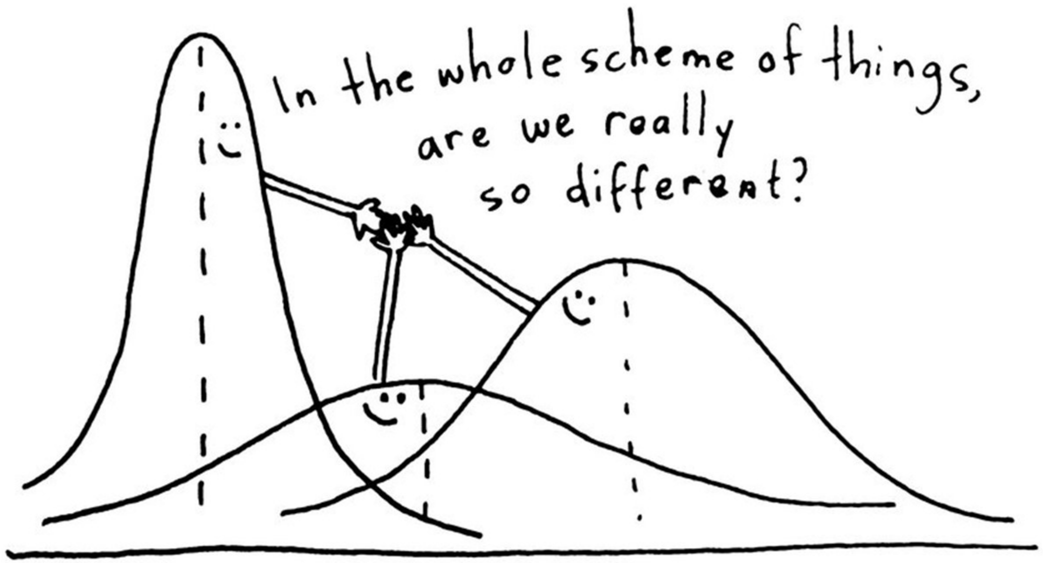
D. It requires continuous outcome (DV) data

E. It is an Analysis of Variance

Introduction to analysis of variance

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

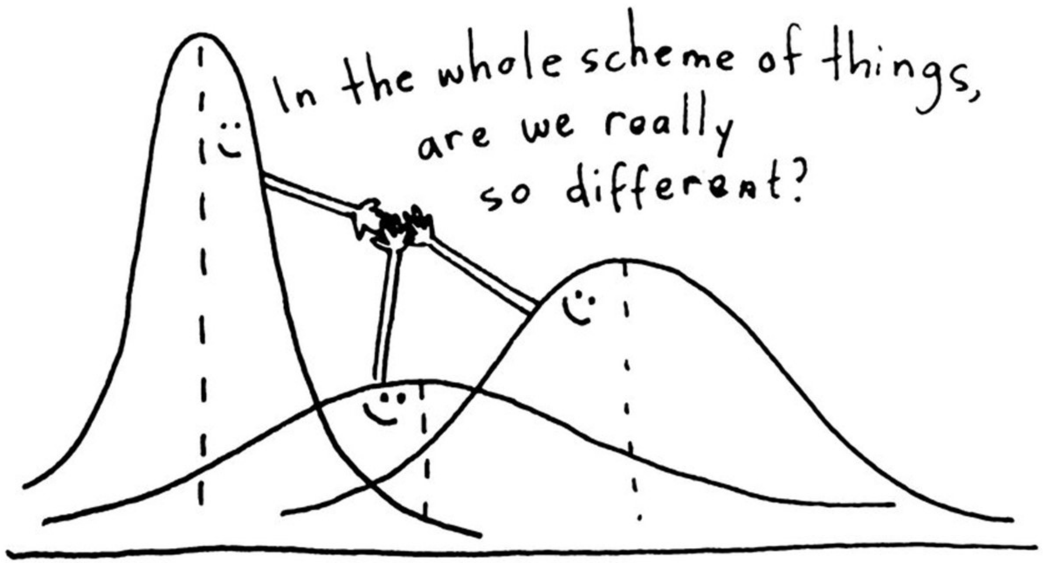


Source: Questionpro

Introduction to analysis of variance

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

- At least one categorical independent variable (i.e., one factor)
- One continuous dependent variable (outcome measure)



Source: Questionpro

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WBA 2 – Q8.

- What would be an example of a violation of the assumption of independence:

A. Participants are tested separately from one another.

B. We have disproportionately more females in one condition than another.

C. We have bimodal data.

D. We have unequal variance across our samples.

E. Our data have been transformed with mathematical functions.

Assumption of independence

What is it?

- Participants should be randomly assigned to a group
- Participants should not cluster, sharing a classification variable
    - Gender
    - Skill level
- There should be no influence across one data point to another

WBA 2 – Q12.

- How do planned comparisons and post hoc tests differ?

A. Planned comparisons always happen before you run an ANOVA, whereas post hoc tests occur after.

B. Post hoc tests always happen before you run an ANOVA, whereas planned comparisons occur after.

C. Planned comparisons produce F statistics, whereas post hoc tests produce Q statistics.

D. Planned comparisons test only the mean differences of interest, while post hoc tests compare all possible combinations of mean differences.

E. They are interested in different studies

Planned comparisons

- Focussed approach to examine specific group differences
- Perfect when certain hypotheses can be tested without comparing all combinations of means
- Should be pre-specified
- Need to keep the number of planned comparisons as low as possible to negate Type I errors – (number of levels – 1)

Group	$\bar{A}_1$	$\bar{A}_2$	$\bar{A}_3$	$\bar{A}_4$	$\bar{A}_5$
$\bar{A}_1$	-	-	-	-	-
$\bar{A}_2$	●	-	-	-	-
$\bar{A}_3$	●	●	-	-	-
$\bar{A}_4$	●	●	●	-	-
$\bar{A}_5$	●	●	●	●	-

Post hoc tests

- Post hoc comes from Latin for "after the event"
- Post hoc tests assess all possible combinations of differences between groups by comparing each mean with the other
- Make adjustments to *p* value, but more conservative than Bonferroni correction

Group	$\bar{A}_1$	$\bar{A}_2$	$\bar{A}_3$	$\bar{A}_4$	$\bar{A}_5$
$\bar{A}_1$	-	-	-	-	-
$\bar{A}_2$	●	-	-	-	-
$\bar{A}_3$	●	●	-	-	-
$\bar{A}_4$	●	●	●	-	-
$\bar{A}_5$	●	●	●	●	-

WBA 2 – Q15.

- In the following image, what is the within-group variance (a.k.a error term):

A. 611.3

B. 48.8

C. 237

D. 6.77e-06

E. 11571

```
          Df Sum Sq Mean Sq F value   Pr(>F)    
Group      2   1223   611.3   12.52 6.77e-06 ***
Residuals 237  11571    48.8                    
```

The meaning of an ANOVA output

```
##               Df Sum Sq Mean Sq F value   Pr(>F)
## Group          2   1223   611.3   12.52 6.77e-06 ***
## Residuals    237  11571    48.8
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

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

$$F = \frac{611.3}{48.8}$$

$\boxed{F = 12.52}$

$\boxed{p = 0.00000677}$

WBA 2 – Q16.

- If running 4 statistical tests, what is the approximate probability of receiving a type I error?

A. 5%

B. 10%

C. 14%

D. 18.5%

E. 22.6%

The problem of multiple comparisons

- Type 1 error - 1 test at $p \leq 0.05$ = 0.95 (i.e., 5% chance we get noise)
- Type 1 error - 2 tests = 0.95 * 0.95, = 0.903. (10% chance)
- Type 1 error - 3 tests = 0.95 * 0.95 * 0.95 = 0.857 (14% chance)
- Type 1 error – 4 tests = 0.95 * 0.95 * 0.95 * 0.95 = 0.815 (18.5% chance)
- Type 1 error – 5 tests = 0.95 * 0.95 * 0.95 * 0.95 * 0.95 = 0.774 (22.6% chance)

WBA 2 – Q20.

- Which of the following is a type of data transformation?

A. Tukey transformation.

B. The square root transformation.

C. The homogeneity transformation.

D. The outlier removal.

E. The post hoc transformation.

Dealing with 'rogue' data

Transforming data

- This involves taking every score from each participant and applying a uniform mathematical function to each
- Report both the original data and the transformed data

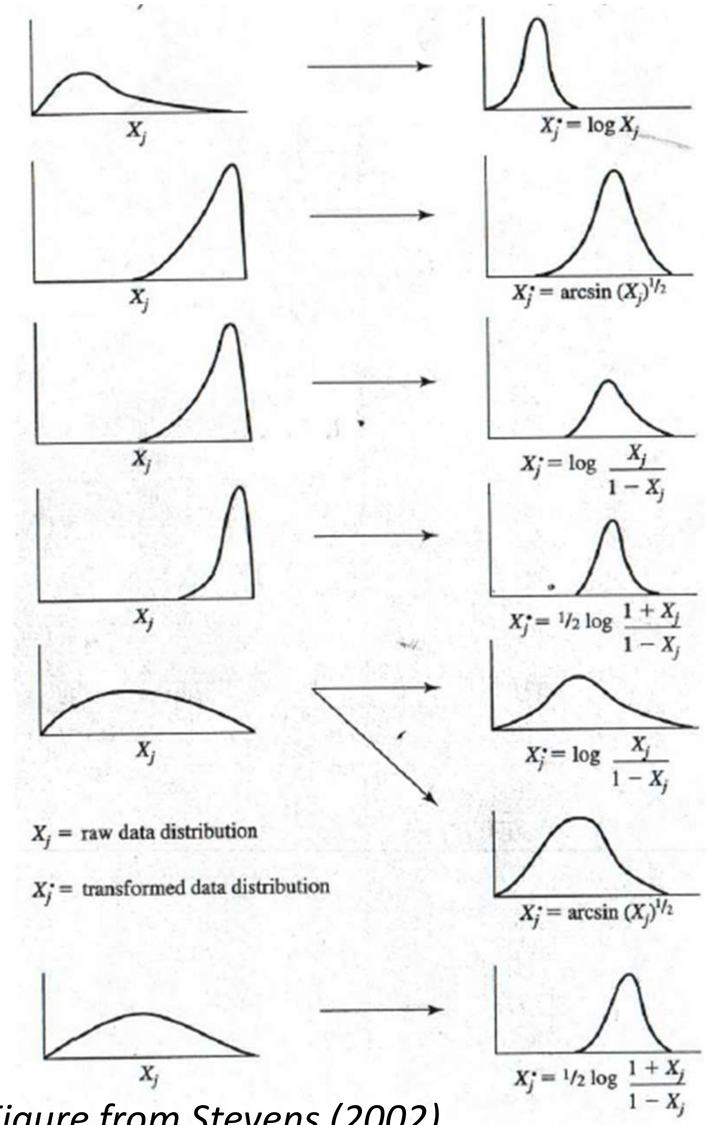

Figure from Stevens (2002)

Dealing with ‘rogue’ data

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How to transform data

Untransformed	Square-root transformed	Log transformed
38	6.164	1.580
1	1.000	0.000
13	3.606	1.114
2	1.414	0.301
13	3.606	1.114
20	4.472	1.301
50	7.071	1.699
9	3.000	0.954
28	5.292	1.447
6	2.449	0.778
4	2.000	0.602
43	6.557	1.633

http://www.biostathandbook.com/transformation.html

Type of Data Transformation	Nature of Data
Log Transformation $(\log(X_i))$	Whole numbers and cover wide range of values, small values with decimal fractions.
Square-root Transformation $(\sqrt{X_i})$	Small whole number & Percentage data where the range is between 0 and 30 % or between 70 and 100 %

Maidapwad & Sananse (2014)

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WBA 3 – Q2.

- Differences among participants in overall performance constitute a source of error for

A. A participant

B. A within-participant design

C. A between-participant design

D. Independent groups

E. Random designs

Within-participants F ratio

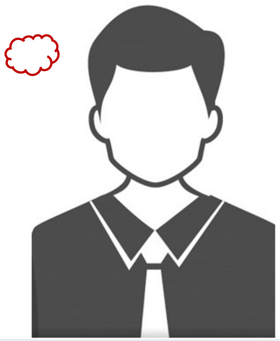
$$F = \frac{\text{between-group variance}}{\text{within-group variance}}$$

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

We calculate the F ratio the same as for the between participants design, with the exception that we are not interested in how participants vary from one another!

We therefore include an additional step to remove the between-participant variability (we spoke of before) from the error term.

We remove the between-participant variability from the within-group variability – leaving only random errors behind – a.k.a., the residual variability



WBA 3 – Q9.

- What is needed to calculate the between-group variance?

A. $SS_{BETWEEN}$ and the $df_{BETWEEN}$

B. $SS_{RESIDUAL}$ and the $df_{BETWEEN}$

C. $SS_{BETWEEN}$ and the $df_{RESIDUAL}$

D. $SS_{RESIDUAL}$ and the $df_{RESIDUAL}$

E. $SS_{BETWEEN}$ and the ΣY^2

What we'll need for the ANOVA

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

$$\text{between-group variance} = \frac{SS_{BETWEEN}}{df_{BETWEEN}} = \frac{47.18}{2} = 23.59$$

a – 1 [i.e., number of levels – 1]

WBA 3 – Q13.

- **Low** between-participant variability means:

A. our participants‘ means are similar

B. our participants‘ means are very different

C. the trends and direction of participant scores are consistent

D. the trends and direction of participant scores are inconsistent

E. the variability within a participant is volatile

Between-participant variability

Table 5. Burgers consumed before (A_1) and after (A_2) Cowspiracy

	A_1	A_2	ΔA	*P Mean*
P_1	5	3	-2	*4*
P_2	9	7	-2	*8*
P_3	3	1	-2	*2*
P_4	7	5	-2	*6*
P_5	4	6	2	*5*
A Mean	5.6	4.4		*5*

High between-participant variability

The extent to which participants, on average, differ from another regardless of their stage of the experiment

- In this example, there is wider variability between participant means.

Between-participant variability

The extent to which participants, on average, differ from another regardless of their stage of the experiment

- In this example, there is zero variability between participant means.
- Zero differences = zero variance.

Low between-participant variability

Table 6. Burgers consumed before (A_1) and after (A_2) Cowspiracy

	A_1	A_2	ΔA	*P Mean*
P_1	9	1	-8	*5*
P_2	5	5	0	*5*
P_3	4	6	2	*5*
P_4	6	4	-2	*5*
P_5	4	6	2	*5*
A Mean	5.6	4.4		*5*

WBA 3 – Q15.

- In virtually all within-participants studies, we:

A. would be predominately interested in between-participant differences

B. would hypothesise the amount of change a participant would experience

C. would hypothesise that a score at one time would significantly differ from a score at another

D. would control for all extraneous variables

E. would expect that we would violate the majority of data assumptions

Within-participants F ratio

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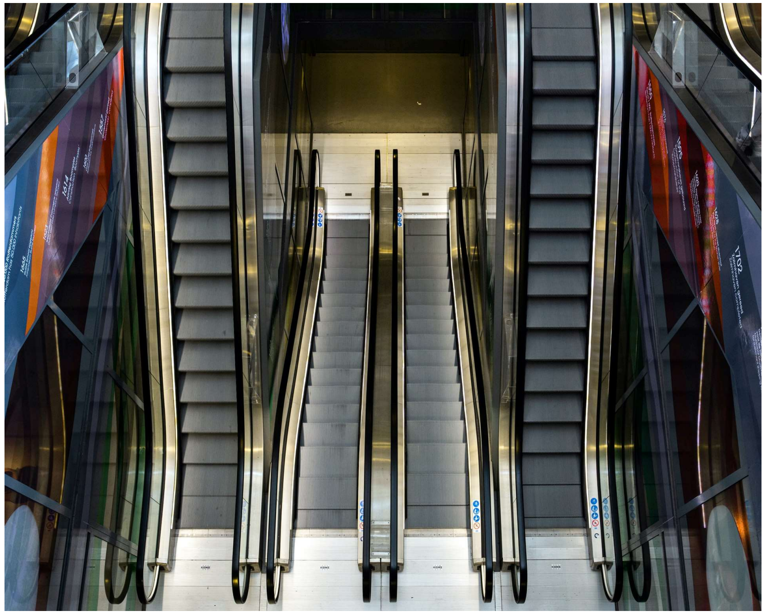
Ways in which people can differ:

- Overall level of performance/score
- Trends in their scores (↗ ↘ →)
- Both!



One factor within-participants ANOVA

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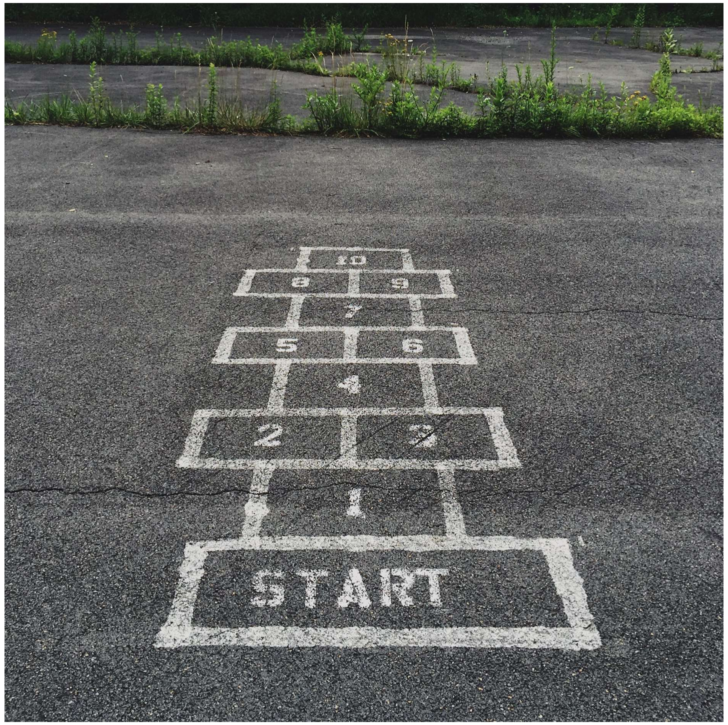
Between-participant variability vs Residual variance

- In virtually all within-participant studies, we hypothesise that a score at one time would significantly differ from at another time.
- Less interested in the actual change in scores and not interested in between participant differences.
- As such, we are more interested in the residual variance than the between participant variability.



WBA 3 – Q19.

- What is removed from our F ratio when calculating a within-participants F statistic?

A. The *p* value

B. The individual differences

C. The group differences

D. The error term

E. The signal to noise ratio

Between-participants F ratio

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

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

individual differences + random (residual) errors

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

Within-participants F ratio

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

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

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