Basic Analysis of Factorial Designs

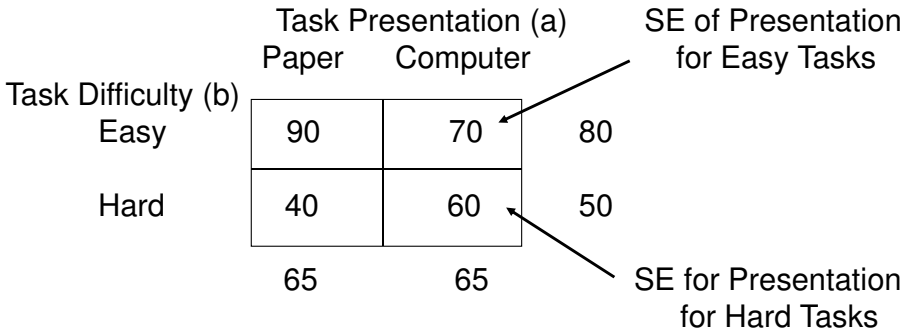
- The F-tests of a Factorial ANOVA
- Using LSD to describe the pattern of an interaction

Statistical Analysis of 2x2 Factorial Designs

Like a description of the results based upon inspection of the means, formal statistical analyses of factorial designs has five basic steps:

1. Tell IVs and DV
2. Present data in table or figure
3. Determine if the interaction is significant
   - if it is, describe it in terms of one of the sets of simple effects.
4. Determine whether or not the first main effect is significant
   - if it is, describe it
   - determine if that main effect is descriptive or misleading
5. Determine whether or not the second main effect is significant
   - if it is, describe it
   - determine if that main effect is descriptive or misleading

Statistical Analysis of a 2x2 Design



Presentation Main Effect	Difficulty Main Effect	Interaction Effect
$SS_{Presentation}$	$SS_{Dificulty}$	$SS_{Interaction}$
65 vs. 65	80 vs. 50	SE_{Easy} vs. SE_{Hard}

Constructing F-tests for a 2x2 Factorial

$$F_{Presentation} = \frac{(SS_{Presentation} / df_{Presentation})}{(SS_{Error} / df_{Error})}$$

$$F_{Difficulty} = \frac{(SS_{Difficulty} / df_{Difficulty})}{(SS_{Error} / df_{Error})}$$

$$F_{Interaction} = \frac{(SS_{Interaction} / df_{Interaction})}{(SS_{Error} / df_{Error})}$$

Statistical Analyses Necessary to Describe the Interaction of a 2x2 Design

The F-test of the interaction only tells us whether or not there is a "statistically significant" interaction…

- it does not tell use the pattern of that interaction
- to determine the pattern of the interaction we have to compare the simple effects
- to describe each simple effect, we must be able to compare the cell means

we need to know how much of a cell mean difference is "statistically significant"

Using Pairwise Comparisons (PrC) to Compare cell means to describe the simple effects of a 2x2 Factorial design

- LSD PrC can be used to determine how large of a cell mean difference is required to treat it as a "statistically significant mean difference"
- Will need to know three values to use the computator
  - df_{error} -- look on the printout or use N – 4
  - MS_{error} – look on the printout
  - n = N / 4 -- use the decimal value – do not round to the nearest whole number!

Remember – for a 2x2 Design, only use the lsdmmd PrC to compare cell means. Marginal means are compared using the man effect F-tests.

Applying lsd_{mmd} to 2x2 BG ANOVA

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

for the interaction
F(1,56) = 6.5, Mse= 300,
p = .023

Is there an Interaction? Based on what? Yes! F-test of Int

What info do we need to compute the LSDmmd?

k = 4 groups
n = (df + k) / k = (56 + 4) / 4 = 15
MSe = 6.5
df error = 56 (round down to 50)

k = 4 groups
n = (df + k) / k = (56 + 4) / 4 = 15
MSe = 6.5
df error = 56 (round down to 50)

With an LSDmmd = 12.7

LSD & HSD Minimum Mean Difference

Enter k (number of conditions in the effect) =>	4
Enter n (average number of data points upon which each mean is based - N/k) =>	15
Enter MSe (Mean Square Error) =>	300
Select dferror (error degrees of freedom - use "next smallest" if no exact match) =>	50
LSD minimum mean difference =	12.70

	SE mean dif	sig?
Simple effect of Task Presentation		
SE of Task Presentation for Easy Tasks	30	>
SE of Task Presentation for Hard Tasks	10	=
Simple effects of Task Difficulty		
SE of Task Difficulty for Paper Pres.	0	=
SE of Task Difficulty for Comp. Pres.	20	>

Support for Interaction RH:s

To be "fully supported" a RH: about an interaction must correctly specify both of the SEs involved in that RH: test.

Date	Type of Toy: Elec.	Type of Toy: Puzzle
1990	>	
2010	=	

Tell if each RH: is fully, partially or not supported

- 1990 children will prefer Electric Toys to Puzzles, while 2010 children will prefer Puzzles to Toys. — partial
- 2010 children will prefer Electric Toys to Puzzles, while 1990 children will show no preference — none
- 1990 children will prefer Electric Toys to Puzzles, 2010 children will too, but to a lesser extent. — partial
- 1990 children will prefer Electric Toys to Puzzles, while 2010 children will have no preference — full

Statistical Analyses Necessary to Describe Main Effects of a 2x2 Design

In a 2x2 Design, the Main effects F-tests are sufficient to tell us about the relationship of each IV to the DV…

- since each main effect involves the comparison of two marginal means -- the corresponding significance test tells us what we need to know …
  - whether or not those two marginal means are "significantly different"
  - Don't forget to examine the means to see if a significant difference is in the hypothesized direction !!!

Support for Main effect RH:s

A RH: about a Main effect is only fully supported if that Main effect is descriptive.

RH: Electric Toys are preferred to Puzzles – tell if each of the following give full, partial or no support …

	Elec	Puz	
1990	>		
2010	=		
	>		

Partial

	Elec	Puz	
1990	=		
2010	=		
	=		

None

	Elec	Puz	
1990	=		
2010	>		
	=		

None? / Partial ?

	Elec	Puz	
1990	=		
2010	>		
	>		

Partial

	Elec	Puz	
1990	>		
2010	=		
	=		

None? / Partial ?

	Elec	Puz	
1990	>		
2010	>		
	>		

Full

What statistic is used for which factorial effects????

Age	Task Experience: Yes	Task Experience: No	
5	30	30	30
10	20	30	25
	25	30	

There will be 4 statistics

1. F_{Age}
2. F_{TExp}
3. F_{Int}
4. LSD PrC

This design as 7 "effects"

1. Main effect of age
2. Main effect of TExp
3. Interaction of age & TExp
4. SE of age for Exp
5. SE of age for Not Exp
6. SE of TExp for 5 yr olds
7. SE of TExp for 10 yr olds

What statistic is used for which factorial effects????

Age	Task Experience: Yes	Task Experience: No	
5	50	30	40
10	60	80	70
	25	30	

1. F_{Age} p = .021
2. F_{TExp} p = .082
3. F_{Int} p = .001
4. PrC LSD_{mmd} = 15

Are 40 & 70 different ?	F_{Age}
Are 50 & 30 different ?	LSDmmd
Are 30 & 80 different ?	LSDmmd
Are 50 & 60 differently different than 30 & 80 ?	F_{Int}
Are 50 & 60 different ?	LSDmmd
Are 25 & 30 different ?	F_{TExp}
Are 50 & 30 differently different than 60 & 80 ?	F_{Int}
Are 60 & 80 different ?	LSDmmd

Applying lsd_{mmd} to 2x2 BG ANOVA

Task Difficulty	Task Presentation: Paper	Task Presentation: Computer	
Easy	60	90	75
Hard	60	70	65

for Difficulty ME
F(1,56) = 4.5, p = .041

lsd_{mmd} = 14

Is there a Task Difficulty main effect? Based on what?

Yes! F-test of ME

Is main effect descriptive (unconditional) or potentially misleading (conditional)?

Simple effects of Task Difficulty

SE of Task Difficulty for Paper Pres.	0	=
SE of Task Difficulty for Comp. Pres.	20	>

Descriptive only for Computer presentation; misleading for Paper presentations.

Applying lsd_{mmd} to 2x2 BG ANOVA

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

for the interaction
F(1,56) = 6.5, p = .023

lsd_{mmd} = 14

Is there an interaction effect? Based on what?

Yes! F-test of Int

for the following, tell the mean difference and apply the lsd_{mmd}

Simple effect of Task Presentation

SE of Task Presentation for Easy Tasks	30	>
SE of Task Presentation for Hard Tasks	10	=

Simple effects of Task Difficulty

SE of Task Difficulty for Paper Pres.	0	=
SE of Task Difficulty for Comp. Pres.	20	>

Applying lsd_{mmd} to 2x2 BG ANOVA

Task Difficulty	Task Presentation: Paper	Computer
Easy	60	90
Hard	60	70
	60	80

for Presentation ME
$F(1,56) = 7.2$, $p = .011$

$lsd_{mmd} = 14$

Is there a Task Presentation main effect? Based on what? Yes! F-test of ME

Is main effect descriptive (unconditional) or potentially misleading (conditional)?
Simple effects of Task Difficulty

SE of Task Presentation for Easy Tasks 30 **<**
SE of Task Presentation for Hard Tasks 10 **=**

Descriptive only for Easy tasks; misleading for Difficult tasks.

Here's one to watch out for…

Comp Comfort	Task Presentation: Paper	Computer
Low	70	60
High	60	70

for the interaction
$F(1,86) = 4.2$, $p = .044$

apply $lsd_{mmd} = 13$

Huh ??? But…

The interaction F-tests ➔ tests whether SEs are "***different from each other"!!***

It doesn't test if either of them is different from "0"!!!

"10" & "-10" are "different from each other", but neither is different from "0"!

You can't use the LSDmmd to say that -10 & 10 are sig dif!
Rem!!! This is based on the F-test!!

Effect Sizes for 2x2 BG Factorial designs

For Main Effects & Interaction (each w/ df=1)

$$r = \sqrt{[\, F / (F + df_{error})]}$$

Rem: This effect size can only be compared with other interaction effects from exactly the same factorial design

For Simple Effects

$$d = (M1 - M2) / \sqrt{Mserror}$$

$$r = \sqrt{\left[\frac{d^2}{d^2 + 4}\right]}$$ (An "approximation formula")

Rem: The effects size for a pairwise comparison can be compared with that pair of conditions from any study.