

# ANOVA With More Than One IV

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## 2-way ANOVA

- So far, 1-Way ANOVA, but can have 2 or more IVs. IVs aka *Factors*.
- Example: Study aids for exam
  - IV 1: workbook or not
  - IV 2: 1 cup of coffee or not

	Workbook (Factor A)	
Caffeine (Factor B)	No	Yes
Yes	Caffeine only	Both
No	Neither (Control)	Workbook only

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## Main Effects

N=30 per cell	Workbook (Factor A)		Row Means
	No	Yes	
Caffeine (Factor B)			
Yes	Caff $\bar{X}=80$ SD=5	Both $\bar{X}=85$ SD=5	82.5
No	Control $\bar{X}=75$ SD=5	Book $\bar{X}=80$ SD=5	77.5
Col Means	77.5	82.5	80

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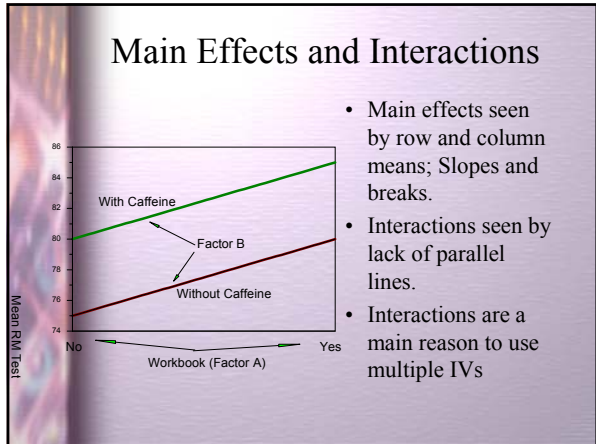
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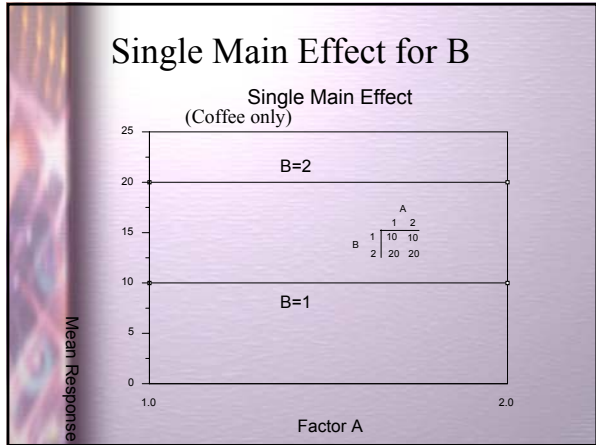
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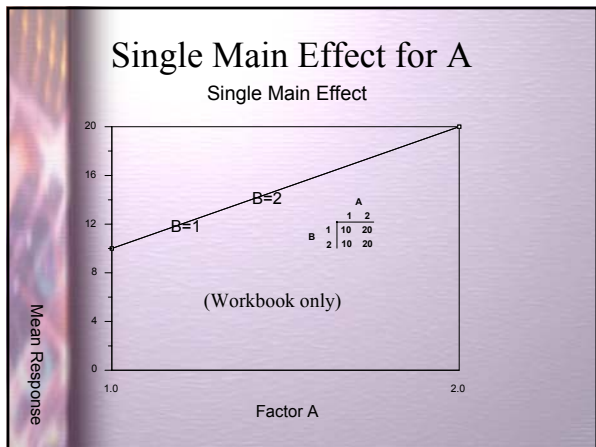
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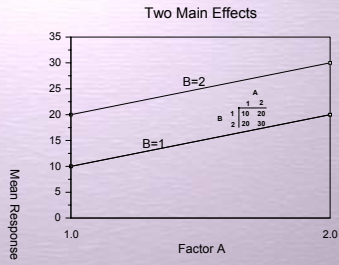
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## Two Main Effects; Both A & B

Both workbook and coffee




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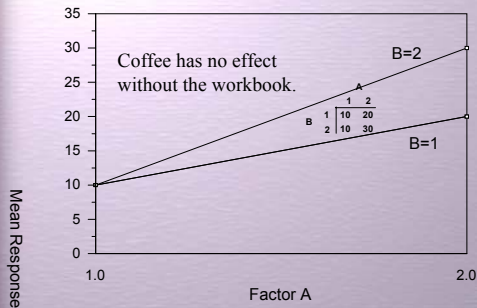
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## Interaction (1)

Interactions take many forms; all show lack of parallel lines.

Interaction 1




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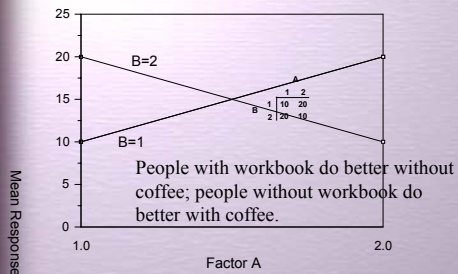
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## Interaction (2)

Interaction 2




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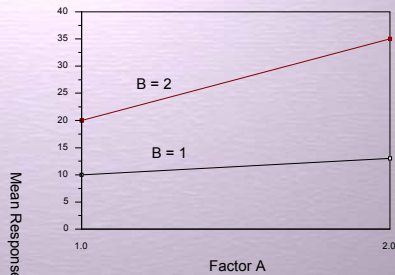
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### Interaction (3)

Coffee always helps, but it helps more if you use workbook.

Interaction 3



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### Labeling Factorial Designs

- Levels – each IV is referred to by its number of levels, e.g., 2X2, 3X2, 4X3 designs. Two by two factorial ANOVA.
- Assignment Types
  - Between – different people in each cell.
  - Within – dependent (usually same) people across all cells.
  - Mixed – same across some cells, different across other cells.

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### Example Factorial Design (1)

- Effects of fatigue and alcohol consumption on driving performance.
- Fatigue
  - Rested (8 hrs sleep then awake 4 hrs)
  - Fatigued (24 hrs no sleep)
- Alcohol consumption
  - None (control)
  - 2 beers
  - Blood alcohol .08 %

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## Cells of the Design

	Alcohol (Factor A)		
Fatigue (Factor B)	None	2 beers	.08 %
Tired	Cell 1	Cell 2	Cell 3
Rested	Cell 4	Cell 5: Rested, 2 beers, Porsche 911	Cell 6

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## Example Factorial Design (2)

- DV – performance on closed driving course rated by driving instructor.
- Possible assignments:
  - Between – 1 person/ cell
  - Within – each person all cells (have to return)
  - Mixed – between for fatigue, within for alcohol

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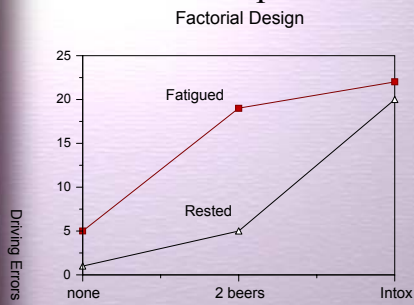


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## Factorial Example Results



*Main Effects?*  
*Interactions?*  
 Both main effects and the interaction appear significant.

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## ANOVA Summary Table

Two Factor, Between Subjects Design

Source	SS	Df	MS	F
A	$SS_A$	a-1	$SS_A/df_A$	$MS_A/MS_{Error}$
B	$SS_B$	b-1	$SS_B/df_B$	$MS_B/MS_{Error}$
AxB	$SS_{AxB}$	(a-1)(b-1)	$SS_{AxB}/df_{AxB}$	$MS_{AxB}/MS_{Error}$
Error	$SS_{Error}$	ab(n-1) or N-ab	$SS_{Error}/df_{Error}$	
Total	$SS_{Total}$	N-1		

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