Introduction to "Kinds" of 2-way Factorial Designs

- Incorporating within-groups comparisons
- ANOVA for BG, MG & WG designs
- Causal Interpretation of Factorial Effects
- Comparing the different Factorial Models & F-tests
- Applying LSD_{mmd} to kxk designs
- Using Factorial Designs in Programmatic Research

"Kinds" of 2-factor Designs

BETWEEN GROUPS FACTORIAL DESIGN:
- each IV uses a between groups comparison
- each participant completes only one condition of the design

WITHIN-GROUPS FACTORIAL DESIGN:
- each IV uses a within-groups comparison
- each participant completes all conditions of the design

MIXED FACTORIAL DESIGN:
- one IVs uses a between groups comparison and the other IV uses a within-groups comparison.
- each participant completes both conditions of the within-groups IV, but completes only one condition of the between groups IV.
- it is important to specify which IV is "BG" and which is "WG"

Between groups factorial design → experimental or natural grps designs used to study "differences"

Each participant is in only one condition, having a particular combination of Initial Diagnosis and Type of Treatment.

Initial Diagnosis	Type of Treatment: Individual Therapy	Type of Treatment: Group Therapy
Depression	Clients diagnosed as depressed who are treated with individual therapy	Clients diagnosed as depressed who are treated with group therapy
Social Anxiety	Clients diagnosed with social anxiety who are treated with individual therapy	Clients diagnosed with social anxiety who are treated with group therapy

Mixed group factorial design → natural groups designs used to study "different changes" or "changing differences"

Species was a between groups IV (a turtle can only be a member of one species). Each turtle participated in both the mid-morning & dusk conditions of the Time of Day IV.

Time of Day	Species of Turtle: Snapping Turtle	Species of Turtle: Painted Turtle
Mid-morning	Each snapping turtle completed a trial during mid-morning	Each painted turtle completed a trial during mid-morning
Evening	Each snapping turtle completed a trial during the evening	Each painted turtle completed a trial during the evening

Mixed group factorial design → experimental designs used to increase data collection efficiency or statistical power

Type of Evidence was a between groups IV -- people can't read the "same study" twice & give independent ratings. Each participant rated the guilt of both Defendants -- a within-groups IV --as they would in this type of case.

Defendant	Type of Evidence: DNA	Type of Evidence: Eye Witness
Major Actor	DNA evidence was presented against the major actor	An eye witness testified to seeing the major commit the crime
Conspirator	DNA evidence was presented against the conspirator	An eye witness testified to seeing the conspirator commit the crime

Within-groups factorial design – experimental designs used to increase data collection efficiency or statistical power

Each participant completed four trials, one of each combination of Retention Interval and Word Type.

Word Type	Retention Interval: Immediate Test	Retention Interval: Delayed Test
Familiar	The test was given immediately after the study of a list of 40 familiar words.	The test was given 5 minutes after the study of a list of 40 familiar words.
Unfamiliar	The test was given immediately after the study of a list of 40 unfamiliar words.	The test was given 5 minutes after the study of a list of 40 unfamiliar words.

Within-groups factorial design – natural designs to study "changing changes"

Each participant was observed in both School & Home (WG) settings both when they were 12 &16 (WG)

Setting	Age: 12 years old	Age: 16 years old
School	Participants were observed in a school setting at age 12.	Participants were observed in a school setting at age 16.
Home	Participants were observed in a home setting at age 12.	Participants were observed in a home setting at age 16.

Practice Identifying Types of Factorial Designs - answers next page

The purpose of the study was to examine the possible influence of two variables upon maze-learning by rats, length of the maze (either 10 feet or 30 feet) and the size of the reward (either 1sugar pellet or 5 sugar pellets).

Here are three "versions" of the study tell which is BG, WG & MG

a. Each rat completed one trial. Each was assigned to either the longer or the shorter maze, and also assigned to receive either 1 or 5 sugar pellets upon completing the maze.

b. Each rat completed two trials in either the longer or the shorter maze. Following one trial in the assigned maze, each received 1 pellet reward, after the other trial they received the 5 pellets.

c. Each rat completed four trials, two in the shorter maze and two in the longer maze. Each received 1 pellet after one of the short-maze trials and 5 pellets after the other, and also 1 pellet after one of the long-maze trials and 5 pellets after the other.

Another Example -- 3 versions of the same study

The researcher wanted to investigate infant's startle responses to loud sounds. The two variables of interest were the Position of the Sound (in front of versus behind the infant) and the Type of Sound (a hand-clap versus deep male voice saying "Hey").

Here are three "versions" of the study tell which is BG, WG & MG

a. Each infant completed trials all involving a hand-clap or all involving the voice saying "Hey". During some of the trials, the appropriate type of sound was made in front of the infant. During other trials, the appropriate type of sound was made behind the infant.

b. Each infant had some trials during which the sound was made in front of then and some during which the sound was made behind them. Some of the sounds were the hand-clap and the others were the voice saying "Hey".

c. Each infant always heard either the hand-clap or the "Hey", and whatever sound they heard was always played either in front of them or behind them.

Remember about the causal interpretation of effects of a factorial design

Start by assessing the causal interpretability of each main effect

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

For each of the following: Tell the IVs and tell what effects could be causally interpreted (assuming proper RA, IV manip. and confound control were used):

1. Male and female participants who were African American, Mexican American, or European American were asked to complete a questionnaire about satisfaction with their Senators.

2. Children played with either a toy gun, a toy car or a puzzle, some while their parents were in the room and some not. The DV was the amount of aggressive behavior they exhibited.

3. Participants played with either a simple puzzle or a complex puzzle in pairs made up of two boys, two girls or one boy & one girl.

F-tests of the BG Factorial Designs

$$SS_{total} = SS_A + SS_B + SS_{INT} + SS_{Error}$$

$$F_A = \frac{SS_A / df_A}{SS_E / df_E} \qquad F_B = \frac{SS_B / df_B}{SS_E / df_E} \qquad F_{INT} = \frac{SS_{INT} / df_{INT}}{SS_E / df_E}$$

F-tests of the BG Factorial Designs

$$SS_{total} = SS_A + SS_B + SS_{INT} + SS_{Error}$$

$$F_A = \frac{SS_A / df_A}{SS_E / df_E} \qquad F_B = \frac{SS_B / df_B}{SS_E / df_E} \qquad F_{INT} = \frac{SS_{INT} / df_{INT}}{SS_E / df_E}$$

F-tests of the MG Factorial Designs

$$SS_{total} = SS_A + SS_{S/A} + SS_B + SS_{INT} + SS_{BxS/A}$$

$$F_A = \frac{SS_A / df_A}{SS_{S/A} / df_{S/A}} \qquad F_B = \frac{SS_B / df_B}{SS_{BxS/A} / df_{BxS/A}} \qquad F_{INT} = \frac{SS_{INT} / df_{INT}}{SS_{BxS/A} / df_{bxS/A}}$$

F-tests of the WG Factorial Designs

$$SS_{total} = SS_{Sub} + SS_A + SS_{SxA} + SS_B + SS_{SxB} + SS_{INT} + SS_{SxInt}$$

$$F_A = \frac{SS_A / df_A}{SS_{SxA} / df_{SxA}} \qquad F_B = \frac{SS_B / df_B}{SS_{SxB} / df_{SxB}} \qquad F_{INT} = \frac{SS_{INT} / df_{INT}}{SS_{SxINT} / df_{SxINT}}$$

Computing LSDmmd for BG, MG & WG designs

The first part should sound familiar…

When do you need a LSDmmd value ???

General rule: You will need an LSDmmd value to compare pairs of means whenever a significant effect has k>2 conditions

#1 Whenever the interaction is significant → LSDmmd for the cell means is needed to :

- describe the pattern of the SEs to describe the interaction pattern
- describe the pattern of the SEs to determine whether each ME is descriptive or misleading (necessary to do for each ME -- whether the ME is significant or not)

#2 Whenever a ME is significant → LSDmmd for those marginal means is needed to

- describe the patter of that ME

Computing LSDmmd for BG, MG & WG designs

The second part is also important

#1 Be sure to use the right MS_{error}

- BG → only one error term for cell means and both sets of marginal means
- WG → separate error term for each effect, cell means and the set of marginal means for each main effect
- MG → one error term for cell means and marginal means of WG main effect, second error term for marginal means of the BG effect

#2 Be sure to use the right "n"

- n will be different for cell mean LSDmmd and marginal mean LSDmmd computatioins
- n is the average number of data points that each of the means being compared are based on – N / k

Using Factorial Designs in Programmatic Research I

Adding a 2nd Treatment

Perhaps the most common application of factorial designs it so look at the separate (main) and combined (interaction) effects of two IVs. One important version of this is making a potential confound an IV – are both "controlling" and "studying" its relationship with the DV

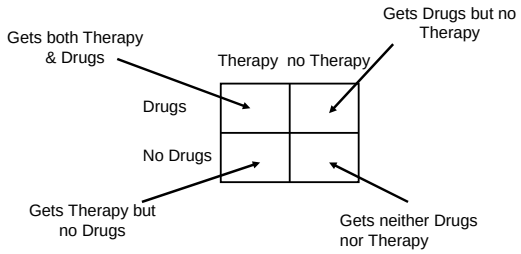
Often our research starts with a simple RH: that requires only a simple 2-group BG research design.

Therapy	no Therapy

Keep in mind that to run this study, we made sure that none of the participants had any other treatments !

Factorial Designs – Separate (Main) and combined (interaction) effects of two treatments

At some point we are likely use Factorial designs to ask ourselves about how a 2nd IV also relates to the DV and if the two IVs interact



Using Factorial Designs in Programmatic Research II

"Correcting" Bivariate Studies

Sometimes "neither IV is related to the DV, but both are"! Huh???

Our well sampled, carefully measured, properly analyzed study showed …

… nothing !

High	Low
40	40

Our well sampled, carefully measured, properly analyzed study showed …

… nothing !

Male	Female
40	40

Looks like neither IV is related to the DV !!!

However, when we analyzed the same data including both variables as IVs …

	High	Low	
High	60	20	40
Low	20	60	40
	40	40	

There are treatment effects both for those who are "Low" & those who are "High" – the marginal means are an "aggregation error"

There are High-Low effects both for those in Tx1" & those in TX2 – the marginal means are an "aggregation error"

So, instead of the "neither variable matters" bivariate results, the multivariate result shows that both variables are related to the DV and they interact too (i.e., diferent effects of each IV for different values of the other IV)!!!

Using Factorial Designs in Programmatic Research III

Between Groups Factorial Designs – Generalization across Populations, Settings & Tasks

Often our research starts with a simple RH: that requires only a simple 2-group BG research design.

Computer	Lecture

Keep in mind that to run this study, we had to make some choices/selections:

For example:
population → College Students
setting → Lecture setting
stim/task → teach Psychology

When we've found and replicated an effect, making certain selections, it is important to check whether changing those selections changes the results.

Computer	Lecture
60	40

If there is no interaction – if the results "don't depend upon" the population, task/stimulus, setting, etc – we need to know that, so we can apply the results of the study to our theory or practice, confident in their generalizability

If there is an interaction – if the results "depend upon" the population, task/stimulus, setting, etc – we need to know that, so we can apply the "correct version" of the study to our theory or practice

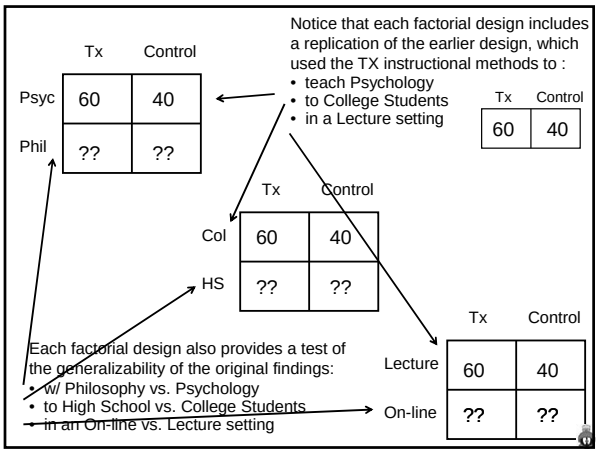
At some point we are likely use BG Factorial designs to ask ourselves how well the results will generalize to:

- other populations – college vs. high school
- other settings – lecture vs. laboratory
- other tasks/stimuli – psyc vs. philosophy

	Tx	Control
Col		
HS		

	Tx	Control
Psyc		
Phil		

	Tx	Control
Lecture		
On-line		



Using Factorial Designs in Programmatic Research IV

Mixed Groups Factorial Designs – Time Course Investigations

(or → Do effects "depend upon" length of treatment ?)

As before, often our research starts with a simple RH: that requires only a simple 2-group BG research design.

Tx_1	Tx_2
20	20

Time Course Investigations

In order to run this study we had to select ONE treatment duration (say 16 weeks):

- we assign participants to each condition
- begin treatment of the Tx groups
- treat for 16 weeks and then measured the DV

Using this simple BG design we can "not notice" some important things. A MG Factorial can help explore the time course of the Tx effects.

Tx_1	Tx_2
20	20

By using a MG design, with different lengths of Tx as the 2nd IV, we might find different patterns of data that we would give very different interpretations

	16 wks	50 wks
Tx_1	20	40
Tx_2	20	40

	16 wks	50 wks
Tx_1	20	40
Tx_2	20	20

	16 wks	50 wks
Tx_1	20	40
Tx_2	20	60

	16 wks	50 wks
Tx_1	20	0
Tx_2	20	40

Using Factorial Designs in Programmatic Research V

Mixed Groups Factorial Designs – Evaluating Initial Equivalence when Random assignment is not possible

As before, often our research starts with a simple RH: that requires only a simple 2-group BG research design.

	Tx_1	Tx_2

Initial Equivalence Investigations

In order to causally interpret the results of this study, we'd have to have initial equivalence

- but we can't always RA & manipulate the IV
- So what can we do to help interpret the post-treatment differences of the two treatments?
- Answer – compare the groups before treatment too!

By using a MG design, we can compare the groups pre-treatment and use that information to better evaluate post-treatment group differences (but can't really infer cause). For which of these would you be more comfortable concluding that $Tx_1 > Tx_2$??

	Pre	Post
Tx_1	40	40
Tx_2	20	20

Nah – Post dif = pre dif !

	Pre	Post
Tx_1	60	40
Tx_2	20	20

Nah – Tx_1 lowered score

	Pre	Post
Tx_1	30	60
Tx_2	20	40

Maybe – more increase by Tx_1

	Pre	Post
Tx_1	20	40
Tx_2	20	20

As good as it gets!