What is a **treatment effect**? Come up with an example from class

What is a **Block**? Come up with an example from class

What is the difference between **main**, **specific**, and **interaction** effects?

What is a **treatment effect**? Come up with an example from class

Effect of changing from Sitting to Standing on Pulse

Effect of changing from Burbank to Alpine variety on yield

Manipulative vs **Mensurative** treatments

are you trying to explain **why**?

What is a **Block**? Come up with an example from class

Any grouping variable with 2+ treatment levels

Mensurative treatments

The basis for direct estimates

Person (for pulse), moderator treatment, region of field

Replicate of a whole experiment

What is the difference between **main**, **specific**, and **interaction** effects?

specific effect: Treatment effect in a specific condition defined by another variable

interaction effect: How treatment effects **change** between levels of the moderator

main effect: **Average** treatment effects over all levels of the moderator

Design tables:

Structure	Variable	#levels	Block	EU
Focal	Feed	2	Cool, Mother	Pig
Moderator	Cool	2	Mother, Pig	Cut
Combo	Feed:Cool	4	Mother, Pig	Cut
Design				
Response				

List steps of creating this table:

Rules for making Design Table

1) Response: One Variable, always numeric

2) Treatments: Variables we want to study

Focal, Moderator, in a factorial

List Blocks and EUs for every treatment variable

Don't list Focal as a Block

3) Create Treatment:Block variables

If both "Treatment" and "Block" are treatments, include these as Combo treatment

Otherwise, Treatment:Block is a Design variable

4) Design: All other variables necessary to describe the experiment

Must be random ⟶ Every EU variable

Every Block variable that **is not a Treatment**

**Can be random** ⟶ Every Treatment:Block variable that **is not a Combo Treatment**

A variable to describe each unique observation
(same # levels as the response)

Turning a Design Table into a model

Structure	Variable	#levels	Block	EU
Focal	Feed	2	Cool, Mother	Pig
Moderator	Cool	2	Mother, Pig	Cut
Combo	Feed:Cool	4	Mother, Pig	Cut
			Cool:Mother	
Design	Mother	36		
	Pig	72		
	Feed:Mother	72		
	Cool:Mother	72		
	Feed:Cool:Mother	144		
	Cut	144		
	Cool:Pig	144		
Response	Tenderness	144		

1) Drop variables with # levels == # responses

2) Determine if any variables are aliased

Are these **aliased**?

Yes

Pig
Feed:Mother
Cool:Mother

No

If YES, drop all but one
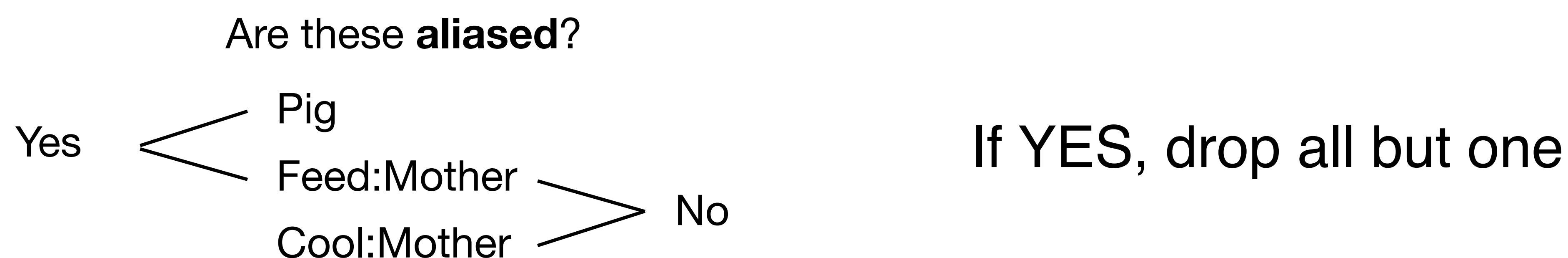
3) Write all model variables:

Response ~ A + B + C + …

4) Declare random variables with (1|B) …

5) Decide on lm() or lmer() based on if there are random variables

6) Add the data table inside the function:

lmer(Response ~ A + B + (1|C), data)

Turning a Design Table into a model

Structure	Variable	#levels	Block	EU
Focal	Feed	2	Cool, Mother	Pig
Moderator	Cool	2	Mother, Pig	Cut
Combo	Feed:Cool	4	Mother, Pig	Cut
			Cool:Mother	
Design	Mother	36		
	Pig	72		
	Feed:Mother	72		
	Cool:Mother	72		
	Feed:Cool:Mother	144		
	Cut	144		
	Cool:Pig	144		
Response	Tenderness	144		

What variables are random?

Every EU variable

Treatment:Block when we want the **main effect** averaged over blocks

(optional) Incomplete blocks

(optional) complete blocks (this has no effect!)

Every variable **nested** in a random variable

nested variables must have more # levels

Analyses

Factorial experiments:

Define focal and moderator treatments

A) **Test** specific or interaction effects

anova() - only look at focal:moderator row (should be last)

for specific effects, re-write model dropping focal variable

B) **Estimate/Describe** specific or interaction effects

1) Estimate means of focal by moderator

2) Estimate **specific effects**

3) Re-group specific effects by effect_name

4) Estimate **interaction effects**

* Always use the full model here, not the specific effect model

Analyses

Blocked experiments

A) Main effects

Average treatment effect across blocks

Treatment:Block is **random**

DF = (b-1)*(t-1)

B) Specific effects

Treat Block as a moderator treatment

Treatment:Block is **fixed**

C) Interaction effects

Treat Block as a moderator treatment

DF = b*t*(n_i-1)

n_i is *per block*

Treatment:Block is **fixed**

How are B and C different from a factorial experiment?

Analysis approach is exactly the same

Interpretation is different:

We can't say **why** some blocks change the treatment effects

What properties of the design are required form B/C?

2+ replicates of each treatment in each block

What makes a good block?

EU are similar

Study: Precision with ancient archery

Question: How does the weight and/or size of the arrowhead affect shooting precision?

Design: 10 archers were recruited.

Each shot 12 arrows, 3 with each combination of two factors: Weight (light or heavy) and Size (small or large).

Response: Precision was defined as the distance from the place of impact to the center of the target

Structure	Variable	#levels	Blocks	EU

Treatments: What questions?

Design:
      What type of design?

      Blocks?

      EU?

What if the same 12 arrows were re-used by each archer?

What if a different 12 arrows were used by each archer?

Archer1

W1S1 123	W1S2 456
W2S2 789	W2S1 abc

Archer2

W2S2 789	W2S1 abc
W1S2 456	W1S1 123

Archer3

W1S2 456	W1S1 123
W2S1 abc	W2S2 789

12 arrows

Does it matter if arrows are randomized within each archer?

Archer1

W1S1 XXX	W1S2 XXX
W2S2 XXX	W2S1 XXX

Archer2

W2S2 XXX	W2S1 XXX
W1S2 XXX	W1S1 XXX

Archer3

W1S2 XXX	W1S1 XXX
W2S1 XXX	W2S2 XXX

120 arrows

Archer1

W1S1 XXX	W1S2 XXX
W2S2 XXX	W2S1 XXX

Archer2

W2S2 XXX	W2S1 XXX
W1S2 XXX	W1S1 XXX

Archer3

W1S2 XXX	W1S1 XXX
W2S1 XXX	W2S2 XXX

120 arrows

Structure	Variable	#levels	Blocks	EU
focal	Weight	2	Size, Archer	Arrow
moderator	Size	2	Archer	Arrow
combo	Weight:Size	4	Archer	Arrow
Design	Archer	10		
	Weight:Archer	20		
	Size:Archer	20		
	W:S:Archer	40		
	Arrow	120		
Response	Precision	120		

Analysis #1: Average specific effects of Weight (over Archers)

   Specific-effect model (drop "Weight")

   "Main effect" from RCBD (Treatment:Block is random)   Treatment = Weight:Size

   lmer(Precision ~ Size + Weight:Size + Archer + Weight:Archer

          + Size:Archer + (1|Weight:Size:Archer))

   Weight:Archer and Size:Archer are **incomplete blocks** so **can be random** (but not required)

Analysis #2: Specific effects of Weight for each Archer

   Specific-effect model (drop "Weight")

   Weight:Size:Archer is **not random**   (Weight:Archer and Size:Archer cannot be random)

   lm(Precision ~ Size + Weight:Size + Archer + Weight:Archer

          + Size:Archer + Weight:Size:Archer)

Archer1	
W1S1 XXX	W1S2 XXX
W2S2 XXX	W2S1 XXX

Archer2	
W2S2 XXX	W2S1 XXX
W1S2 XXX	W1S1 XXX

Archer3	
W1S2 XXX	W1S1 XXX
W2S1 XXX	W2S2 XXX

120 arrows

Structure	Variable	#levels	Blocks	EU	EU
focal	Weight	2	Size, Archer	Arrow	Weight:Size:Archer
moderator	Size	2	Archer	Arrow	Weight:Size:Archer
combo	Weight:Size	4	Archer	Arrow	Weight:Size:Archer
Design	Archer	10			
	Weight:Archer	20			
	Size:Archer	20			
	W:S:Archer	40			
	Arrow	120			
Response	Precision	120			

What if individual arrows were not randomized within each archer?

   arrows are **subsamples**

Analysis #1: Average specific effects of Weight (over Archers)

   lmer(Precision ~ Size + Weight:Size + Archer + Weight:Archer

      + Size:Archer + (1|Weight:Size:Archer))

   no change!

Analysis #2: Specific effects of Weight for each Archer

   lm(Precision ~ Size + Weight:Size + Archer + Weight:Archer

      + Size:Archer + Weight:Size:Archer)

   Weight:Size:Archer **must be random because it is an EU**

      We cannot do this analysis!

Archer1		Archer2		Archer3	
W1S1 123	W1S2 456	W2S2 789	W2S1 abc	W1S2 456	W1S1 123
W2S2 789	W2S1 abc	W1S2 456	W1S1 123	W2S1 abc	W2S2 789

12 arrows

Does it matter if arrows are randomized within each archer?

Structure	Variable	#levels	Blocks	EU
focal	Weight	2	Size, Archer	Arrow
moderator	Size	2	Archer	Arrow
combo	Weight:Size	4	Archer	Arrow
Design	Archer	10		
	Weight:Archer	20		
	Size:Archer	20		
	W:S:Archer	40		
	Arrow	12		
	Archer:Arrow	120		
Response	Precision	120		

Analysis #1: Average specific effects of Weight (over Archers)

lmer(Precision ~ Size + Weight:Size + Archer + Weight:Archer

+ Size:Archer + (1|Weight:Size:Archer) + (1|Arrow))

Arrow is EU so it must be random

Weight:Size:Arrow is **nested in Arrow** so it must be random

It is OK if Arrows are always shot 1,2,3 (as long as the order of the W:S combos is different for each archer)

Analysis #2: Specific effects of Weight for each Archer

Weight:Size:Archer cannot be random for this analysis, but must be because it is nested in Arrow

So we cannot do this analysis again!

We can't separate specific effects of the arrow for each Archer from specific effects of Weight for each Archer