Two-Factor Between-Participants Designs

PSYC214: Statistics For Group Comparisons

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Week 7

2 × 2 Factorial Design
Structure
Main Effects
Simple Main Effects
Analysis a 2 × 2 Design
Data
Basic Ratios
SS WITHIN, BETWEEN, & TOTAL
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SS Interaction
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ANOVA Table
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Between-Group SS & DF
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Learning Objectives

- How to calculate F ratios for two-factor between-participants designs
- How to calculate simple main effects, if the interaction is significant

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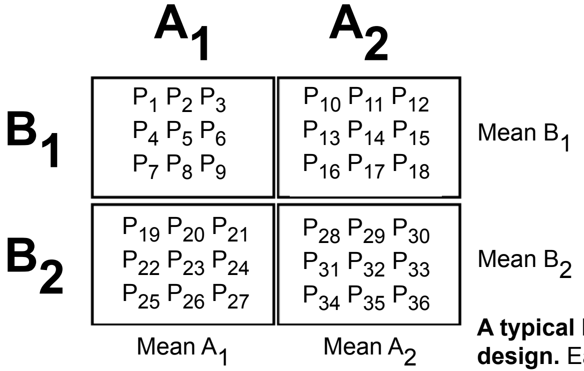
Two-Factor Between-Participants Designs

- The simplest two-factor between-participants design is a 2 $\times$ 2 factorial design:
  - there are two factors, each with two levels, yielding a total of four cells or conditions
  - each participant contributes a single score to one condition only
- We can ask whether either of the **main effects** is significant
- We can also ask whether the **interaction** is significant
  - an interaction is interpreted in terms of the **simple main effects**

A Typical Between-Participants 2 × 2 Design



A typical between-participants 2x2 design. Each participant only performs one of the four possible combinations of conditions

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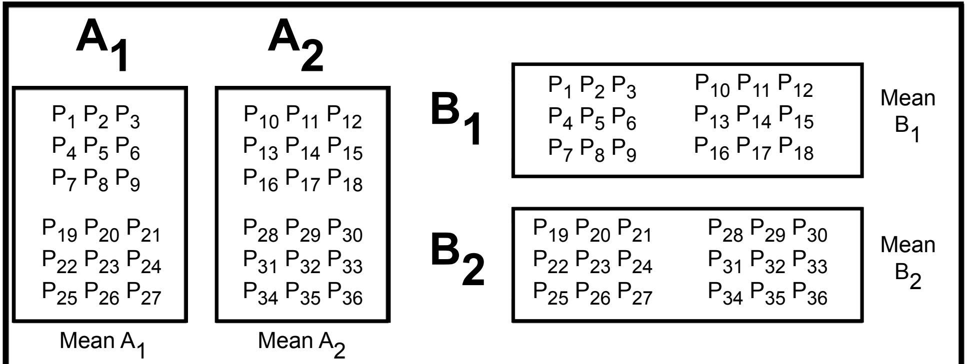
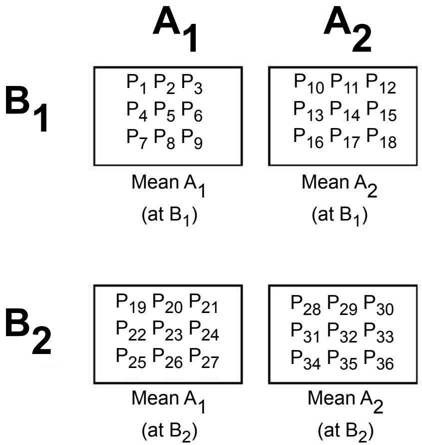
Main Effects



Main effect of A: Is the difference between means of A_1 and A_2 significant (ignoring factor B)?

Main effect of B: Is the difference between means of B_1 and B_2 significant (ignoring factor A)?

Simple Main Effects of Factor A



Simple main effect of A at B_1:
Is the difference between means of A_1 and A_2 significant at B_1 of factor B?

Simple main effect of A at B_2:
Is the difference between means of A_1 and A_2 significant at B_2 of factor B?

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Simple Main Effects of Factor B

	A_1		A_2	
B_1	P_1 P_2 P_3 P_4 P_5 P_6 P_7 P_8 P_9	Mean B_1 (at A_1)	P_{10} P_{11} P_{12} P_{13} P_{14} P_{15} P_{16} P_{17} P_{18}	Mean B_1 (at A_2)
B_2	P_{19} P_{20} P_{21} P_{22} P_{23} P_{24} P_{25} P_{26} P_{27}	Mean B_2 (at A_1)	P_{28} P_{29} P_{30} P_{31} P_{32} P_{33} P_{34} P_{35} P_{36}	Mean B_2 (at A_2)

Simple main effect of B at A_1: Is the difference between means of B_1 and B_2 significant at A_1 of factor A?

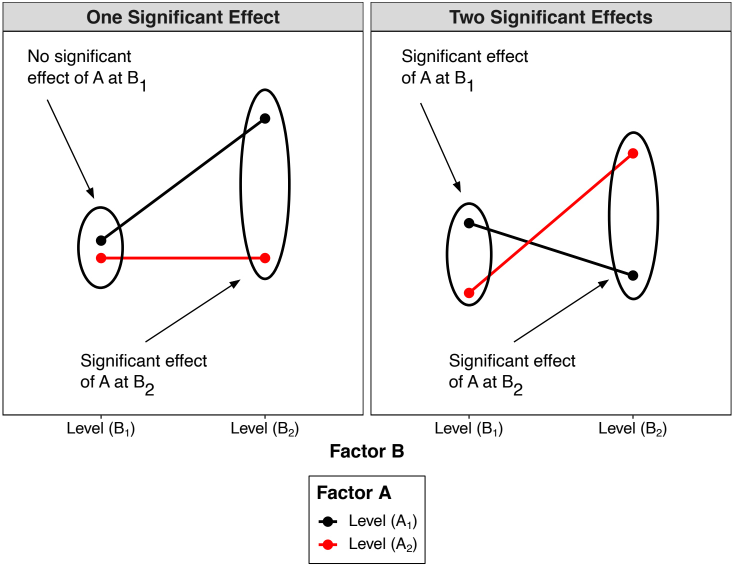
Simple main effect of B at A_2: Is the difference between means of B_1 and B_2 significant at A_2 of factor A?

Simple Main Effects

- There are two ways a pair of simple main effects may differ in their trends:

  1. one of a pair has a significant difference but not the other. For example, the mean of A_1 differs from the mean of A_2 at level B_2 *but not* at level B_1
  2. both simple main effects are significant, but in the opposite direction. For example, the mean of A_1 is greater than the mean of A_2 at level B_1, but the pattern is reversed at level B_2

Simple Main Effects



Analysis a 2 × 2 Between-Participants Factorial Design

- The first stage of analysis seeks to uncover which of the two main effects and interactions are significant
- If the interaction is significant, then in a second stage we perform a simple main effects analysis
- Although a second factor has been added, the *F* ratio remains the same:

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

- As this is a between-participants design:

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

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Analysis a 2 $\times$ 2 Between-Participants Factorial Design

- The main difference is that there are now three F ratios, one for each of the three effects

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Hypothetical Data For COVID-19 Study

		Factor A: Fear	
		Level A_1	*Level A_2*
		no fear appeal	*fear appeal*
Factor B: Efficacy	Level B_1 no efficacy message	P_1 5	P_{13} 6
		P_2 4	P_{14} 4
		P_3 6	P_{15} 4
		P_4 4	P_{16} 5
		P_5 5	P_{17} 8
		P_6 6	P_{18} 3
	Level B_2 efficacy message	P_7 6	P_{19} 10
		P_8 6	P_{20} 9
		P_9 5	P_{21} 6
		P_{10} 3	P_{22} 9
		P_{11} 8	P_{23} 8
		P_{12} 3	P_{24} 7

Hypothetical Data For COVID-19 Study

		Factor A: Fear		
		Level A_1	*Level* A_2	
		no fear appeal	*fear appeal*	*Overall*
Factor B:	Level B_1 no efficacy message	5.00	5.00	5.00
Efficacy	Level B_2 efficacy message	5.17	8.17	6.67
	Overall	5.08	6.58	5.83

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Notation

$$SS_{BETWEEN} = \frac{(\sum A_1)^2 + (\sum A_2)^2}{N_A} - \frac{(\sum Y)^2}{N}$$

$$SS_{WITHIN} = \sum Y^2 - \frac{(\sum A_1)^2 + (\sum A_2)^2}{N_A}$$

$$SS_{TOTAL} = \sum Y^2 - \frac{(\sum Y)^2}{N}$$

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$$SS_{TOTAL} = \sum Y^2 - \frac{(\sum Y)^2}{N}$$

Notation

$$\frac{(\sum Y)^2}{N} \text{ is } \frac{(\text{grand total})^2}{\text{the number of scores that make up the grand total}}$$

$$\frac{(\sum A_1)^2 + (\sum A_2)^2}{N_A} \text{ is } \frac{(\text{level total of } A_1)^2 + (\text{level total of } A_2)^2}{\text{the number of scores that make up each level}}$$

$$\sum Y^2 \text{ is } \frac{(\text{score}_1)^2 + (\text{score}_2)^2 + (\text{score}_3)^2 (\text{and so on})}{1 \text{ (only one number makes up each individual score)}}$$

Basic Ratios

$$[T] : \text{basic ratio of the grand total, } \frac{(\sum Y)^2}{N}$$

$$[A] : \text{basic ratio of the level totals, } \frac{(\sum A_1)^2 + (\sum A_2)^2}{N_A}$$

$$[Y] : \text{basic ratio of the individual scores, } \sum Y^2$$

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Basic Ratios

- To compute the components of a factorial between-participants ANOVA, two additional ratios are required
- $[B]$ is the basic ratio of the level totals of factor B. If there are two levels in factor B, then $[B]$ =

$$\frac{(\text{level total of } B_1)^2 + (\text{level total of } B_2)^2}{\text{the number of scores that make up each level}} = \frac{(\sum B_1)^2 + (\sum B_2)^2}{N_B}$$

Basic Ratios

- $[AB]$ is the basic ratio of the cell totals, where a cell total is the total of all the scores in any one of the cells. For a 2 × 2 design, $[AB]$ =

$$\frac{(\text{cell total of } A_1B_1)^2 + (\text{cell total of } A_1B_2)^2 + (\text{cell total of } A_2B_1)^2 + (\text{cell total of } A_2B_2)^2}{\text{the number of scores in each cell}}$$

$$= (\sum A_1B_1)^2 + (\sum A_1B_2)^2 + (\sum A_2B_1)^2 + (\sum A_2B_2)^2$$

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Calculating Basic Ratios For The Hypothetical Data

		Factor A: Fear			
		Level A_1 no fear appeal	Level A_2 fear appeal		
Factor B Efficacy	Level B_1 no efficacy message	Total A_1B_1 = 30	Total A_2B_1 = 30	Total B_1 = 30 + 30 = 60	$[B] = \frac{60^2 + 80^2}{12} = \frac{3600 + 6400}{12} = 833.3333$
	Level B_2 efficacy message	Total A_1B_2 = 31	Total A_2B_2 = 49	Total B_2 = 31 + 49 = 80	
		Total A_1 = 30 + 31 = 61	Total A_2 = 30 + 49 = 79	$[Y] = 910$	
		$[A] = \frac{61^2 + 79^2}{12} = \frac{3721 + 6241}{12} = \frac{9962}{12} = 830.1667$		$[T] = \frac{140}{24} = \frac{19600}{24} = 816.6667$	

$$[AB] = \frac{30^2 + 30^2 + 31^2 + 49^2}{6} = \frac{900 + 900 + 961 + 2401}{6} = \frac{5162}{6} = 860.3333$$

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Calculating The Sum of Squares For The Error Term

- Within-group variance is a measure of the extent to which people within each of the groups behave differently, despite being treated alike
- For a 2 $\times$ 2 between-participants design, people have been treated exactly alike *only* within each of the four cells
- To calculate the error term, we compute and combine the Sums of Squares and degrees of freedom using the smallest unit of identically treated participants—the four cells
- This gives a single measure of experimental error that can be used for calculating the *F*s for all the effects

Calculating The Sum of Squares For The Error Term

- We calculate the error term, SS_{WITHIN}, as follows:

$$SS_{WITHIN} = [Y] - [AB] \quad SS_{WITHIN}\text{will be designated } SS_{S/AB}$$

- This produces the error term that will be used to calculate all the *F*s
- This is the overall measure of the extent to which participants behaved differently despite being treated alike

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Between-Group Sum of Squares

- We also need to calculate the total between-group Sum of Squares for the four cells
- This is a measure of the variability due to the various experimental treatments
- It is a measure of how distant each of the four cell means is from the grand mean
- It tells us the overall extent to which the treatments caused scores to differ
- The between-group Sum of Squares is calculated as:

$$SS_{BETWEEN} = [AB] - [T] \quad SS_{BETWEEN} \text{ will be designated } SS_{AB}$$

Total Sum of Squares

- We also need to calculate the total Sum of Squares
- This is a measure of total variability for the entire data set *irrespective* of experimental treatments
- It is calculated as:

$$SS_{TOTAL} = [Y] - [T]$$

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Calculating The Sums of Squares For The Two Main Effects

- Two between-group sums of squares are required, one for each of the main effects
- Each main effect is treated as being completely independent from the other
  - e.g., when calculating the main effect of factor A, the fact participants were treated in different ways at factor B is ignored
- The Sums of Squares for the two main effects are calculated as:

$$\text{for the between-group sums of squares for factor } A,\ SS_A = [A] - [T]$$
$$\text{for the between-group sums of squares for factor } B,\ SS_B = [B] - [T]$$

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Calculating The Sums of Squares For The Two Main Effects

- To test the significance of the interaction, a final Sums of Squares is required
- This is calculated as:

$$SS_{INTERACTION}, SS_{A \times B} = [AB] - [A] - [B] + [T]$$

- This is the variability in thee group means not accounted for by the main effects
- It is the variability caused by the interaction between factor A and factor B

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Calculating The Sums of Squares Discussed So Far

Within-group Sum of Squares: $SS_{S/AB} = [Y] - [AB]$

$$= 910 - 860.3333 = 49.67$$

Total between-group Sum of Squares: $SS_{AB} = [AB] - [T]$

$$= 860.3333 - 816.6667 = 43.67$$

Total Sum of Squares: $SS_{TOTAL} = [Y] - [T]$

$$= 910 - 816.6667 = 93.33$$

Calculating The Sums of Squares Discussed So Far

Between-group Sum of Squares for factor A: $SS_A = [A] - [T]$

$$= 830.1667 - 816.667 = 13.50$$

Between-group Sum of Squares for factor B: $SS_B = [B] - [T]$

$$= 833.3333 - 816.6667 = 16.67$$

Sum of Squares for interaction: $SS_{A \times B} = [AB] - [A] - [B] + [T]$

$$= 860.3333 - 830.1667 - 833.3333 + 816.6667 = 13.50$$

Degrees of Freedom

- For the main effects:

$$df_A = (\text{number of levels in factor } A - 1) = (a - 1)$$
$$(a \text{ is the number of levels in factor } A)$$

$$df_B = (\text{number of levels in factor } B - 1) = (b - 1)$$
$$(b \text{ is the number of levels in factor } B)$$

- For the interaction:

$$df_{A \times B} = df_A \times df_B = (a - 1)(b - 1)$$

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Degrees of Freedom

- For the within-group variance (the error term):

$$df_{S/AB} = [(\text{number of cells}) \times (\text{number of scores in cell} - 1)]$$
$$= ab(s - 1)$$
$$(s \text{ is the number of scores in a cell})$$

- For the total degrees of freedom:

$$df_{TOTAL} = (\text{total number of scores } - 1) = (abs) - 1$$

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Degrees of Freedom

- The various degrees of freedom should add up so that:

$$df_{TOTAL} = df_A + df_B + df_{A \times B} + df_{S/AB}$$

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Calculating The Degrees of Freedom Discussed So Far

$$df_A = (a - 1) = 2 - 1 = 1 \text{(factor } A \text{ has two levels)}$$

$$df_B = (b - 1) = 2 - 1 = 1 \text{(factor } B \text{ has two levels)}$$

$$df_{A \times B} = (a - 1)(b - 1) = 1 \times 1 = 1$$

$$df_{S/AB} = ab(s - 1) = 2 \times 2(6 - 1) = 20 \text{ (six participants per cell)}$$

$$df_{TOTAL} = (abs) - 1 = (2 \times 2 \times 6) - 1 = 23$$

Summary ANOVA Table By Components

Source	Sum of Squares	Degrees of freedom	Mean Square	F	p
A	$[A] - [T]$	$(a - 1)$	$\frac{[A] - [T]}{(a - 1)}$	$\frac{\text{Mean Square}_A}{\text{Mean Square}_{S/AB}}$	tables
B	$[B] - [T]$	$(b - 1)$	$\frac{[B] - [T]}{(b - 1)}$	$\frac{\text{Mean Square}_B}{\text{Mean Square}_{S/AB}}$	tables
$A \times B$	$[AB] - [A] - [B] + [T]$	$(a - 1)(b - 1)$	$\frac{[AB] - [A] - [B] + [T]}{(a - 1)(b - 1)}$	$\frac{\text{Mean Square}_{A \times B}}{\text{Mean Square}_{S/AB}}$	tables
S/AB	$[Y] - [AB]$	$ab(s - 1)$	$\frac{[Y] - [AB]}{ab(s - 1)}$		
TOTAL	$[Y] - [T]$	$(abs) - 1$			

ANOVA Table For Hypothetical Data

Source	Sum of Squares	Degrees of Freedom	Mean Square	*F*	*P*
A	13.50	1			
B	16.67	1			
$A \times B$	13.50	1			
S/AB	49.67	20			
TOTAL	93.33	23			

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ANOVA Table For Hypothetical Data

Source	Sum of Squares	Degrees of Freedom	Mean Square	F	P
A	13.50	1	13.50		
B	16.67	1	16.67		
$A \times B$	13.50	1	13.50		
S/AB	49.67	20	2.48		
$TOTAL$	93.33	23	4.06		

ANOVA Table For Hypothetical Data

Source	Sum of Squares	Degrees of Freedom	Mean Square	*F*	*P*
A	13.50	1	13.50	5.44	
B	16.67	1	16.67	6.72	
$A \times B$	13.50	1	13.50	5.44	
S/AB	49.67	20	2.48		
TOTAL	93.33	23	4.06		

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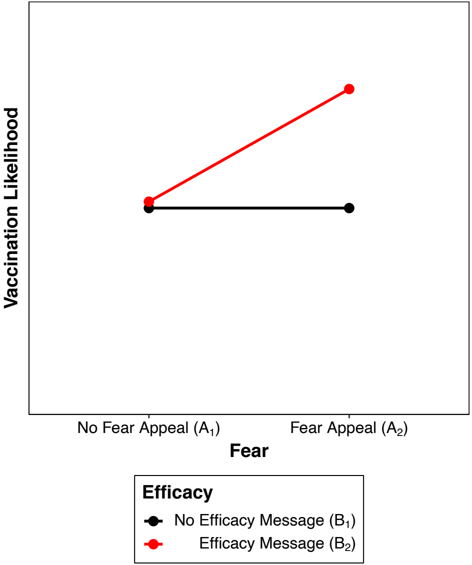
ANOVA Table For Hypothetical Data

Source	Sum of Squares	Degrees of Freedom	Mean Square	F	P
A	13.50	1	13.50	5.44	$< .05$
B	16.67	1	16.67	6.72	$< .05$
$A \times B$	13.50	1	13.50	5.44	$< .05$
S/AB	49.67	20	2.48		
$TOTAL$	93.33	23	4.06		

ANOVA Table For Hypothetical Data

Source	Sum of Squares	Degrees of Freedom	Mean Square	F	P
A	13.50	1	13.50	5.44	$< .05$
B	16.67	1	16.67	6.72	$< .05$
$A \times B$	13.50	1	13.50	5.44	$< .05$
S/AB	49.67	20	2.48		
$TOTAL$	93.33	23	4.06		

Interaction Plot



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Simple Main Effects

- If the interaction is significant, then we interpret it by analysing the simple main effects
- In a 2 $\times$ 2 design, these are simply pairwise comparisons, analogous to using four t-tests
- This involves calculating the between-group variance for each simple main effect, before dividing each variance by the error term (S/AB) from the original ANOVA
- Thus, the significance of the simple main effects is evaluated using the same error term used to test the significance of the main effects and interaction

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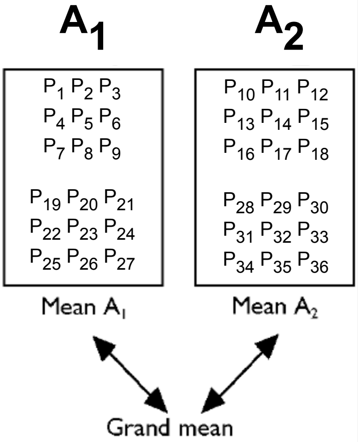
Simple Main Effects

Main effect of A: To find out whether the main effect of A is significant, calculate the between-group variance of the means of A_1 and A_2 in relation to the grand mean (ignoring factor B). The bigger thee variance, the bigger the difference between thee means and the more likely that the difference is significant.



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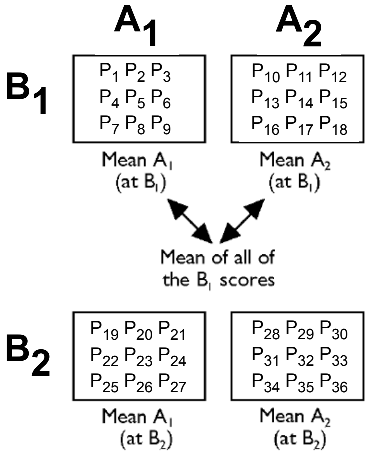
Simple Main Effects



Simple main effect of A at B_1: To find out whether this simple main effect is significant, calculate the between-group variance for means A_1 and A_2 in relation to the overall mean of all the B_1 scores. The bigger the variance, the bigger the difference between the means and the more likely that the difference is significant.

Ignore B_2 when testing the significance of the simple main effect of A at B_1

Calculating Between-Group Sum of Squares

- The formula for calculating a between-group Sum of Squares is the basic ratio of the group totals of interest, minus the basic ratio of the total of these totals [T]
- For example, the formula for calculating the between-group variance for the main effect of factor A is [A] - [T]
- The basic ratios used to calculate the between-group variances for the simple main effects are analogous to these

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Calculating Between-Group Sum of Squares

- For example:

- $[A_{B_1}]$ is the basic ratio of factor A, but *only* for the B_1 scores: square the total for A_1B_1, square the total for A_2B_1, add the squares together and divide by the number of scores that make up each cell.

- $[T_{B_1}]$ is the basic ratio of the total of the scores at level B_1 of factor B: take the total of all the scores in level B_1 and square the total, divide the square by the number of scores making up this total.

- *Eight basic ratios are required to test the four simple main effects ...*

Calculating Between-Group Sum of Squares

Sum of Squares between groups of factor A at level B_1 ($SS_{A\ at\ B_1}$) :

$$[A_{B_1}] - [T_{B_1}]$$

Sum of Squares between groups of factor A at level B_2 ($SS_{A\ at\ B_2}$) :

$$[A_{B_2}] - [T_{B_2}]$$

Sum of Squares between groups of factor B at level A_1 ($SS_{B\ at\ A_1}$) :

$$[B_{A_1}] - [T_{A_1}]$$

Sum of Squares between groups of factor B at level A_2 ($SS_{B\ at\ A_2}$) :

$$[B_{A_2}] - [T_{A_2}]$$

Calculating Between-Group Degrees Of Freedom

- All degrees of freedom are equal to the number of ([number of levels in each simple main effect]) - 1
- For the two simple main effects of *A*, the degrees of freedom are given by (a - 1), where a is the number of levels in factor *A*
- For the two simple main effects of *B*, the degrees of freedom are given by (b - 1), where b is the number of levels in factor *B*

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Calculating Between-Group Sum of Squares

		Factor A: Fear		
		Level A_1 no fear appeal	Level A_2 fear appeal	
Factor B Efficacy	Level B_1 no efficacy message	Total A_1B_1 = 30	Total A_2B_1 = 30	Total B_1 = 30 + 30 = 60
	Level B_2 efficacy message	Total A_1B_2 = 31	Total A_2B_2 = 49	Total B_2 = 31 + 49 = 80
		Total A_1 = 30 + 31 = 61	Total A_2 = 30 + 49 = 79	

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Calculating Between-Group Sum of Squares

- Fear (no fear appeal *vs.* fear appeal) for no efficacy message (A at B_1)

$$[A_{B_1}] = \frac{30^2 + 30^2}{6} = 300 \;\; [T_{B_1}] = \frac{60^2}{12} = 300 \;\; [A_{B_1}] - [T_{B_1}] = 0$$

- Fear (no fear appeal *vs.* fear appeal) for efficacy message (A at B_2)

$$[A_{B_2}] = \frac{31^2 + 49^2}{6} = 560.33 \;\; [T_{B_2}] = \frac{80^2}{12} = 533.33 \;\; [A_{B_2}] - [T_{B_2}] = 27$$

Calculating Between-Group Sum of Squares

- Fear (no fear appeal *vs.* fear appeal) for no efficacy message (A at B_1)

$$[A_{B_1}] = \frac{30^2 + 30^2}{6} = 300 \quad [T_{B_1}] = \frac{60^2}{12} = 300 \quad [A_{B_1}] - [T_{B_1}] = 0$$

- Fear (no fear appeal *vs.* fear appeal) for efficacy message (A at B_2)

$$[A_{B_2}] = \frac{31^2 + 49^2}{6} = 560.33 \quad [T_{B_2}] = \frac{80^2}{12} = 533.33 \quad [A_{B_2}] - [T_{B_2}] = 27$$

Calculating Between-Group Sum of Squares

		Factor A: Fear		
		Level A_1 no fear appeal	Level A_2 fear appeal	
Factor B Efficacy	Level B_1 no efficacy message	Total A_1B_1 = 30	Total A_2B_1 = 30	Total B_1 = 30 + 30 = 60
	Level B_2 efficacy message	Total A_1B_2 = 31	Total A_2B_2 = 49	Total B_2 = 31 + 49 = 80
		Total A_1 = 30 + 31 = 61	Total A_2 = 30 + 49 = 79	

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Calculating Between-Group Sum of Squares

- Fear (no fear appeal *vs.* fear appeal) for no efficacy message (A at B_1)

$$[A_{B_1}] = \frac{30^2 + 30^2}{6} = 300 \quad [T_{B_1}] = \frac{60^2}{12} = 300 \quad [A_{B_1}] - [T_{B_1}] = 0$$

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$$[A_{B_2}] = \frac{31^2 + 49^2}{6} = 560.33 \quad [T_{B_2}] = \frac{80^2}{12} = 533.33 \quad [A_{B_2}] - [T_{B_2}] = 27$$

Calculating Between-Group Sum of Squares

		Factor A: Fear		
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Factor B Efficacy	Level B_1 no efficacy message	Total A_1B_1 = 30	Total A_2B_1 = 30	Total B_1 = 30 + 30 = 60
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		Total A_1 = 30 + 31 = 61	Total A_2 = 30 + 49 = 79	

Calculating Between-Group Sum of Squares

- Fear (no fear appeal *vs.* fear appeal) for no efficacy message (A at B_1)

$$[A_{B_1}] = \frac{30^2 + 30^2}{6} = 300 \quad [T_{B_1}] = \frac{60^2}{12} = 300 \quad [A_{B_1}] - [T_{B_1}] = 0$$

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$$[A_{B_2}] = \frac{31^2 + 49^2}{6} = 560.33 \quad [T_{B_2}] = \frac{80^2}{12} = 533.33 \quad [A_{B_2}] - [T_{B_2}] = 27$$

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Calculating Between-Group Sum of Squares

- Efficacy (no efficacy message *vs.* efficacy message) for no fear appeal (B at A_1)

$$[B_{A_1}] = \frac{30^2 + 31^2}{6} = 310.17 \;\; [T_{A_1}] = \frac{61^2}{12} = 310.08 \;\; [B_{A_1}] - [T_{A_1}] = .09$$

- Efficacy (no efficacy message *vs.* efficacy message) for fear appeal (B at A_2)

$$[B_{A_2}] = \frac{30^2 + 49^2}{6} = 550.17 \;\; [T_{A_2}] = \frac{79^2}{12} = 520.08 \;\; [B_{A_2}] - [T_{A_2}] = 30.09$$

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Calculating Between-Group Sum of Squares

		Factor A: Fear	
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Factor B Efficacy	Level B_1 no efficacy message	Total A_1B_1 = 30	Total A_2B_1 = 30	Total B_1 = 30 + 30 = 60
	Level B_2 efficacy message	Total A_1B_2 = 31	Total A_2B_2 = 49	Total B_2 = 31 + 49 = 80
		Total A_1 = 30 + 31 = 61	Total A_2 = 30 + 49 = 79	

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Calculating Between-Group Sum of Squares

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$$[B_{A_1}] = \frac{30^2 + 31^2}{6} = 310.17 \quad [T_{A_1}] = \frac{61^2}{12} = 310.08 \quad [B_{A_1}] - [T_{A_1}] = .09$$

- Efficacy (no efficacy message *vs.* efficacy message) for fear appeal (B at A_2)

$$[B_{A_2}] = \frac{30^2 + 49^2}{6} = 550.17 \quad [T_{A_2}] = \frac{79^2}{12} = 520.08 \quad [B_{A_2}] - [T_{A_2}] = 30.09$$

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Summary Simple Main Effects Table By Components

SOURCE	Sum of Squares	Degrees of freedom	Mean Square	F	p
A at B_1	$[A_{B_1}] - [T_{B_1}]$	$(a - 1)$	$\frac{[A_{B_1}] - [T_{B_1}]}{(a - 1)}$	$\frac{\text{Mean Square}_{A \text{ at } B_1}}{\text{Mean Square}_{S/AB}}$	tables
A at B_2	$[A_{B_2}] - [T_{B_2}]$	$(a - 1)$	$\frac{[A_{B_2}] - [T_{B_2}]}{(a - 1)}$	$\frac{\text{Mean Square}_{A \text{ at } B_2}}{\text{Mean Square}_{S/AB}}$	tables
B at A_1	$[B_{A_1}] - [T_{A_1}]$	$(b - 1)$	$\frac{[B_{A_1}] - [T_{A_1}]}{(b - 1)}$	$\frac{\text{Mean Square}_{B \text{ at } A_1}}{\text{Mean Square}_{S/AB}}$	tables
B at A_2	$[B_{A_2}] - [T_{A_2}]$	$(b - 1)$	$\frac{[B_{A_2}] - [T_{A_2}]}{(b - 1)}$	$\frac{\text{Mean Square}_{B \text{ at } A_2}}{\text{Mean Square}_{S/AB}}$	tables
S/AB	$[Y] - [AB]$	$ab(s - 1)$	$\frac{[Y] - [AB]}{ab(s - 1)}$		

Simple Main Effects Table For Hypothetical Data

Source	Sum of Squares	Degrees of Freedom	Mean Square	*F*	*P*
A at B_1	0.00	1	0.00	0.00	1.000
A at B_2	27.00	1	27.00	10.89	$< .01$
B at A_1	0.09	1	0.09	0.04	.856
B at A_2	30.09	1	30.09	12.13	$< .01$
S/AB (error)	49.67	20	2.48		

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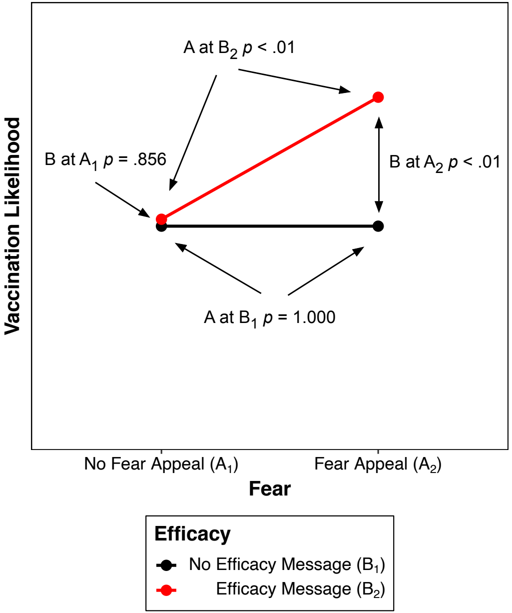

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Additional Resources

- The R code for all plots generated in this lecture (minus annotations) has been uploaded with these slides to the Week 6 lecture folder (R Plots For Lecture 7.R)

In Next Week's Lab ...

- Running a 2 $\times$ 2 (and 2 $\times$ 3) between-participants ANOVA in R
- Calculating and interpreting simple main effects

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References

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