Factorial Designs: Research Hypotheses & Describing Results

- Research Hypotheses of Factorial Designs
- Inspecting tables to describe factorial data patterns
- Augmenting & Interfering interaction patterns
- Interactions and other data patterns
- Interaction effects vs data patterns

Describing Factorial Results based on "Inspection"

Now that we have the basic language we will practice examining and describing main effects.

As in other designs we have looked at "an effect" as a statistically significant difference between two "things", in factorial analyses…

Main effects involve differences between marginal means.

Simple effects involve differences between cell means.

Interactions involve the differences between simple effects.

RH: for Factorial Designs

Research hypotheses for factorial designs may include

- RH: for main effects
  - involve the effects of one IV, while ignoring the other IV
  - tested by comparing the appropriate marginal means
- RH: for interactions
  - usually expressed as "different differences" -- differences between a set of simple effects
  - tested by comparing the results of the appropriate set of simple effects
  - That's the hard part -- determining which set of simple effects gives the most direct test of the interaction RH:

Sometimes the Interaction RH: is explicitly stated

- when that happens, one set of SEs will provide a direct test of the RH: (the other won't)

Here's an example:

Easy tasks will be performed equally well using paper or computer presentation, however, hard tasks will be performed better using computer presentation than paper.

Task Diff.	Presentation: Comp	Presentation: Paper
Easy	=	
Hard	<	

This is most directly tested by inspecting the simple effect of paper vs. computer presentation for easy tasks, and comparing it to the simple effect of paper vs. computer for hard tasks.

Your Turn...

Young boys will rate playing with an electronic toy higher than playing with a puzzle, whereas young girls will have no difference in ratings given to the two types of toys.

Gender	Type of Toy: Elec.	Type of Toy: Puzzle
Boys	>	
Girls	=	

Judges will rate confessions as more useful than eyewitness testimony, whereas Lawyers will rate eyewitness testimony as more useful than confessions.

Who	Type of Evidence: Confession	Type of Evidence: Witness
Judge	>	
Lawyer	<	

Sometimes the set of SEs to examine use is "inferred" ...

Often one of the IVs in the study was used in previous research, and the other is "new".

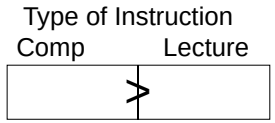
- In this case, we will usually examine the simple effect of the "old" variable, at each level of the "new" variable
- this approach gives us a clear picture of the replication and generalization of the "old" IV's effect.

e.g., Previously I demonstrated that computer presentations lead to better learning of statistical designs than does using a conventional lecture. I would like to know if the same is true for teaching writing.

Let's take this "apart" to determine which set of SEs to use to examine the pattern of the interaction...

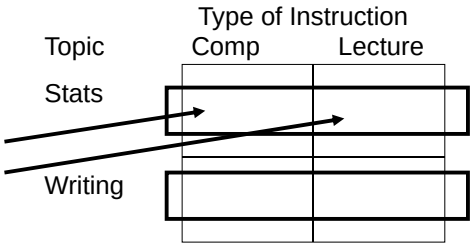
Previously I demonstrated that computer presentations lead to better learning of statistical designs than does using a conventional lecture. I would like to know if the same is true for teaching writing.

Here's the design and result of the earlier study about learning stats.



Here's the design of the study being planned.

What cells are a replication of the earlier study ?

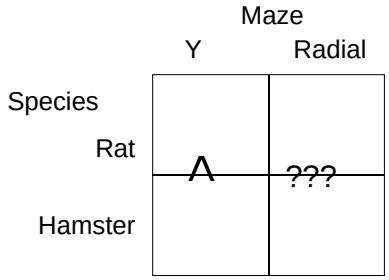


So, which set of SEs will allow us to check if we got the replication, and then go on to see of we get the same results with the new topic ?

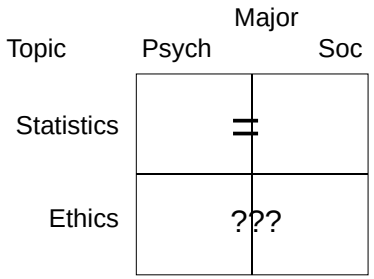
Yep, SE of Type of Instruction, for each Topic ...

Your Turn – "Draw the boxes" & use <, > or = to depict the interaction.

#1 I have previously demonstrated that rats learn Y-mazes faster than do hamsters. I wonder if the same is true for radial mazes?
(DV = time to complete maze)



SE of Species for each Type of Maze



SE of Major for each Topic

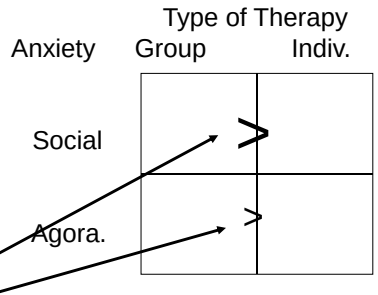
#2 I've discovered that Psyc and Soc majors learn statistics about equally well. My next research project will also compare these types of students on how well they learn research ethics.
(DV = % correct on exam)

Sometimes the RH: about the interaction and one of the main effects are "combined"

- this is particularly likely when the expected interaction pattern is of the > vs. > type

Here's an example…

Group therapy tends to work better than individual therapy, although this effect is larger for patients with social anxiety than with agoraphobia.



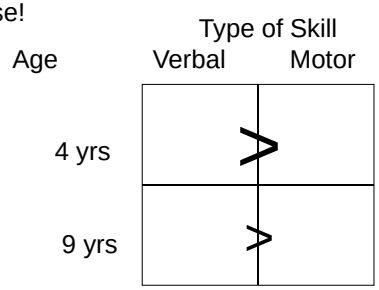
Int. RH: >

Main effect RH:

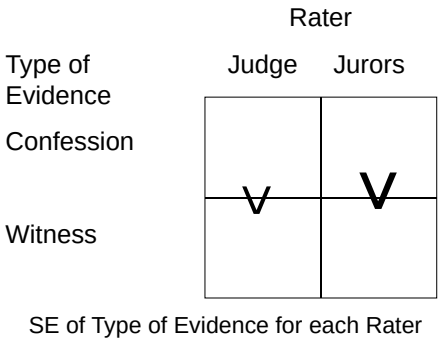
So, we would examine the interaction by looking at the SEs of Type of Therapy for each type of Anxiety.

Your Turn – “Draw the boxes” & use <, > or = to depict the interaction.
Tell which set of SEs you will use!

Young girls have better verbal skills than motor skills, however the difference gets smaller with age (DV = skill score)



SE of Skill for each gender



SE of Type of Evidence for each Rater

Confession is considered more convincing than eyewitness testimony. This preference is stronger for jurors than for judges.

DV = convincingness rating)

About the causal interpretation of effects of a factorial design…

Start by assessing the causal interpretability of each main effect

In order to causally interpret an interaction, you must be able to casually interpret BOTH main effects.

Study of Age and Gender — no casually interpretable effects (main effects nor interaction)

Study of Age and Type of Toy (RA + Manip) — only casually interpretable effect would be the main effect of Type of Toy (not the main effect of Age, nor the interaction).

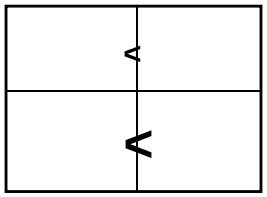
Study Type of Toy (RA + Manip) and Playing Situation (RA + manip) — all effects are causally interpreted (both main effects and the interaction).

Some Practice…

Task Presentation
Paper Computer

DV = % correct

Task Difficulty
Easy
Hard



RH: Computer presentations will work better than Paper presentations, although this effect will be greater for Hard than for Easy tasks

What sort of RH: is this ? Interaction – names 2 IVs

Which Simple Effect will you use to test it ? SE of Task Present

Use <, > & = to represent the RH: above.

Inspecting a Table to determine simple effects & interaction…

Simple Effects of Task Presentation

SE of Task Pres for EasyTasks

90 vs. 90 SE = 0

As hypothesized? No

SE of Task Pres for HardTasks

50 vs. 70 SE = 20

As hypothesized? Yes

Task Difficulty	Task Presentation: Paper	Task Presentation: Computer
Easy	90	90
Hard	50	70

Is the interaction RH supported ? Partial support

As hypothesized, there is an interaction of Task Difficulty and Task Presentation as they relate to performance. As hypothesized, for hard tasks computer presentations led to higher scores than did paper presentations, however contrary to the hypothesis, there was no difference for easy tasks.

Inspecting a Table to test Factorial RH:

DV = % correct

Task Difficulty	Task Presentation: Paper	Task Presentation: Computer
Easy	II	V
Hard		

RH: When using Computer presentations, people will perform better on Easy than on Hard tasks, however there will be no such effect when using Paper presentations.

What sort of RH: is this ? Interaction – names 2 IVs

Which Simple Effect will you use to test it ? SE of Task Diff

Use <, > & = to represent the RH: above.

Inspecting a Table to determine simple effects & interaction…

Simple Effects of Task Difficulty

SE of Task Diff for Paper Pres.

90 vs. 50 SE = 40

As hypothesized? No

SE of Task Diff for Computer Pres.

90 vs. 70 SE = 20

As hypothesized? Yes

Task Difficulty	Task Presentation: Paper	Task Presentation: Computer
Easy	90	90
Hard	50	70

Is the interaction RH supported ? Partial support

As hypothesized, there is an interaction of Task Difficulty and Task Presentation as they relate to performance. Easy tasks are consistently performed better than hard tasks, as was hypothesized for computer presentations, but contrary to the hypothesis for paper presentations

Inspecting a Table to test Factorial RH:

DV = % correct

Task Difficulty	Task Presentation: Paper	Task Presentation: Computer
Easy	<	
Hard	<	

<

RH: Computer presentations will work better than Paper presentations.

What sort of RH: is this ? Main effect of Presentation

Use <, > & = to represent the RH: above.

Use <, > & = to show the data pattern that would completely support the RH:

Inspecting a Table to determine main effects …

Task Difficulty	Task Presentation: Paper	Task Presentation: Computer
Easy	90	90
Hard	50	70
	70	80

Compute the marginal means for Task Presentation

As hypothesized ? Yes

Is ME descriptive for Easy Tasks? No

Is ME descriptive for Hard Tasks? Yes

Is ME conditional or unconditional? conditional

Is the RH: supported? Partial support

Remember, for a main effect to be fully supported, that main effect must be fully descriptive (unconditional).

As hypothesized, there was better overall performance on computer than paper tasks. However, this was not descriptive for easy tasks.

Inspecting a Table to test Factorial RH:

DV = % correct

Task Difficulty	Task Presentation: Paper	Task Presentation: Computer
Easy	V	V
Hard		

V

RH: People will perform better on Easy tasks than on Hard tasks.

What sort of RH: is this ? Main effect of Task Difficulty

Use <, > & = to represent the RH: above.

Use <, > & = to show the data pattern that would completely support the RH:

Inspecting a Table to determine main effects …

Task Difficulty	Task Presentation: Paper	Task Presentation: Computer	
Easy	90	90	90
Hard	50	70	60

Compute the marginal means for Task Difficulty

As hypothesized ? Yes

Is ME descriptive for Paper? No

Is ME descriptive for Hard Tasks? Yes

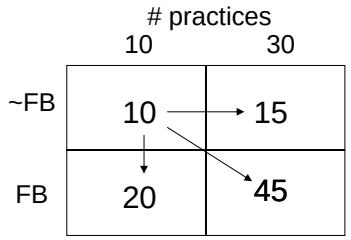
Is ME conditional or unconditional? conditional

Is the RH: supported? Partial support

As hypothesized, there was better overall performance on Easy than Difficult tasks.

A couple interaction patterns common & important enough to "have names" !

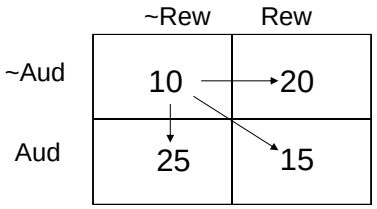
"Augmenting" Interaction



The combined effect is ***greater*** than would be expected as the additive effect!

Practice effect = 5
Feedback effect = 10
Expected additive effect = 15
Joint effect = 35

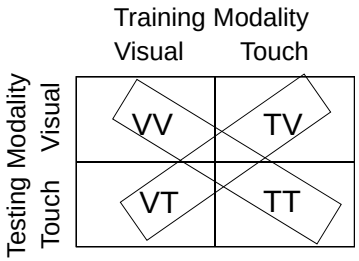
"Interfering" Interaction



The combined effect is ***less*** than would be expected as the additive effect!

Reward effect = 10
Audience effect = 15
Expected additive effect = 25
Joint effect = 5

More about data patterns… Sometimes our hypotheses aren't about patterns of simple effects, but … are about other kinds of mean difference patterns…



The IVs are "Training Modality" and "Testing Modality" leading to this 2x2 factorial design…

Among these conditions, 2 are "intramodal" (VV & TT) & 2 are "cross-modal" (VT & TV).

RH:s for the study were…
RH1: VV > TT → hypothesized dif among intramodal conditions
RH2: VT > TV → hypothesized dif among cross-modal conditions
Neither of which corresponds to a "simple effect" !

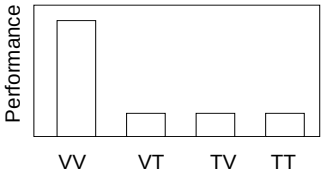
In this case there is an “organizational” solution…
Just re-label the IVs…
“Training Modality” → Vision vs. Touch &
“Testing Modality” → Intramodal vs. Cross-modal then…

Testing Modality \ Training Modality	Visual	Touch
Intra	VV	TT
Cross	VT	TV

RH1: VV > TT → SE of Training Modality for Intramodal tests
RH2: VT > TV → SE of Training Modality for Cross-modal tests

Another Example – same research area…

This was the common design for studying intra- and cross-modal memory with the usual RH: VV > VT > TV = TT



… which can be directly & completely tested using the 6 pairwise comparisons among the 4 conditions.

After several studies, someone noticed that these conditions define a factorial…

Testing Modality \ Training Modality	Visual	Touch
Visual	99.6%	24.8 %
Touch	26.2 %	25.6 %

There was an interaction!

There was a (misleading) main effect of Training Modality.

There was a (misleading) main effect of Testing Modality.

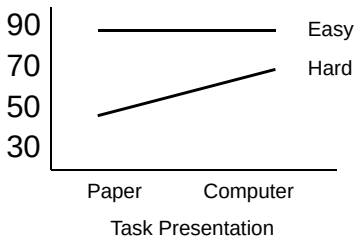
Testing Modality \ Training Modality	Visual	Touch
Visual	99.6%	24.8 %
Touch	26.2 %	25.6 %

Notice how the very large VV cell mean “drives” both main effects (while ensuring they will each be misleading) as well as driving the interaction!?!

However interesting and informative was the idea from the significant interaction, that “performance is the joint effect of Training and Testing Modalities” – none of these “simple effect tests” give a direct test of the RH:

The set of 6 pairwise comparisons gives the most direct RH test!!!

"Describing a pattern of data that includes an interaction" vs.
"Describing the Interaction in a pattern of data"



The pattern of data shown the figure demonstrate that while Task Presentation has no effect for Easy tasks, for Hard tasks, those using Computer did better than when using Paper.

This is "a description of a pattern of data that includes an interaction"

Technically, it would be **wrong** to say that "The interaction shown in the figure demonstrates that while Task Presentation has no effect for Easy tasks, for Hard tasks, those using Computer did better than when using Paper.

In order to "describe the interaction effect" we have to isolate the "interaction effect" from the main effects…

The process, called "mean polishing," involves residulaizing the data for the main effects, leaving the interaction effect…

	Presentation			
	Paper	Comp	means	row effect
Easy	90	90	90	+15
Hard	50	70	60	-15
means	70	80	75	← grand mean
col effect	-5	+5		

Correcting for row effects (subtract +/- 15)

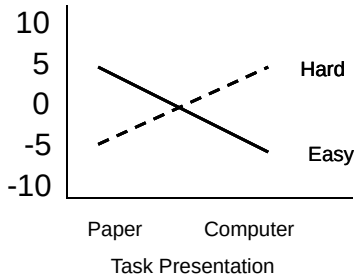
	Presentation	
	Paper	Comp
Easy	75	75
Hard	65	85

Correcting for column effects (subtract +/- 5)

	Presentation	
	Paper	Comp
Easy	80	70
Hard	70	80

Correcting for Grand Mean (subtract 75)

	Presentation	
	Paper	Comp
Easy	5	-5
Hard	-5	5

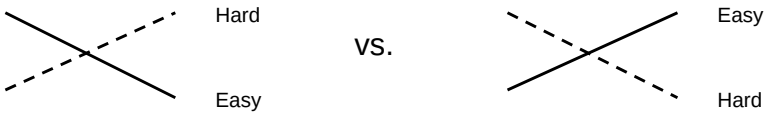


The proper description of "the interaction effect" is

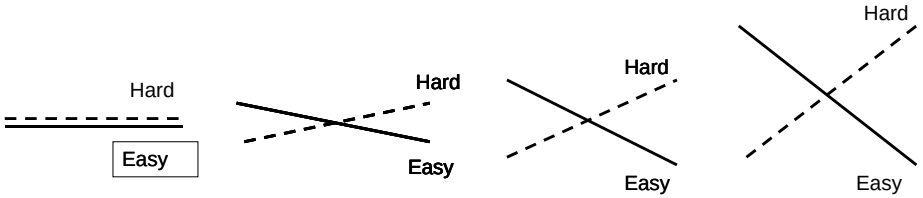
The interaction shown in the figure demonstrates that for Easy tasks those using Paper performed better than those using Computer, however, for Hard tasks, those using Computer performed better than those using Paper.

Looked at in this way, interactions differ in only 2 ways…

Which group has “increase” and which had “decrease”



The “strength” of the interaction effect…



null small medium large