Factorial ANOVA
(part 2)

Lecture 17

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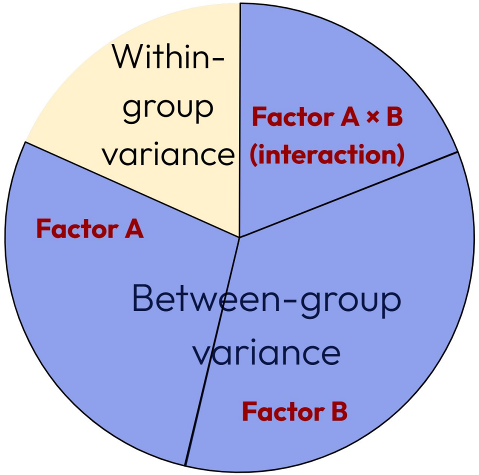
Recap: From our last class

- Factorial ANOVA (2*2, 2*3, ...)

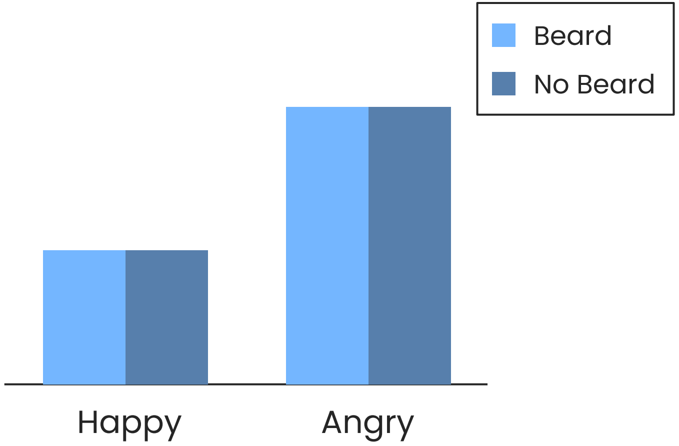
2 x 2 Design
(DV: ADHD symptoms)

		Factor A: ADHD medications	
		Stimulant	Non-Stimulant
Factor B: Heart Condition	Present	**Has heart condition** and **on stimulant**	**Has heart condition** and **not on stimulant**
	None	**No heart condition** and **on stimulant**	**No heart condition** and **not on stimulant**



Recap: Visually identify main effects & interaction

“Eyeball” Method



“Table” Method

		Factor A: Treatment		Marginal Means
		CBT	Mindful	
Factor B: Modality	In-person	30	50	**40**
	Online	40	60	**50**
Marginal Means		**35**	**55**	

Going back to our example from last class…

If you're deciding which ADHD medication to recommend, just seeing an interaction between medication type and heart condition isn't enough.

You need to statistically test if your effect is real, like what we have been doing all along with NHST.

TODAY'S PLAN

01

Key Concepts

02

Factorial ANOVA Source Table

03

Worked Example

04

Exam 2 Information & Wrap Up

Learning objectives

- **Conduct** a two-way (two-factor) ANOVA, including measures of effect size, for both main effects and the interaction.
- Complete a two-way ANOVA **source table** (when given initial numbers).
- **Report and interpret** the results of a two-way ANOVA are reported in APA style.

01

Key Concepts

Let's think with what we already know...

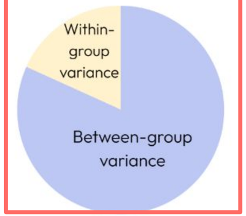
Since our goal is to statistically test whether the main effects and interactions are real, we know based on our experience so far that:

- We need some kind of **statistic** to make **decisions** with!
  - In independent and paired t-tests, we used the t-statistic
  - In one-way ANOVA, we used the F-statistic

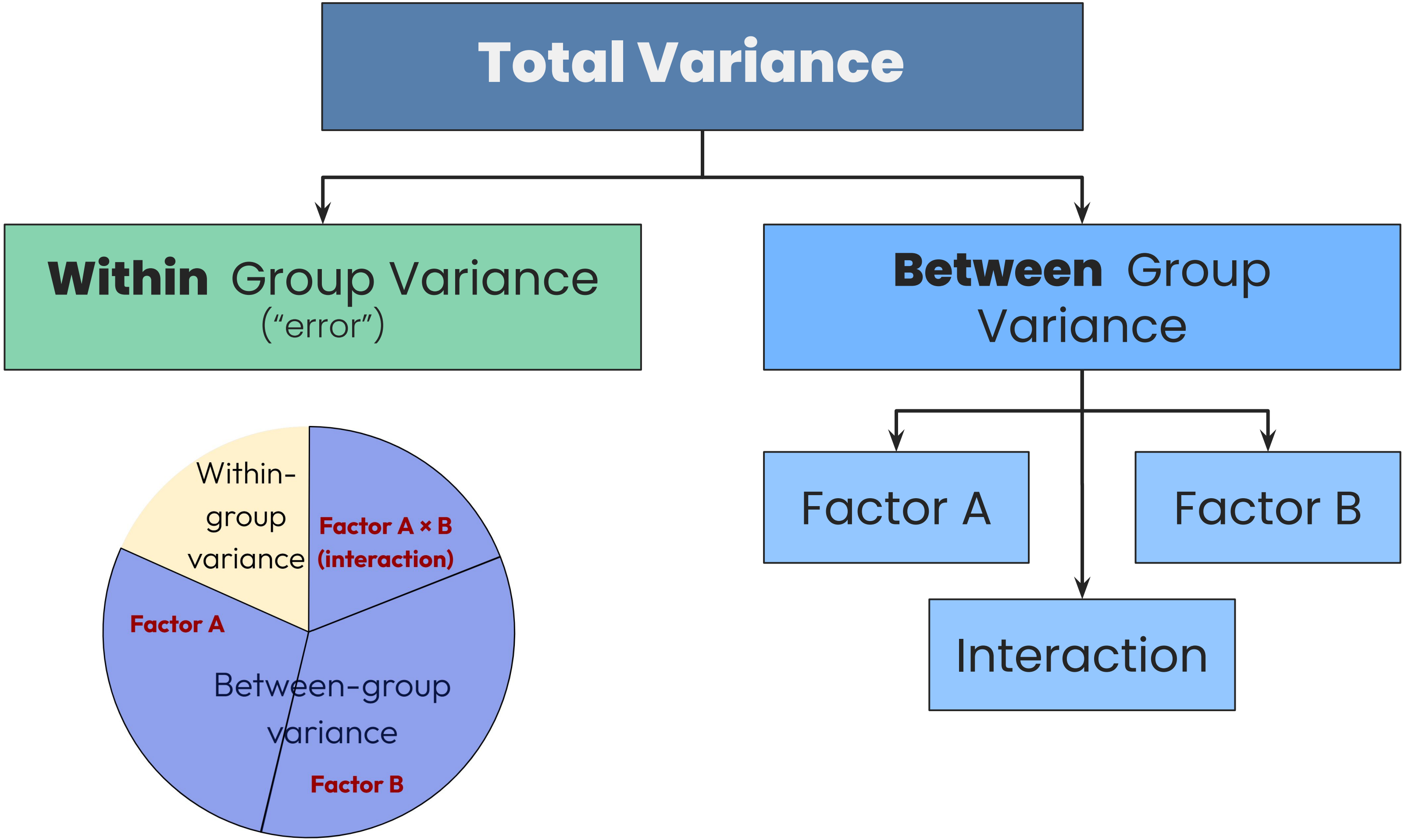
Okay, we are getting somewhere!
Since factorial ANOVA is just an extension of one-way ANOVA, we should probably still use the F-statistic

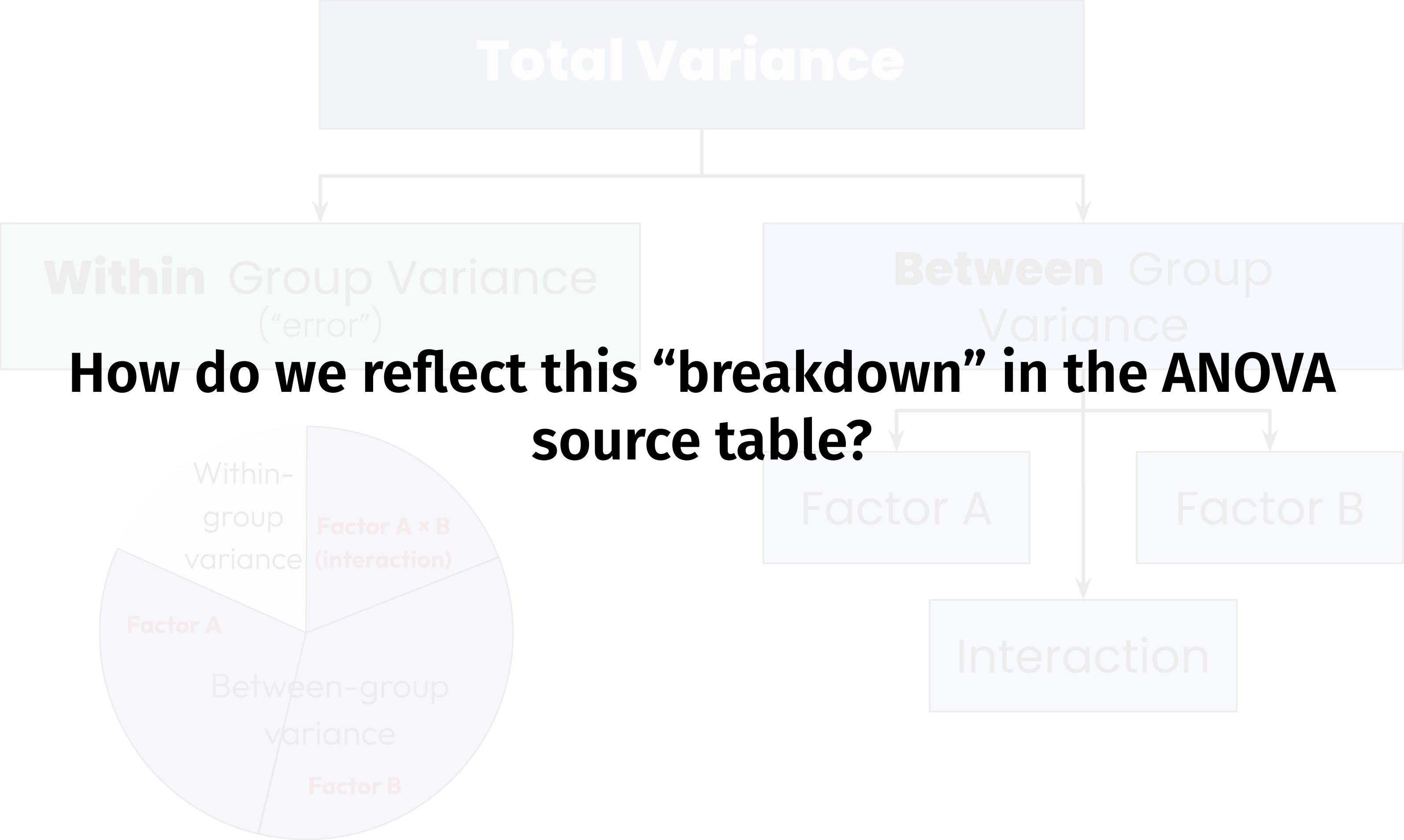
Factorial ANOVA is just an extension of One-way ANOVA

This is the one-way ANOVA source table:

Source	***SS***	***df***	***MS***	***F***
Between		**k** – 1	SS_b / df_b	MS_b / MS_w
Within		**N** – k	SS_w / df_w	
Total	SS_b + SS_w	N – 1		

These will probably change!


Total Variance
Within Group Variance
("error")
Between Group Variance
Factor A
Factor B
Interaction
Within-group variance
Factor A × B (interaction)
Factor A
Between-group variance
Factor B



How do we reflect this "breakdown" in the ANOVA source table?

Three F-Ratios

Because of between-group variance is now **split into three**, we need to calculate **three separate F-ratios**

$$F = \frac{MS_{between}}{MS_{within}}$$

MAIN EFFECT
Factor A

$$F = \frac{MS_{FactorA}}{MS_{within}}$$

MAIN EFFECT
Factor B

$$F = \frac{MS_{Factor\ B}}{MS_{within}}$$

INTERACTION
AxB

$$F = \frac{MS_{AxB}}{MS_{within}}$$

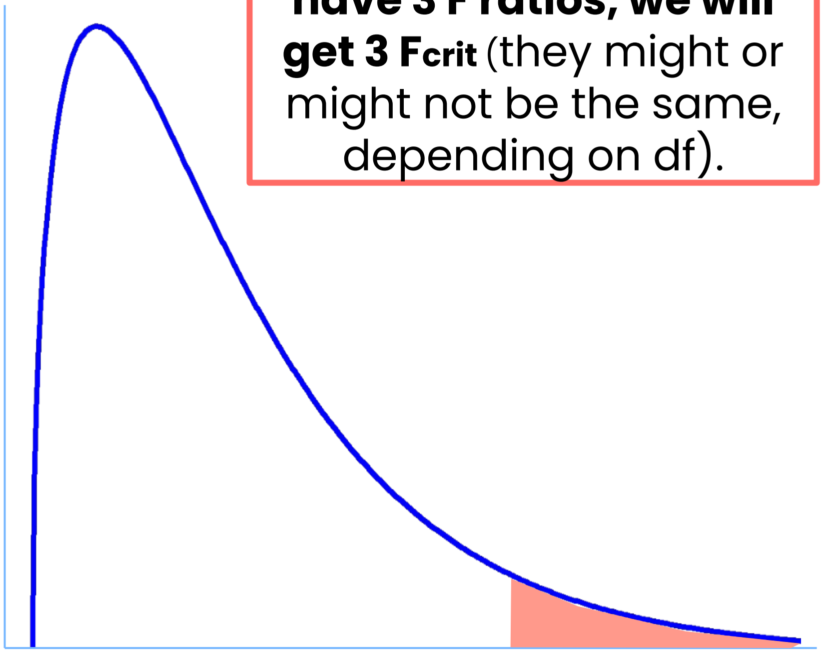
For *each* of the three F-ratios, we compare the calculated F-ratio to the F_{crit} to determine whether the main effects or interaction are "statistically significant."

This is like doing 3 separate NHST tests!
Our null: there is no effect
Our alternative: there is an effect

Use an F-Table to find your critical value (F_{CRIT})

df within (denominator)	*df* between (numerator) 1	2	3	4	5	6	7	8	9	10
1	161	200	216	225	230	234	237	239	241	242
2	18.51	19.00	19.16	19.25	19.30	19.33	19.36	19.37	19.38	19.39
3	10.13	9.55	9.28	9.12	9.01	8.94	8.88	8.84	8.81	8.78
4	7.71	6.94	6.59	6.39	6.26	6.16	6.09	6.04	6.00	5.96
5	6.61	5.79	5.41	5.19	5.05	4.95	4.88	4.82	4.78	4.74
6	5.99	5.14	4.76	4.53	4.39	4.28	4.21	4.15	4.10	4.06
7	5.59	4.74	4.35	4.12	3.97	3.87	3.79	3.73	3.68	3.63
8	5.32	4.46	4.07	3.84	3.69	3.58	3.50	3.44	3.39	3.34
9	5.12	4.26	3.86	3.63	3.48	3.37	3.29	3.23	3.18	3.13
10	4.96	4.10	3.71	3.48	3.33	3.22	3.14	3.07	3.02	2.97
11	4.84	3.98	3.59	3.36	3.20	3.09	3.01	2.95	2.90	2.86
12	4.75	3.88	3.49	3.26	3.11	3.00	2.92	2.85	2.80	2.76
13	4.67	3.80	3.41	3.18	3.02	2.92	2.84	2.77	2.72	2.67
14	4.60	3.74	3.34	3.11	2.96	2.85	2.77	2.70	2.65	2.60
15	4.54	3.68	3.29	3.06	2.90	2.79	2.70	2.64	2.59	2.55
16	4.49	3.63	3.24	3.01	2.85	2.74	2.66	2.59	2.54	2.49

Note: We use the F-table to find the F_{crit}. **Since we have 3 F ratios, we will get 3 F_{crit}** (they might or might not be the same, depending on df).



Effect Size

For a two-factor ANOVA, we compute **three** separate values for **η^2 (eta-squared)**: one measuring *the percentage of the variance explained* by 1) the main effect for factor A, 2) the main effect for factor B, and 3) the interaction.

MAIN EFFECT
Factor A

$$\eta_p^2 = \frac{SS_A}{SS_A + SS_{within}}$$

MAIN EFFECT
Factor B

$$\eta_p^2 = \frac{SS_B}{SS_B + SS_{within}}$$

INTERACTION
AxB

$$\eta_p^2 = \frac{SS_{AxB}}{SS_{AxB} + SS_{within}}$$

We call these ***partial eta-squared (η^2_p)***. There's also regular **eta-squared (η^2)**. Since reporting one is sufficient, we won't go into the calculation for η^2.

02

Factorial ANOVA Source Table

Factorial ANOVA Source Table

Source	***SS***	***df***	***MS***	***F***
Between				
→ Factor A				
→ Factor B				
→ Interaction				
Within				
Total				

*Our between group variance is now split into **3 parts***

Factorial ANOVA Source Table

Source	***SS***	***df***	***MS***	***F***
Between		$k - 1$		
→ Factor A		$k_A - 1$		
→ Factor B		$k_B - 1$		
→ Interaction (AxB)		$df_A \times df_B$		
Within		$N - k$		
Total		$N - 1$		

TIP 1: Start with **df** calculations (**k** = # of **<u>cells</u>**, **kA** = # of levels for Factor A, **kB** = # of levels for Factor B, **N** = <u>total</u> sample size)

Factorial ANOVA Source Table

Source	***SS***	***df***	***MS***	***F***
Between		$\boxed{5}$		
→ Factor A		1		
→ Factor B		2		
→ Interaction (AxB)		2		
Within		18		
Total				

TIP 2: $\mathbf{SS_{between}} = SS_A + SS_B + SS_{AxB}$

$\mathbf{df_{between}} = df_A + df_B + df_{AxB}$

Factorial ANOVA Source Table

Source	***SS***	***df***	***MS***	***F***
Between	**120**	**5**		
→ Factor A	70	1		
→ Factor B	40	2		
→ Interaction (AxB)	10	2		
Within		18		
Total				

TIP 2:
$\mathbf{SS_{between}} = SS_A + SS_B + SS_{AxB}$
$\mathbf{df_{between}} = df_A + df_B + df_{AxB}$

Factorial ANOVA Source Table

Source	SS	df	MS	F
Between	120	5		
→ Factor A	70	1		
→ Factor B	40	2		
→ Interaction (AxB)	10	2		
Within	180	18		
Total	**300**	**23**		

TIP 3: $SS_{total} = SS_{beween} + SS_{within}$

$df_{total} = df_{beween} + df_{within}$

Factorial ANOVA Source Table

Source	***SS***	***df***	***MS***	***F***
Between	120	5		
→ Factor A	70 ÷	1		
→ Factor B	40 ÷	2		
→ Interaction (AxB)	10 ÷	2		
Within	180 ÷	18		
Total				

TIP 4: **Divide across** to get your four MS values.

Factorial ANOVA Source Table

Source	***SS***	***df***	***MS***	***F***
Between	120	5		
→ Factor A	70	1	**70**	
→ Factor B	40	2	**20**	
→ Interaction (AxB)	10	2	**5**	
Within	180	18	**10**	
Total				

TIP 4: Divide across to get your four MS values.

Factorial ANOVA Source Table

Source	***SS***	***df***	***MS***	***F***
Between	120	5		
→ Factor A	70	1	**70**	?
→ Factor B	40	2	**20**	?
→ Interaction (AxB)	10	2	**5**	?
Within	180	18	**10**	
Total				

TIP 4: Divide across to get your four MS values.

Factorial ANOVA Source Table

Source	SS	df	MS	F
Between	120	5		
→ Factor A	70	1	**70**	
→ Factor B	40	2	**20**	
→ Interaction (AxB)	10	2	**5**	
Within	180	18	**10**	
Total				

MS_A/MS_B/MS_{AxB} are your 3 **numerators**

MS_{within} is your **denominator**

TIP 5: Divide **MS_A**, **MS_B**, and **MS_{AxB}** by **MS_{within}** (three calculations)

Factorial ANOVA Source Table

Source	***SS***	***df***	***MS***	***F***
Between	120	5		
→ Factor A	70	1	70	**7**
→ Factor B	40	2	20	**2**
→ Interaction (AxB)	10	2	5	**0.5**
Within	180	18	10	
Total				

TIP 5: Divide $\mathbf{MS_{A}}$, $\mathbf{MS_{B}}$, and $\mathbf{MS_{AxB}}$ by $\mathbf{MS_{within}}$ (three calculations)

Practice: **Factorial ANOVA**

Source	***SS***	***df***	***MS***	***F***
Between	75	3		
→ Factor A	50	1		
→ Factor B	20	1		
→ Interaction				
Within	500	100		
Total				

Practice: **Factorial ANOVA**

Source	***SS***	***df***	***MS***	***F***
Between	75	3		
→ Factor A	50	1	**50**	**10**
→ Factor B	20	1	**20**	**4**
→ Interaction	**5**	**1**	**5**	**1**
Within	500	100	**5**	
Total	**575**	**103**		

03

Worked Example

Example Problem

A psychologist wants to know if the effectiveness of learning format (video vs. podcast) depends on the age of the learner. They conduct a 2 (**Age**: Teens vs. Adults) × 2 (**Format**: Video vs. Podcast) factorial ANOVA. Their dependent variable (DV) is performance on a comprehension quiz about the material. The psychologist recruits 24 participants, evenly distributed across the 4 cells of the study design (6 participants per condition).

		Factor A: Age	
		Teens	Adults
Factor B: Format	Video	85	65
	Podcast	90	80

Worked Example

Source	***SS***	***df***	***MS***	***F***
Between				
→ Factor A (age)	25			
→ Factor B (format)	75			
→ Interaction (AxB)	40			
Within	100			
Total				

Where shall we start?

Worked Example

Source	***SS***	***df***	***MS***	***F***
Between		$k - 1$		
→ Factor A (age)	25	$k_A - 1$		
→ Factor B (format)	75	$k_B - 1$		
→ Interaction (AxB)	40	$df_A \times df_B$		
Within	100	$N - k$		
Total		$N - 1$		

Start with **df** calculations (**k** = # of **<u>cells</u>**, **k_A** = # of levels for Factor A, **k_B** = # of levels for Factor B, **N** = <u>total</u> sample size)

Worked Example

Source	SS	df	MS	F
Between		**3**		
→ Factor A (age)	25	**1**		
→ Factor B (format)	75	**1**		
→ Interaction (AxB)	40	**1**		
Within	100	**20**		
Total		**23**		

Start with **df** calculations (**k** = # of **cells**, **k_A** = # of levels for Factor A, **k_B** = # of levels for Factor B, **N** = total sample size)

Worked Example

Source	*SS*	*df*	*MS*	*F*
Between	**140**	3		
→ Factor A (age)	25	1		
→ Factor B (format)	75	1		
→ Interaction (AxB)	40	1		
Within	100	20		
Total	**240**	23		

$\mathbf{SS_{between}} = SS_A + SS_B + SS_{AxB}$

$\mathbf{SS_{between}} = 25 + 75 + 40 = \mathbf{140}$

$\mathbf{SS_{total}} = SS_{between} + SS_{within}$

$\mathbf{SS_{total}} = 140 + 100 = \mathbf{240}$

Worked Example

Source	***SS***	***df***	***MS***	***F***
Between	140	3		
→ Factor A (age)	25	1	**25**	
→ Factor B (format)	75	1	**75**	
→ Interaction (AxB)	40	1	**40**	
Within	100	20	**5**	
Total	240	23		

Divide across to get your four MS values.

Worked Example

Source	*SS*	*df*	*MS*	*F*
Between	140	3		
→ Factor A (age)	25	1	**25**	
→ Factor B (format)	75	1	**75**	
→ Interaction (AxB)	40	1	**40**	
Within	100	20	**5**	
Total	240	23		

numerators

denominator

Divide $\mathbf{MS_A}$, $\mathbf{MS_B}$, and $\mathbf{MS_{AxB}}$ by $\mathbf{MS_{within}}$ (three calculations)

Worked Example

Source	***SS***	***df***	***MS***	***F***
Between	140	3		
→ Factor A (age)	25	1	25	**5**
→ Factor B (format)	75	1	75	**15**
→ Interaction (AxB)	40	1	40	**8**
Within	100	20	5	
Total	240	23		

Worked Example

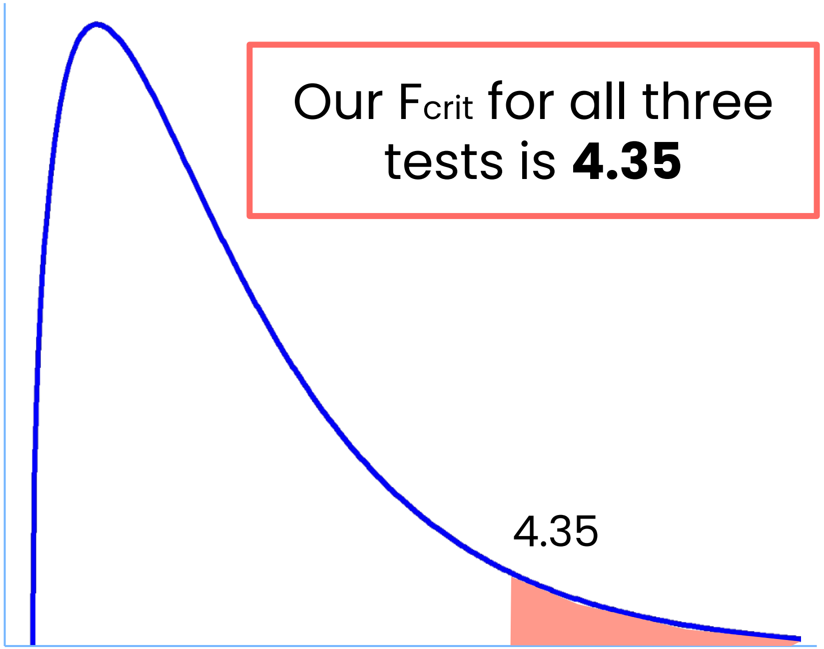
Source	*SS*	*df*	*MS*	*F*
Between	140	3		
→ Factor A (age)	25	**1**	25	5
→ Factor B (format)	75	**1**	75	15
→ Interaction (AxB)	40	**1**	40	8
Within	100	20	5	
Total	240	23		

Because df_A, df_B, df_{AxB} **all equal 1**, we will have the same F_{crit} for all three F-ratios.

F_{crit}

***df**within* (denominator)	***df**between* (numerator) 1	2	3	4	5	6	7	8	9	10
1	161	200	216	225	230	234	237	239	241	242
2	18.51	19.00	19.16	19.25	19.30	19.33	19.36	19.37	19.38	19.39
3	10.13	9.55	9.28	9.12	9.01	8.94	8.88	8.84	8.81	8.78
4	7.71	6.94	6.59	6.39	6.26	6.16	6.09	6.04	6.00	5.96
5	6.61	5.79	5.41	5.19	5.05	4.95	4.88	4.82	4.78	4.74
6	5.99	5.14	4.76	4.53	4.39	4.28	4.21	4.15	4.10	4.06
7	5.59	4.74	4.35	4.12	3.97	3.87	3.79	3.73	3.68	3.63
8	5.32	4.46	4.07	3.84	3.69	3.58	3.50	3.44	3.39	3.34
9	5.12	4.26	3.86	3.63	3.48	3.37	3.29	3.23	3.18	3.13
10	4.96	4.10	3.71	3.48	3.33	3.22	3.14	3.07	3.02	2.97
11	4.84	3.98	3.59	3.36	3.20	3.09	3.01	2.95	2.90	2.86
12	4.75	3.88	3.49	3.26	3.11	3.00	2.92	2.85	2.80	2.76
13	4.67	3.80	3.41	3.18	3.02	2.92	2.84	2.77	2.72	2.67
14	4.60	3.74	3.34	3.11	2.96	2.85	2.77	2.70	2.65	2.60
15	4.54	3.68	3.29	3.06	2.90	2.79	2.70	2.64	2.59	2.55
16	4.49	3.63	3.24	3.01	2.85	2.74	2.66	2.59	2.54	2.49
17	4.45	3.59	3.20	2.96	2.81	2.70	2.62	2.55	2.50	2.45
18	4.41	3.55	3.16	2.93	2.77	2.66	2.58	2.51	2.46	2.41
19	4.38	3.52	3.13	2.90	2.74	2.63	2.55	2.48	2.43	2.38
20	4.35	3.49	3.10	2.87	2.71	2.60	2.52	2.45	2.40	2.35

Our F_{crit} for all three tests is **4.35**



For *each* of the three F-ratios, we compare the calculated F-ratio to the F_{crit} to determine whether the main effects or interaction are “statistically significant."

Make Your Decisions

F_{crit} = **4.35**

Source	***SS***	***df***	***MS***	***F***
Between	140	3		
→ Factor A (age)	25	1	25	5
→ Factor B (format)	75	1	75	15
→ Interaction (AxB)	40	1	40	8
Within	100	20	5	
Total	240	23		

Main Effect (Factor A)
5 > 4.35
significant

Main Effect (Factor B)
15 > 4.35
significant

Interaction
8 > 4.35
significant

Effect Size

Source	*SS*	*df*	*MS*	*F*
Between	140	3		
→ Factor A (age)	25	1	25	**5**
→ Factor B (format)	75	1	75	**15**
→ Interaction (AxB)	40	1	40	**8**
Within	100	20	5	
Total	240	23		

Source	SS
Between	140
→ Factor A (age)	25
→ Factor B (format)	75
→ Interaction (AxB)	40
Within	100
Total	240

Effect Size

MAIN EFFECT
Factor A

$$\eta^2_p = \frac{SS_A}{SS_A + SS_{within}}$$

$$\eta^2_p = \frac{25}{25 + 100}$$

$$= .20$$

MAIN EFFECT
Factor B

$$\eta^2_p = \frac{SS_B}{SS_B + SS_{within}}$$

$$\eta^2_p = \frac{75}{75 + 100}$$

$$= .43$$

INTERACTION
AxB

$$\eta^2_p = \frac{SS_{AxB}}{SS_{AxB} + SS_{within}}$$

$$\eta^2_p = \frac{40}{40 + 100}$$

$$= .29$$

Interpretation Template

(example for **factor A**)

df_A df_B df_{AxB} *p*-value effect size (eta-squared)

$$F(1, 20) = 5.00, p < .05, \eta^2 = .20$$

df_{within} F-ratio α

Interpretation Template

A _ × _ factorial ANOVA was conducted to examine the effects of ***[Factor A]*** and ***[Factor B]*** on ***[DV]***.

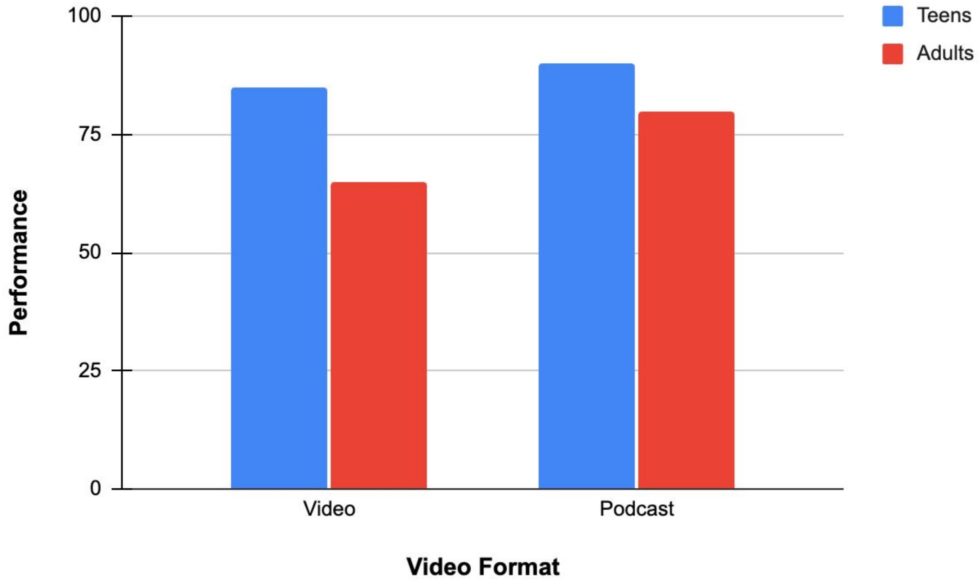
There *[was/was not]* a main effect of ***[Factor A]***, F(?, ?) = ?, p (< or >) .05 and *[was/was not]* main effect of ***[Factor B]***, F(?, ?) = ?, p (< or >) .05.

There *[was/was not]* a significant **interaction** between ***[Factor A]*** and ***[Factor B]***, F(?, ?) = ?, p (< or >) .05

Interpretation

A **2 × 2** factorial ANOVA was conducted to examine the effects of *age* and *learning format* on *comprehension scores*. There was a significant **main effect of age**, $F(1, 20) = 5.00$, $p < .05$ and a significant **main effect of format**, $F(1, 20) = 15.00$, $p < .05$. There was also a significant **interaction** between age and format, $F(1, 20) = 8.00$, $p < .05$.

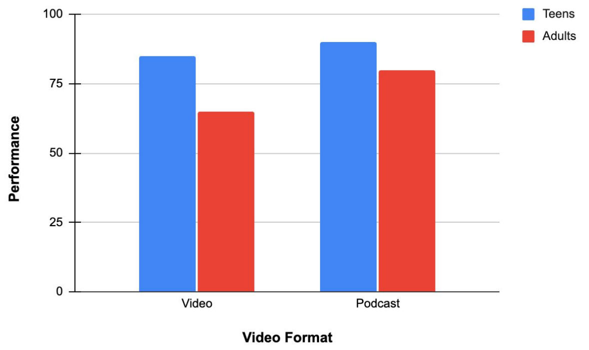
Means Plot



100
75
50
25
0
Performance
Video
Podcast
Video Format
Teens
Adults

Interpretation, plain English

<u>If</u> there is a significant interaction, you should **<u>only</u>** write a plain-English interpretation **when a means plot is provided**. Without the plot, simply report the result in APA format (as shown on the previous slide).
Interactions are tricky to interpret without visualizing them, so only interpret them when you can see the means plot.



Overall, participants performed better when listening to the podcast than when watching the video, and teens performed better than adults. However, the effect of format depended on age: teens' performance stayed about the same across formats, whereas adults performed worse when switching from podcast to video.

ICA 17

You conduct a study with a 2 x 2 factorial design examining the effect of personality (factor A) and caffeine (factor B) on mood. You split group **N = 84** participants into groups of 21 per cell/condition. (assume $\alpha = .05$)

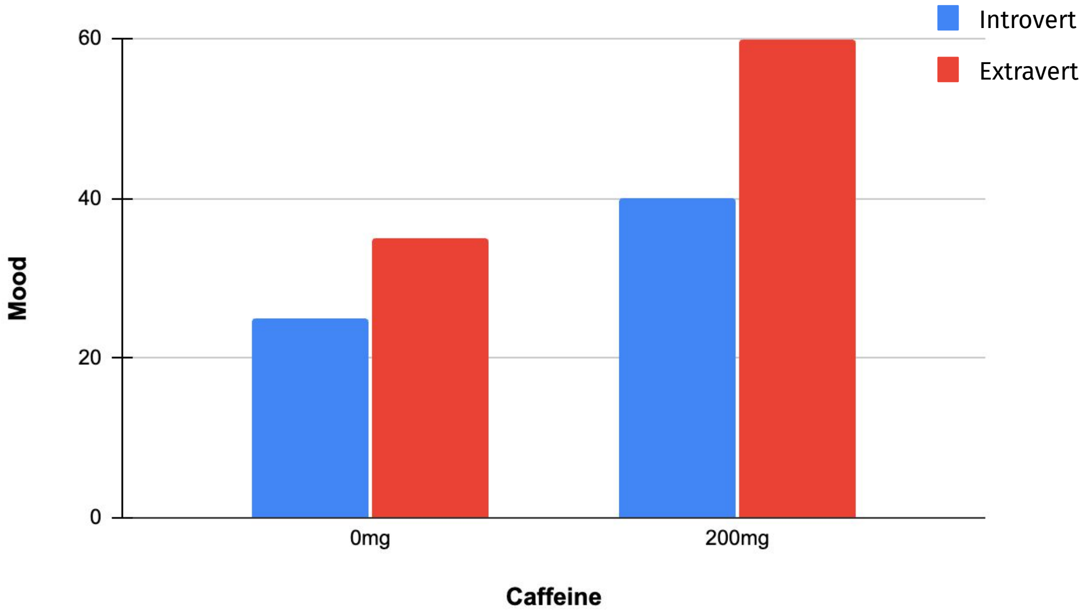
Using the formulas and the tips you learned, complete the table, calculate the effect size, and state decide whether there is a …

- **Main effect** for factor A (personality)?
- **Main effect** for factor B (caffeine)?
- **Interaction**?

		Factor A: Personality	
		Introvert	Extravert
Factor B: Caffeine	0mg	25	35
	200mg	40	60

From our group means, we also get the means plot

		Factor A: Personality	
		Introvert	Extravert
Factor B: Caffeine	0mg	25	35
	200mg	40	60



ICA 17 Source Table

Source	***SS***	***df***	***MS***	***F***
Between	100			
→ Factor A (personality)	10	1		
→ Factor B (caffeine)	50	1		
→ Interaction (AxB)				
Within	400	80		
Total		83		

***df**within*	***df**between* (numerator)									
(denominator)	1	2	3	4	5	6	7	8	9	10
1	161	200	216	225	230	234	237	239	241	242
2	18.51	19.00	19.16	19.25	19.30	19.33	19.36	19.37	19.38	19.39
3	10.13	9.55	9.28	9.12	9.01	8.94	8.88	8.84	8.81	8.78
4	7.71	6.94	6.59	6.39	6.26	6.16	6.09	6.04	6.00	5.96
5	6.61	5.79	5.41	5.19	5.05	4.95	4.88	4.82	4.78	4.74
6	5.99	5.14	4.76	4.53	4.39	4.28	4.21	4.15	4.10	4.06
7	5.59	4.74	4.35	4.12	3.97	3.87	3.79	3.73	3.68	3.63
8	5.32	4.46	4.07	3.84	3.69	3.58	3.50	3.44	3.39	3.34
9	5.12	4.26	3.86	3.63	3.48	3.37	3.29	3.23	3.18	3.13
10	4.96	4.10	3.71	3.48	3.33	3.22	3.14	3.07	3.02	2.97
11	4.84	3.98	3.59	3.36	3.20	3.09	3.01	2.95	2.90	2.86
12	4.75	3.88	3.49	3.26	3.11	3.00	2.92	2.85	2.80	2.76
13	4.67	3.80	3.41	3.18	3.02	2.92	2.84	2.77	2.72	2.67
14	4.60	3.74	3.34	3.11	2.96	2.85	2.77	2.70	2.65	2.60
15	4.54	3.68	3.29	3.06	2.90	2.79	2.70	2.64	2.59	2.55
16	4.49	3.63	3.24	3.01	2.85	2.74	2.66	2.59	2.54	2.49
17	4.45	3.59	3.20	2.96	2.81	2.70	2.62	2.55	2.50	2.45
19	4.38	3.52	3.13	2.90	2.74	2.63	2.55	2.48	2.43	2.38
21	4.32	3.47	3.07	2.84	2.68	2.57	2.49	2.42	2.37	2.32
22	4.30	3.44	3.05	2.82	2.66	2.55	2.47	2.40	2.35	2.30
23	4.28	3.42	3.03	2.80	2.64	2.53	2.45	2.38	2.32	2.28
24	4.26	3.40	3.01	2.78	2.62	2.51	2.43	2.36	2.30	2.26
25	4.24	3.38	2.99	2.76	2.60	2.49	2.41	2.34	2.28	2.24

***df**within*	***df**between* (numerator)									
(denominator)	1	2	3	4	5	6	7	8	9	10
26	4.22	3.37	2.98	2.74	2.59	2.47	2.39	2.32	2.27	2.22
27	4.21	3.35	2.96	2.73	2.57	2.46	2.37	2.30	2.25	2.20
28	4.20	3.34	2.95	2.71	2.56	2.44	2.36	2.29	2.24	2.19
29	4.18	3.33	2.93	2.70	2.54	2.43	2.35	2.28	2.22	2.18
30	4.17	3.32	2.92	2.69	2.53	2.42	2.34	2.27	2.21	2.16
32	4.15	3.30	2.90	2.67	2.51	2.40	2.32	2.25	2.19	2.14
34	4.13	3.28	2.88	2.65	2.49	2.38	2.30	2.23	2.17	2.12
36	4.11	3.26	2.86	2.63	2.48	2.36	2.28	2.21	2.15	2.10
38	4.10	3.25	2.85	2.62	2.46	2.35	2.26	2.19	2.14	2.09
40	4.08	3.23	2.84	2.61	2.45	2.34	2.25	2.18	2.12	2.07
42	4.07	3.22	2.83	2.59	2.44	2.32	2.24	2.17	2.11	2.06
44	4.06	3.21	2.82	2.58	2.43	2.31	2.23	2.16	2.10	2.05
46	4.05	3.20	2.81	2.57	2.42	2.30	2.22	2.14	2.09	2.04
48	4.04	3.19	2.80	2.56	2.41	2.30	2.21	2.14	2.08	2.03
50	4.03	3.18	2.79	2.56	2.40	2.29	2.20	2.13	2.07	2.02
60	4.00	3.15	2.76	2.52	2.37	2.25	2.17	2.10	2.04	1.99
70	3.98	3.13	2.74	2.50	2.35	2.23	2.14	2.07	2.01	1.97
80	3.96	3.11	2.72	2.48	2.33	2.21	2.12	2.05	1.99	1.95
100	3.94	3.09	2.70	2.46	2.30	2.19	2.10	2.03	1.97	1.92
200	3.89	3.04	2.65	2.41	2.26	2.14	2.05	1.98	1.92	1.87
400	3.86	3.02	2.62	2.39	2.23	2.12	2.03	1.96	1.90	1.85
1,000	3.85	3.00	2.61	2.38	2.22	2.10	2.02	1.95	1.89	1.84
∞	3.84	2.99	2.60	2.37	2.21	2.09	2.01	1.94	1.88	1.83

ICA 17 Source Table

Source	*SS*	*df*	*MS*	*F*
Between	100	3		
→ Factor A (personality)	10	1	10	2
→ Factor B (caffeine)	50	1	50	10
→ Interaction (AxB)	40	1	40	8
Within	400	80	5	
Total	500	83		

Our F_{crit} for all three tests is **3.96**

Source	SS
Between	100
→ Factor A (personality)	10
→ Factor B (caffeine)	50
→ Interaction (AxB)	40
Within	400
Total	500

Effect Size

MAIN EFFECT
Factor A

$$\eta^2_p = \frac{SS_A}{SS_A + SS_{within}}$$

$$\eta^2_p = \frac{10}{10 + 400}$$

$$= .02$$

MAIN EFFECT
Factor B

$$\eta^2_p = \frac{SS_B}{SS_B + SS_{within}}$$

$$\eta^2_p = \frac{50}{50 + 400}$$

$$= .11$$

INTERACTION
AxB

$$\eta^2_p = \frac{SS_{AxB}}{SS_{AxB} + SS_{within}}$$

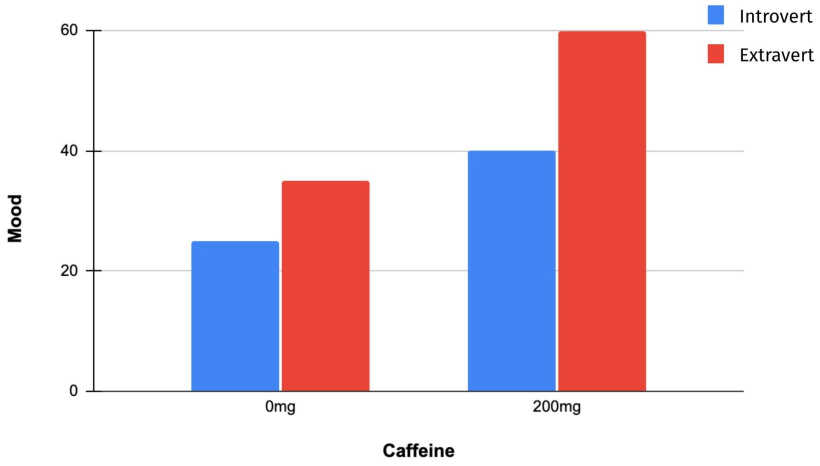
$$\eta^2_p = \frac{40}{40 + 400}$$

$$= .09$$

Interpretation

A **2 × 2** factorial ANOVA was conducted to examine the effects of *personality* and *caffeine* on *mood*. There was a significant **main effect of caffeine**, $F(1, 80) = 10.00$, $p < .05$, but no significant **main effect of personality**, $F(1, 80) = 2.00$, $p > .05$. There was a significant **interaction** between personality and mood, $F(1, 80) = 8.00$, $p < .05$.

Interpretation, plain English



Overall, participants reported better moods when they consumed caffeine, and extraverts tended to have higher moods than introverts, though the difference was not significant. However, caffeine **boosted mood more strongly** for extraverts than for introverts.

04

Exam 2 Information & Wrap Up

SOME EXAM 2 KEY TOPICS

Make sure you know these concepts well!

Independent-samples t-test

Paired-samples t-test

One-way ANOVA

2-way (factorial) ANOVA

Calculation of t-statistic &/ F-ratio

Calculation of effect size & 95% CI

Interpretation

Type 1 & Type 2 errors, Power

Between vs within subjects design & pros & cons

One-way ANOVA follow-ups

Interaction interpretation

Note: see **learning objectives** for each lecture as a "study guide"

EXAM 2 INFORMATION & FORMAT

- Exam will cover content on **lectures 9 – 17**
- Exam 2 will occur in class and will last **75 minutes**
- You are allowed **one double-sided hand-written page of notes**
- It will be mostly **short-answer questions**
- You will be given a **formula sheet** and **t-table & F-table**
- You should ***show all your work***, including formulas
- Round to **two decimal places** (e.g., 10.21, 120.43)

Bring your calculator!!!

Announcements

- Shelby is giving this Thursday's lecture!
  - She will give you lots of examples on menopause

- No lab this Friday, I will post the practice exam on Friday, you can work on it on your own, and the following Tuesday's lecture is for Q&A

- No homework this week. Focus on treating the Practice Exam as an actual exam