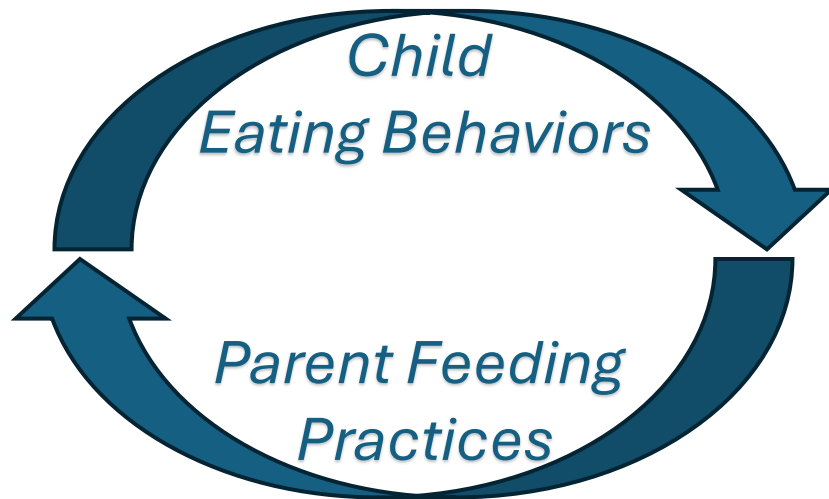


Predictors of Child Eating and Parent Feeding in the ECHO Cohort

Elena Jansen*, *Maxwell Mansolf**, Phillip Sherlock, Shuxian Hua, James Lester Burns, Courtney K. Blackwell, Traci A. Bekelman, Susan Carnell, for the ECHO Cohort Consortium

Background: Early Eating and Feeding Dynamics

Trait/state behaviors affecting food selection



*How parents approach feeding
(responsive vs. non-responsive)*

Both factors are influenced by, and themselves affect...

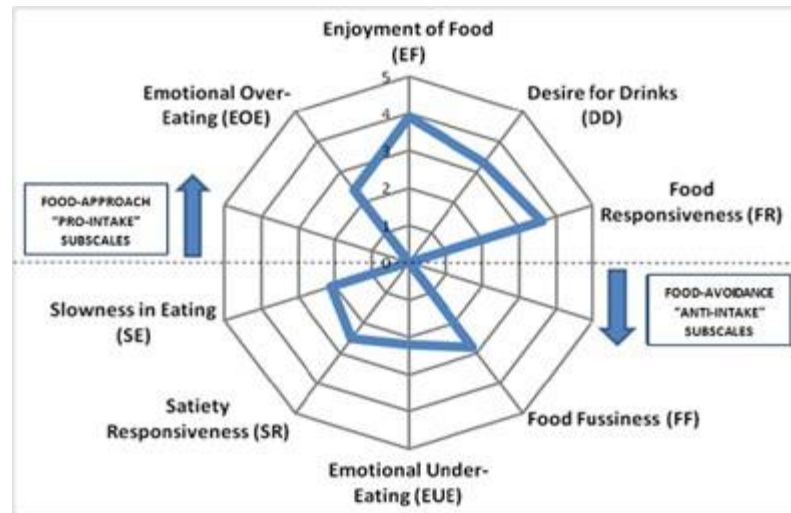
- Each other
- *Child BMI*
- Broader family factors

Previous research has used smaller samples; we leveraged the ECHO cohort to expand on this work.

Key Outcomes: What We're Interested In

Child Eating Behavior Questionnaire (CEBQ) (8 scales)

- Assesses child eating styles
- 35 items; scales described below



Comprehensive Feeding Practices Questionnaire (CFPQ) (12 scales)

- Assesses parent feeding practices
- 49 items, including scales for
 - Child control
 - Emotional regulation
 - Food as reward
 - Modeling
 - Pressure
 - Restriction for weight control

Twenty subscales in total

Both measures rely on parent report

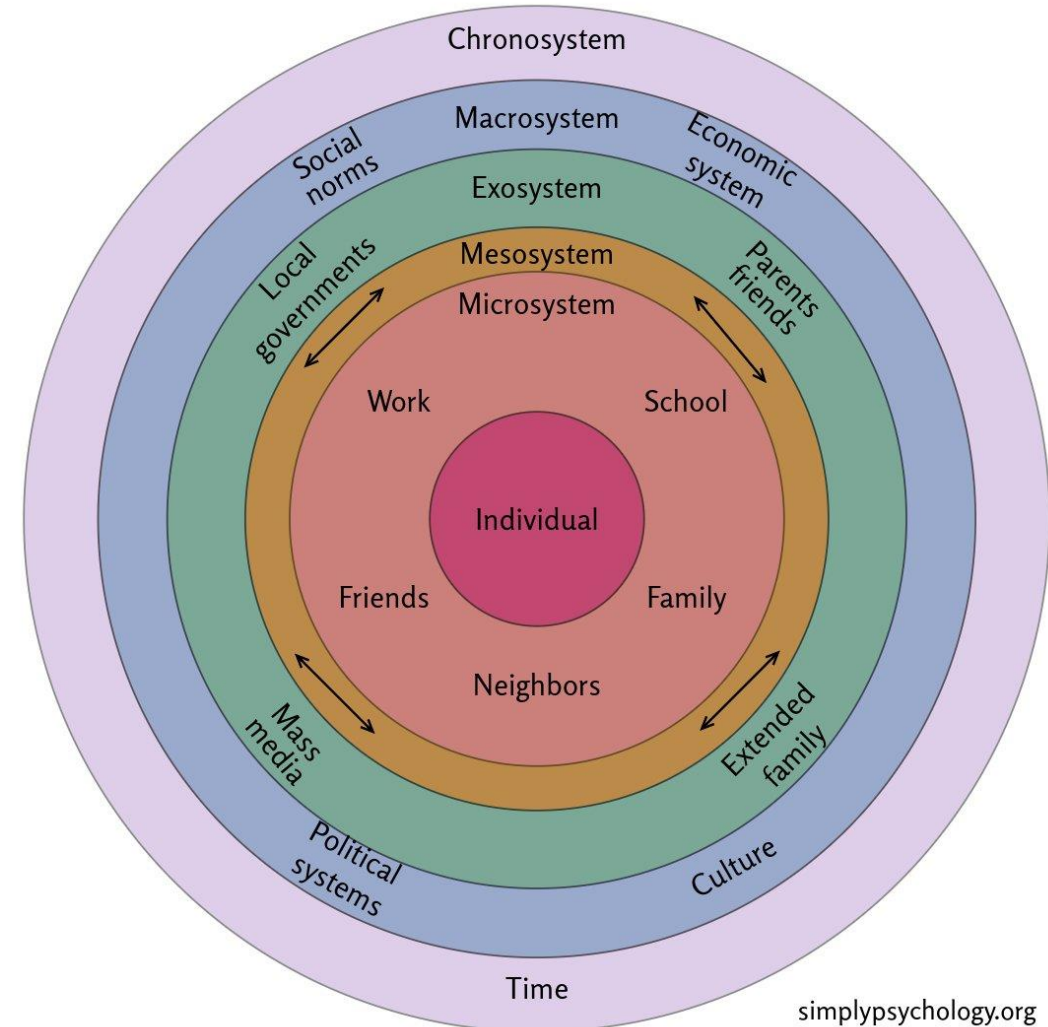
Staying True to Complexity of ECHO Data

Early childhood data are *complicated*.

For this analysis, ECHO provides *cross-sectional* data.

How do we stay true to this complexity in observational research?

- Analytic methods
- Rigor in interpretation



Predictors of Eating and Feeding

Child

- Child Sex
- *Child Race*
- *Child Ethnicity*
- Child Age
- Child BMI

Family

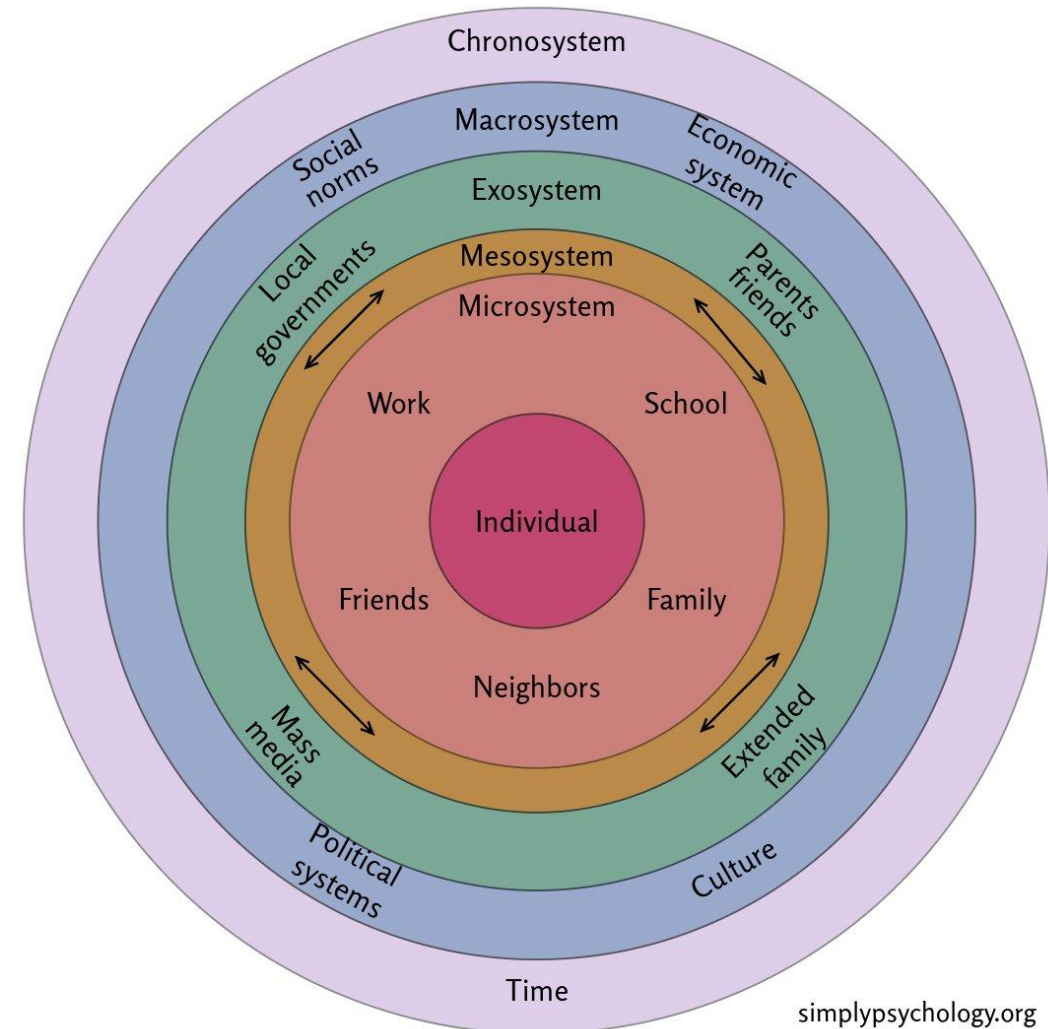
- Household Income
- No. of Children in Household

Caregiver

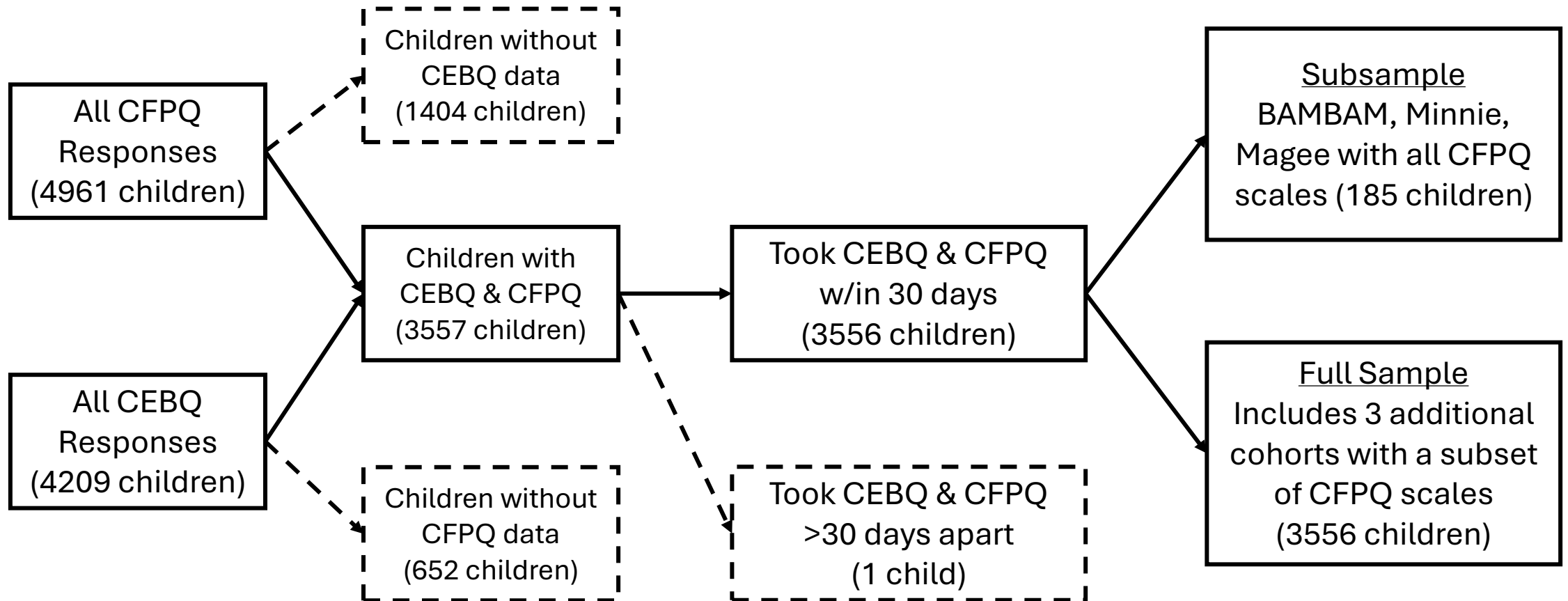
- Caregiver Age
- Caregiver Education
- Caregiver Marital Status
- Perceived stress
- Depression
- Emotional Support
- Informational Support
- Instrumental Support

The Problem: per Bronfenbrenner, all these characteristics can interact in predicting child outcomes. *Our methods must account for this.*

and ECHO study site



Sample Selection



Note. CEBQ = Child Eating Behaviour Questionnaire; CFPQ = Comprehensive Feeding Practices Questionnaire

First Goal: Dimension Reduction (Full Sample)

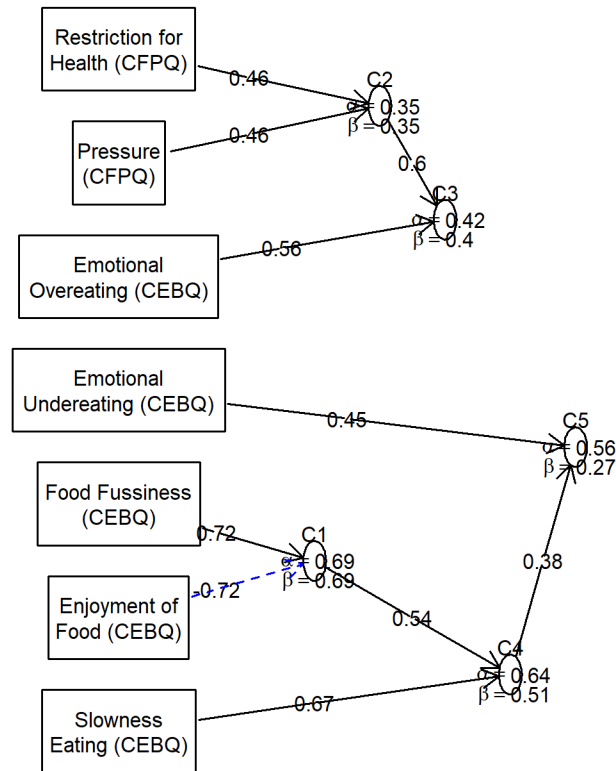
20 subscales = too many outcomes

Can we combine some of them?

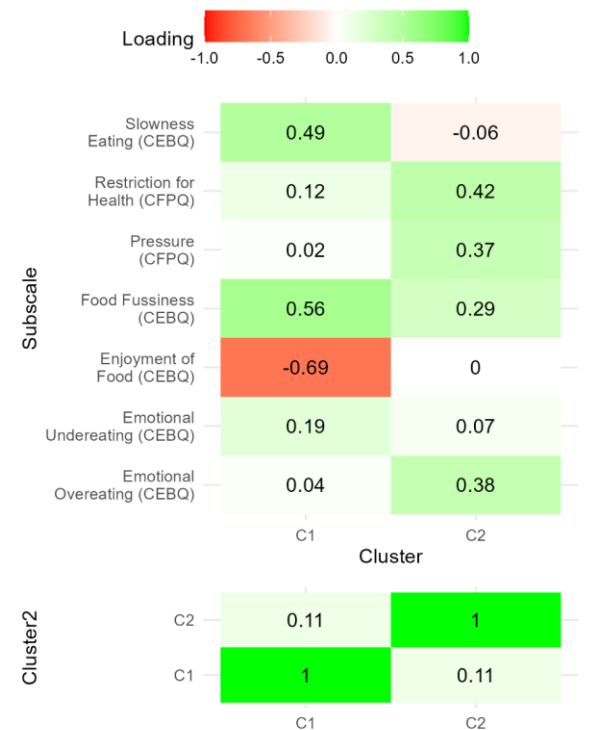
Hierarchical cluster analysis with ICLUST (Revelle, 1978)

This result is for the subset of scales in the full sample ($N=3556$).

Graphical Display



Item-Cluster Loadings



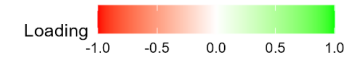
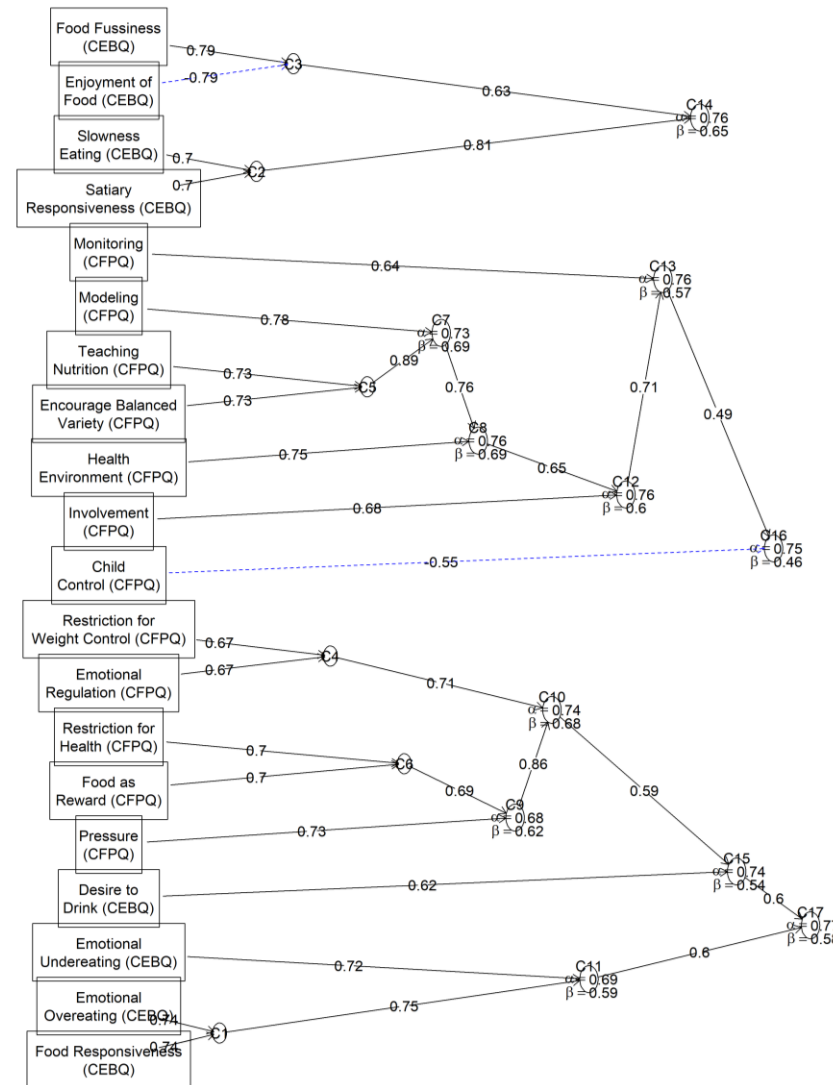
Dimension Reduction (Subsample)

First cluster (column) reflects

- CFPQ: coercive feeding (restriction, pressure)
- CEBQ: food approach (food responsiveness, desire to drink)

Is this two domains, or one phenomenon?

- Also interesting: Enjoyment of Food clusters with *avoidance*



Subscale	C1	C2	C3
Teaching Nutrition (CFPQ)	-0.05	0.69	0.05
Slowness Eating (CEBQ)	0.1	0.24	0.58
Satiety Responsiveness (CEBQ)	0.07	-0.01	0.71
Restriction for Weight Control (CFPQ)	0.63	-0.09	-0.2
Restriction for Health (CFPQ)	0.63	0.12	0.12
Pressure (CFPQ)	0.51	0.11	0.12
Monitoring (CFPQ)	-0.02	0.44	0.02
Modeling (CFPQ)	0.17	0.63	0.01
Involvement (CFPQ)	0.07	0.42	-0.12
Health Environment (CFPQ)	-0.3	0.57	-0.08
Food Responsiveness (CEBQ)	0.67	-0.07	-0.3
Food Fussiness (CEBQ)	0	-0.18	0.65
Food as Reward (CFPQ)	0.66	-0.04	0.13
Enjoyment of Food (CEBQ)	0.2	0.14	-0.72
Encourage Balanced Variety (CFPQ)	0.04	0.78	0.03
Emotional Undereating (CEBQ)	0.39	0.13	0.35
Emotional Regulation (CFPQ)	0.43	-0.11	-0.13
Emotional Overeating (CEBQ)	0.54	-0.01	0
Desire to Drink (CEBQ)	0.39	-0.21	-0.15
Child Control (CFPQ)	0.04	-0.35	0.04
Cluster	C1	C2	C3
Cluster2	C3	C2	C1

Our Eating and Feeding Outcomes

Measure	Domain Name	Component(s)
CEBQ	Food Avoidance	Slowness in Eating; Satiety Responsiveness; Food Fussiness; Enjoyment of Food
	Food Approach	Food Responsiveness; Emotional Overeating; Desire to Drink
	Emotional Undereating	Emotional Undereating
CFPQ	Positive Feeding	Teaching Nutrition; Monitoring; Modeling; Involvement; Healthy Environment; Encourage Balance and Variety
	Coercive Feeding	Restriction for Weight Control; Restriction for Health; Pressure; Food as Reward; Emotion Regulation
	Child Control	Child Control
Both	<i>Combined Food Approach & Coercive Feeding</i>	<i>Food Approach; Coercive Feeding</i>

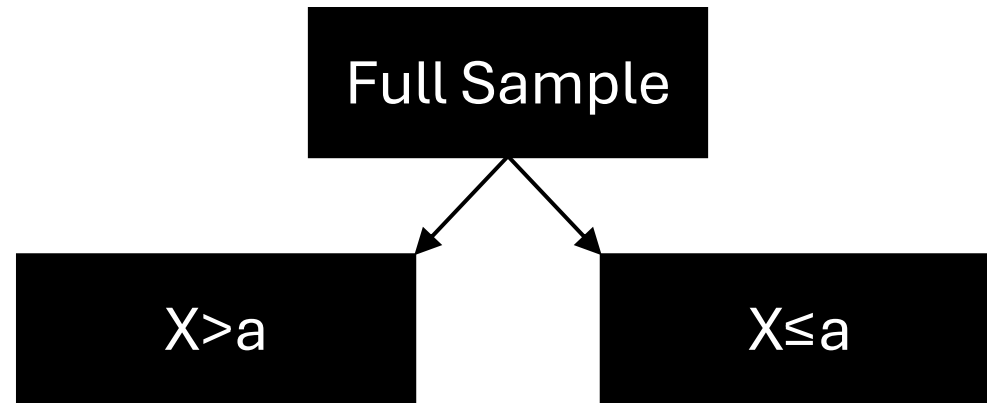
Incorporating Complexity: Recursive Partitioning

Full Sample

First, which predictor leads to the largest, most statistically significant, or otherwise “best” split (*partitioning*) of the data?

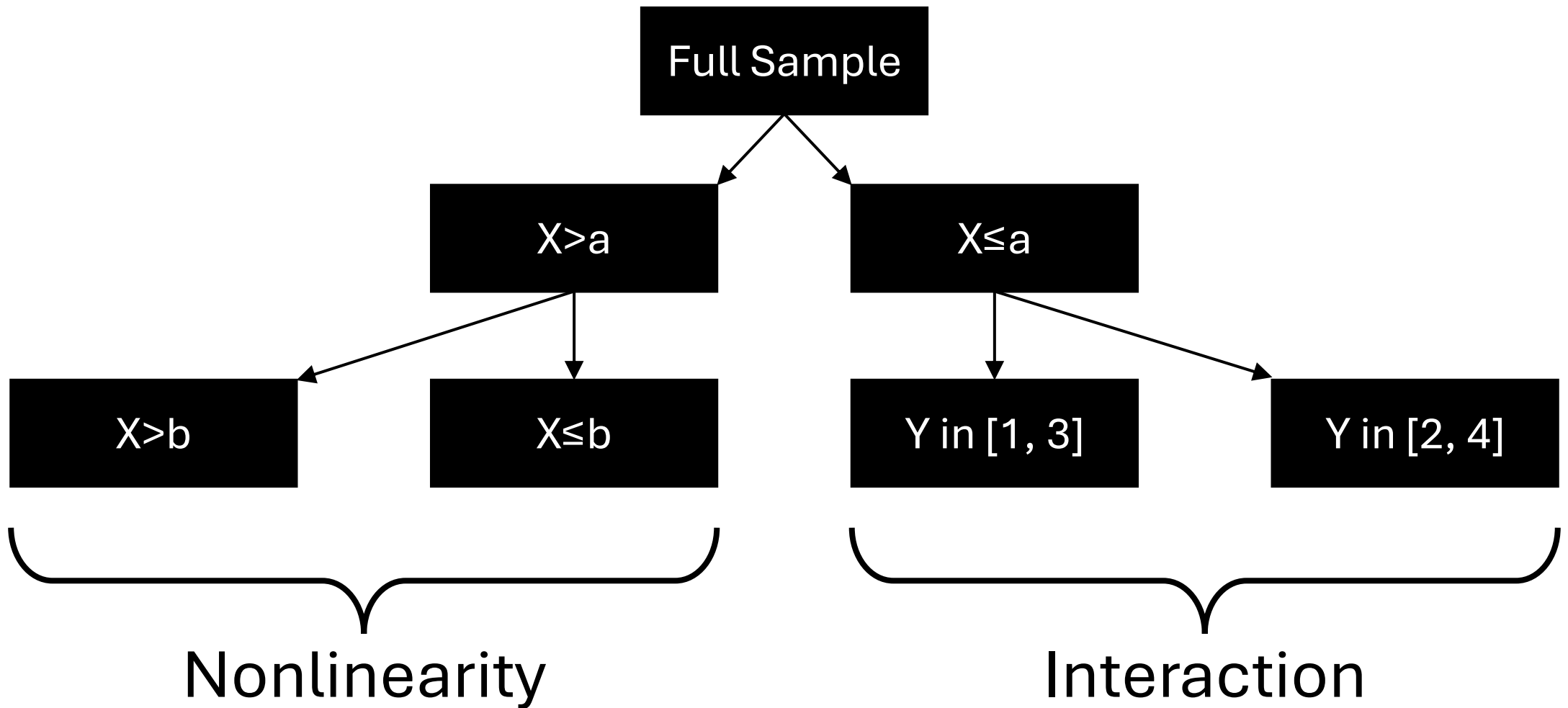
And, if that predictor X is continuous or categorical, which values/levels lead to that split?

Incorporating Complexity: Recursive Partitioning



Next, *within each partition*, which predictor leads to the “best” split?

Incorporating Complexity: Recursive Partitioning



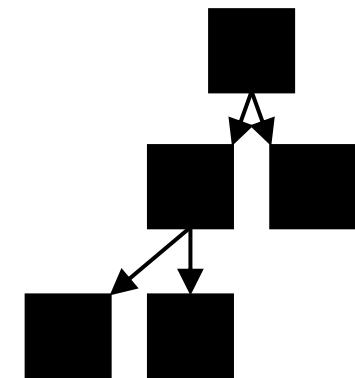
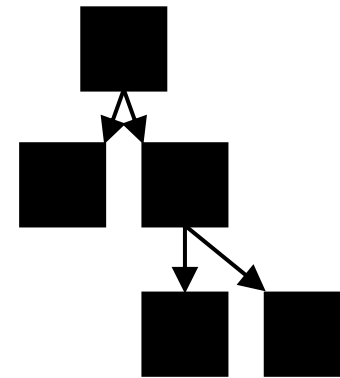
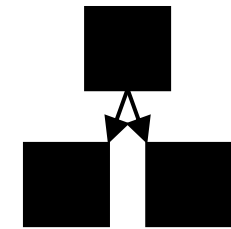
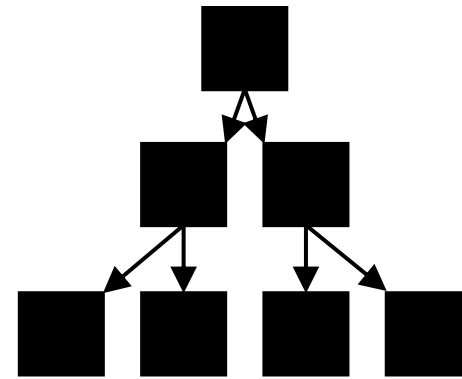
Incorporating Complexity: Recursive Partitioning

Two-stage process:

1. Variable Selection with *random forests*

- Ensemble model: many (500) trees
- Each tree grown from subsample of observations & predictors
- Intentionally overtrained to identify important* predictors.

One random forest per outcome

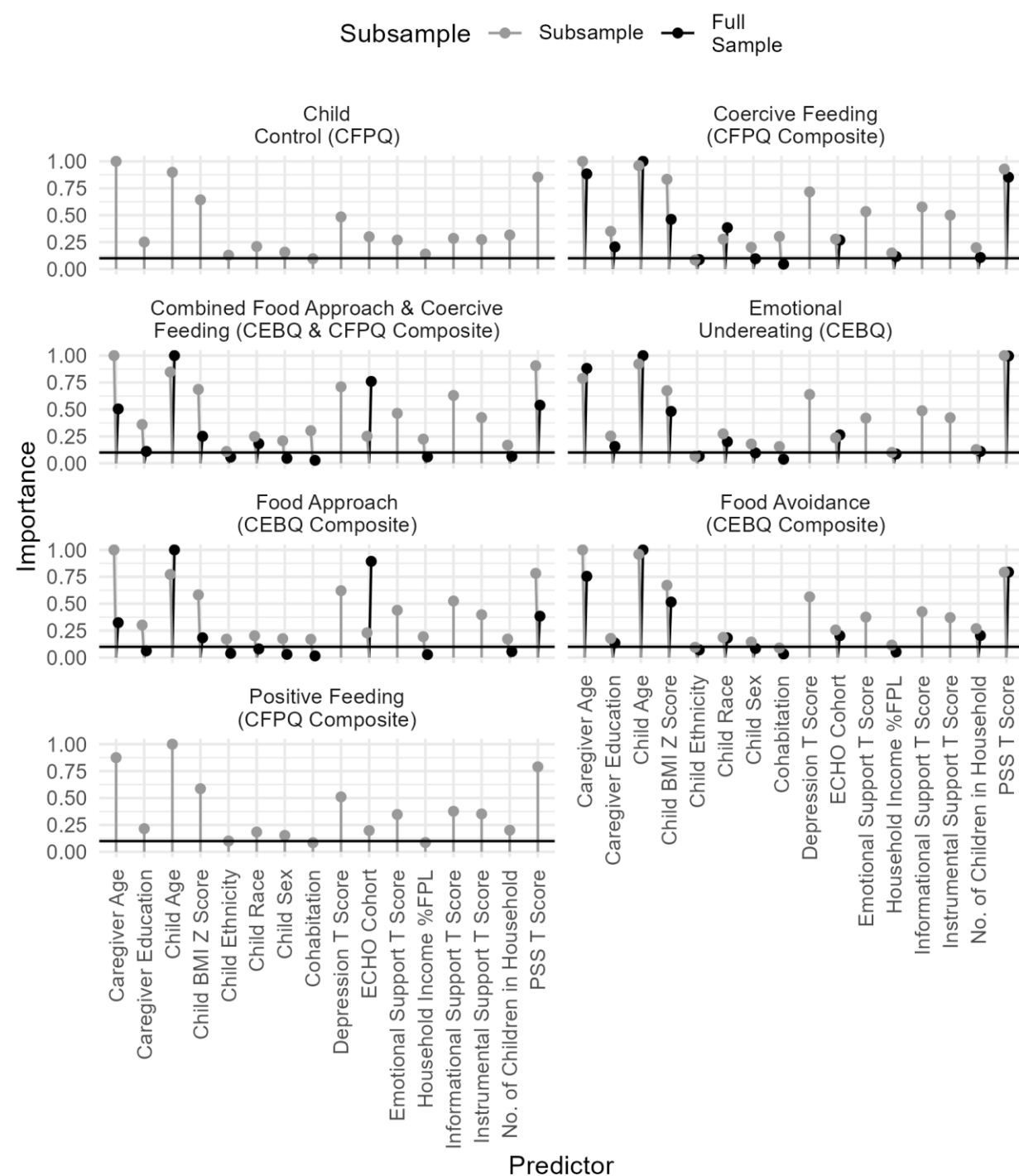


Random Forest Results

In any predictive model, we can scramble a predictor and see how much prediction accuracy (MSE) is reduced.

This quantifies variable *importance* for the predictive model.

Here, importance was rescaled to the maximum for each outcome.

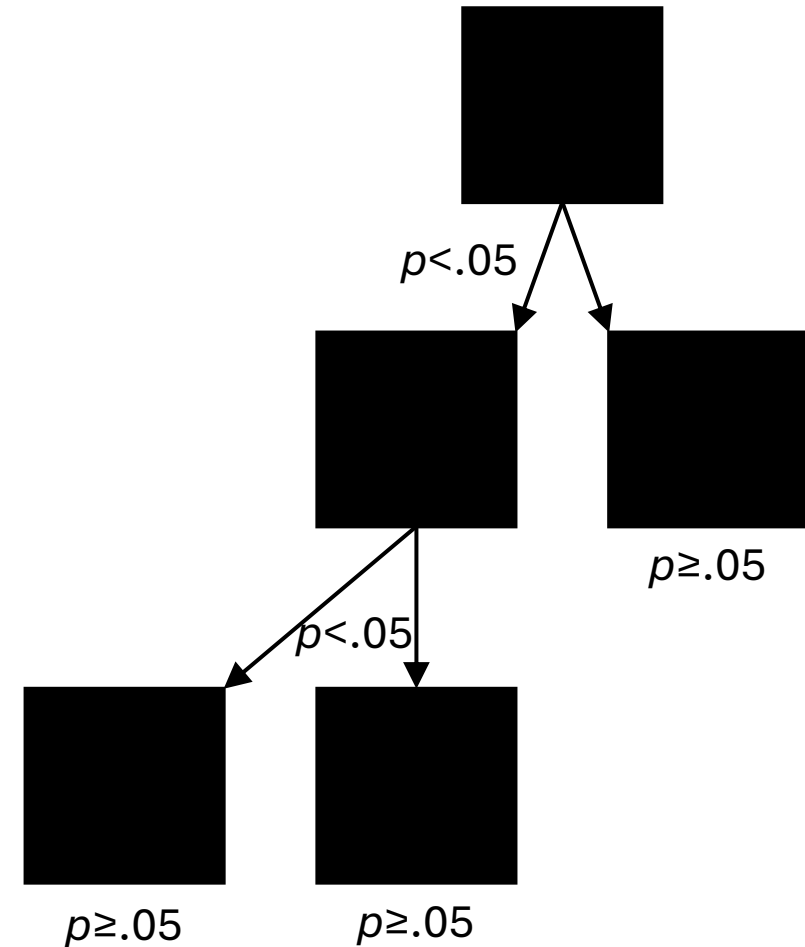


Incorporating Complexity: Recursive Partitioning

Three-Stage Process:

2. A directly interpretable model: *conditional inference trees*

- Splits based on statistical significance
 - For each predictor, find the binary partition that most reduces MSE
 - Get a p -value for it
 - Bonferroni-correct p -values to
 - Select next split, or
 - If nothing is stat sig, stop partitioning



Example: Food Avoidance in Subsample (N=185)

Model formula

cebq_FoodAvoidance ~ ECHO Study Site + PSS T Score + Depression T Score + Emotional Support T Score +
Informational Support T Score + Instrumental Support T Score + Child BMI Z Score +
Caregiver Education + Household Income %FPL + Cohabitation + Child Sex +
Child Race + Caregiver Age + Child Ethnicity + Child Age +
No. of Children in Household

Fitted ctree

[1] root

n

|185

Food Avoidance Mean (SD)

|2.7 (0.6)

Example: Food Avoidance in Subsample (N=185)

Model formula

cebq_FoodAvoidance ~ ECHO Study Site + PSS T Score + Depression T Score + Emotional Support T Score +
Informational Support T Score + Instrumental Support T Score + Child BMI Z Score +
Caregiver Education + Household Income %FPL + Cohabitation + Child Sex +
Child Race + Caregiver Age + Child Ethnicity + Child Age +
No. of Children in Household

Fitted ctree

	n	Food Avoidance Mean (SD)
[1] root	185	2.7 (0.6)
└── [2] Caregiver Age <= 32.9	125	2.6 (0.5)
└── [3] Caregiver Age > 32.9	60	2.9 (0.6)

Bonferroni-corrected $p < .05$



Example: Food Avoidance in Subsample (N=185)

Model formula

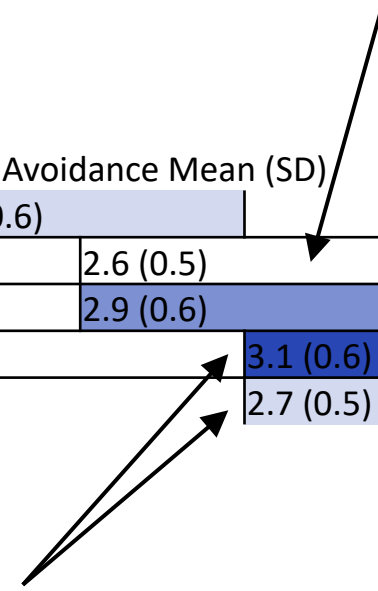
cebq_FoodAvoidance ~ ECHO Study Site + PSS T Score + Depression T Score + Emotional Support T Score +
Informational Support T Score + Instrumental Support T Score + Child BMI Z Score +
Caregiver Education + Household Income %FPL + Cohabitation + Child Sex +
Child Race + Caregiver Age + Child Ethnicity + Child Age +
No. of Children in Household

Fitted ctree

	n	Food Avoidance Mean (SD)
[1] root	185	2.7 (0.6)
└── [2] Caregiver Age <= 32.9	125	2.6 (0.5)
└── [3] Caregiver Age > 32.9	60	2.9 (0.6)
└── [4] Instrumental Support T Score <= 54.19	30	3.1 (0.6)
└── [5] Instrumental Support T Score > 54.19	30	2.7 (0.5)

All Bonferroni-corrected $p \geq .05$

Bonferroni-corrected $p < .05$



Example: Food Avoidance in Full Sample (N=3556)

Fitted ctree	n	Food Avoidance CEBQ Composite Mean (SD)
[1] root	3556	2.6 (0.6)
└─[2] Child Age ≤ 2.14342	1215	2.4 (0.6)
└─└─[3] No. of Children in Household ≤ 2	660	2.5 (0.6)
└─└─└─[4] Child BMI Z Score ≤ -0.54	227	2.6 (0.6)
└─└─└─[5] Child BMI Z Score > -0.54	432	2.5 (0.6)
└─└─[6] No. of Children in Household > 2	555	2.3 (0.5)
└─[7] Child Age > 2.14342	2341	2.7 (0.6)
└─└─[8] No. of Children in Household ≤ 2	1404	2.8 (0.6)
└─└─└─[9] Child BMI Z Score ≤ 0.3	895	2.9 (0.6)
└─└─└─└─[10] PSS T Score ≤ 43.96	260	2.8 (0.6)
└─└─└─└─[11] PSS T Score > 43.96	635	2.9 (0.6)
└─└─└─[12] Child BMI Z Score > 0.3	509	2.7 (0.6)
└─└─[13] No. of Children in Household > 2	937	2.6 (0.6)
└─└─└─[14] No. of Children in Household ≤ 3	575	2.7 (0.6)
└─└─└─└─[15] Child BMI Z Score ≤ 0.13	316	2.8 (0.6)
└─└─└─└─[16] Child BMI Z Score > 0.13	259	2.6 (0.6)
└─└─└─[17] No. of Children in Household > 3	362	2.5 (0.5)
└─└─└─└─[18] Child Race in White, Asian, Other	254	2.5 (0.5)
└─└─└─└─[19] Child Race in Multiple, Black	108	2.4 (0.5)
└─└─└─[20] Caregiver Age ≤ 32.9	75	2.4 (0.5)
└─└─└─└─[21] Caregiver Age > 32.9	33	2.6 (0.6)
└─└─└─└─[22] Child Race in Multiple	20	2.5 (0.6)
└─└─└─└─[23] Child Race in Black	13	2.7 (0.5)

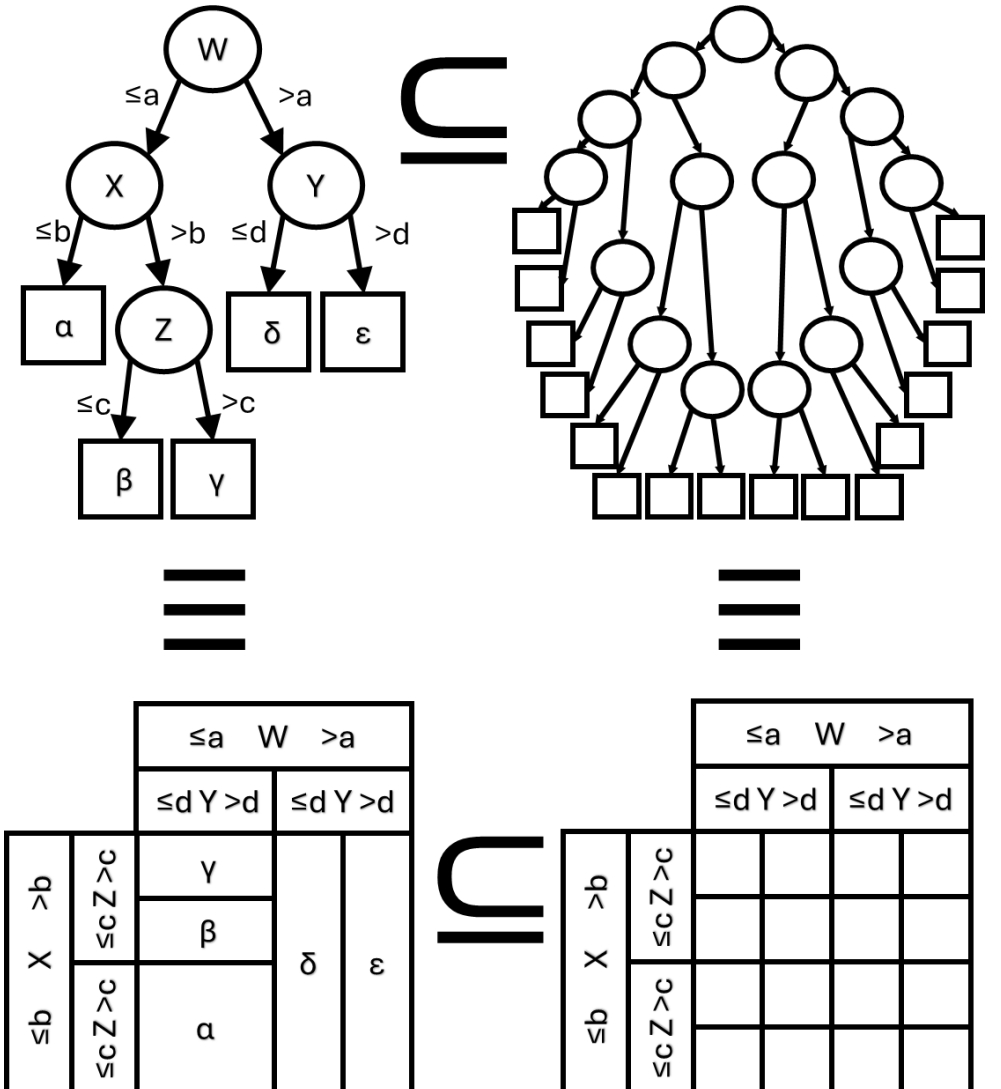
From Trees to ANOVA: Simplification

Every tree subdivides the data (*top-left*)

Data can then be further subdivided by all combinations of splitting variables (*top-right*)

So, if the tree is equivalent to a partitioning of the data... (*bottom-left*)

... then the same relationships can be captured by a fully factorial analysis of variance (ANOVA)



Summary of ANOVA Results

Predictor	Emotional Undereating (CEBQ)	Food Avoidance (CEBQ Composite)	Food Approach (CEBQ Composite)	Combined Food Approach & Coercive Feeding (CEBQ & CFPQ Composite)	Coercive Feeding (CFPQ Composite)	Child Control (CFPQ)	Positive Feeding (CFPQ Composite)
Full Sample							
Caregiver Age		+		-	-		
Caregiver Education				_*	_*		
Child Age		+*		+*	+*		
Child BMI Z Score		_*					
Child Ethnicity			~	~			
Child Race		~	~	~*	~*		
ECHO Study Site			~*	~*	~*		
No. of Children in Household		_*					
PSS T Score		+	+*	+*	+		
Household Income (% FPL)					_*		
Child Race by Child Sex	#						
Subsample							
Caregiver Age		+*	_*				
Caregiver Education	+						+
Child Race				~*	~*		
PSS T Score	+*						
Informational Support T Score				_*	_*		
Emotional Support T Score			_*				
Caregiver Age by Instrumental Support T Score		#*					
ECHO Study Site by Cohabitation						#	

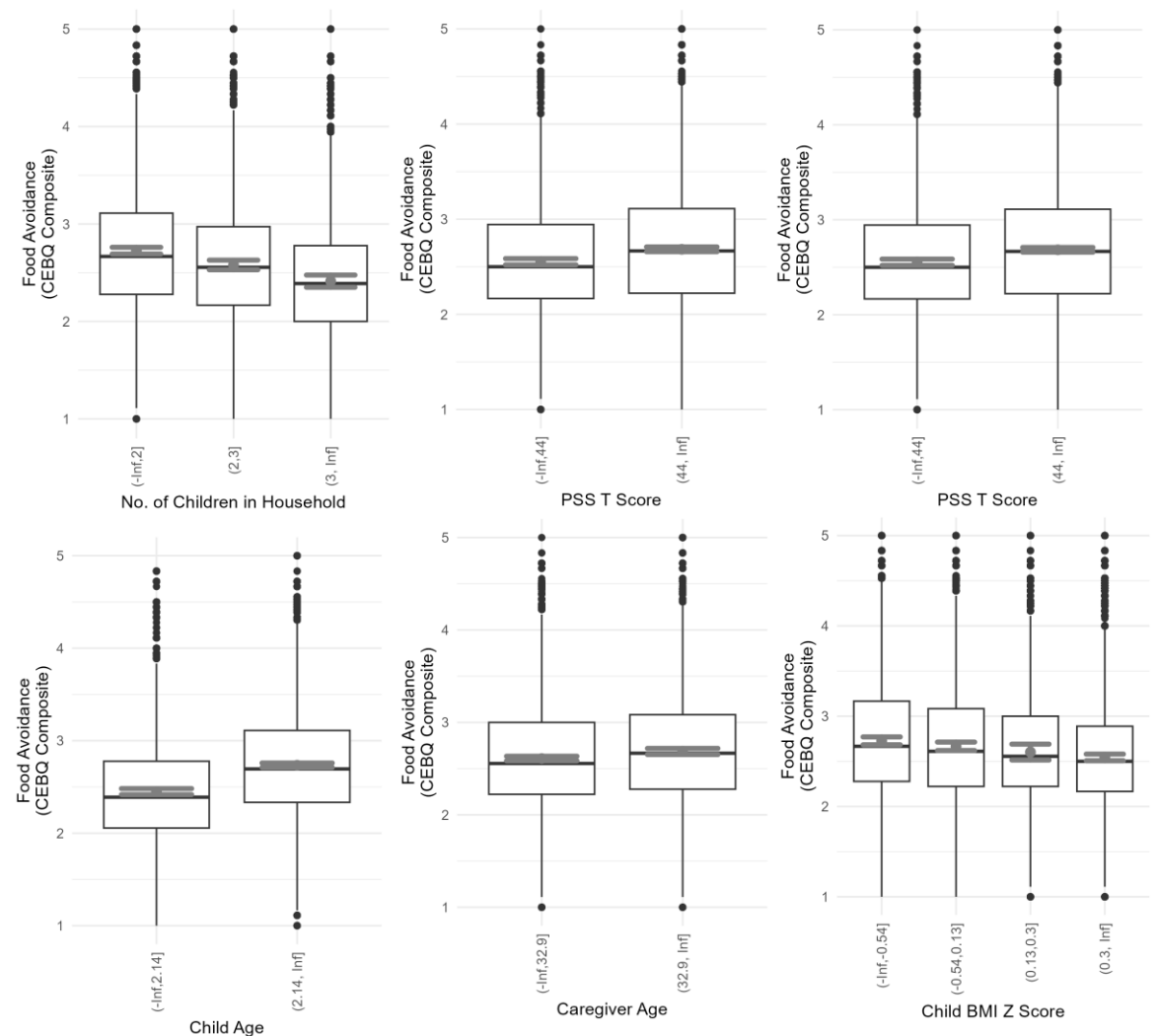
Note. + indicates positive association; - indicates negative association; ~ indicates nondirectional association; # indicates interaction; * indicates significance in Scheffe post-hoc tests

Boxplots for (a few) Significant Results

Six univariate associations for *Food Avoidance* in the full sample (N=3556)

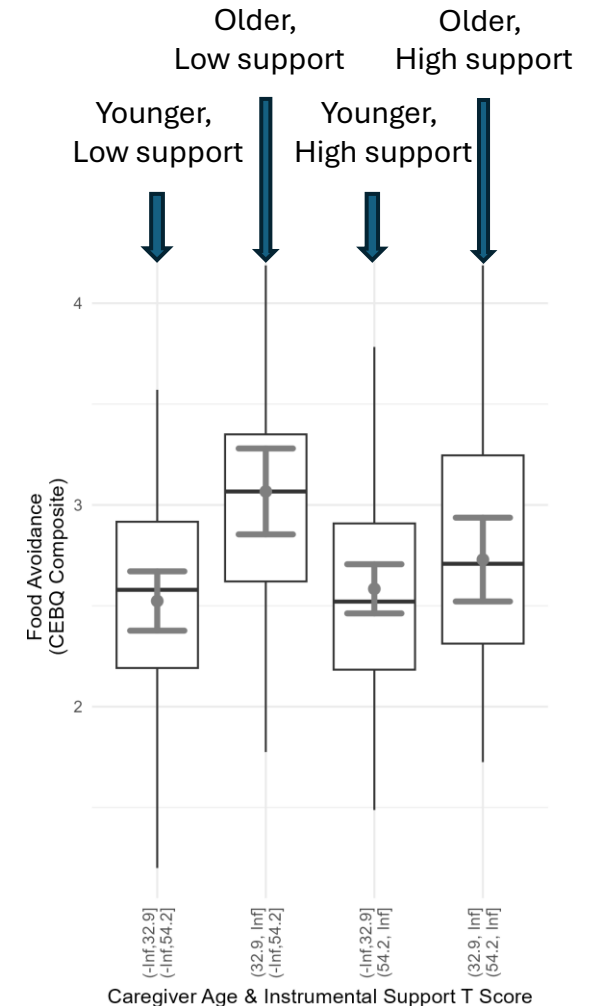
No significant interactions in step-wise ANOVA in full sample

Statistically conservative,
consistent with exploratory aims



A few key results

- Higher stress associated with
 - Coercive feeding, Food approach, Emotional Undereating
- Caregiver and Child Age associated with
 - Food fussiness in older toddlers
 - Coercive feeding in older children and younger parents
- Higher caregiver age associated with *more* picky eating, inconsistent with prior research
- Support helps, and interacts with age. Here, in the subsample...
 - Highest *Food Avoidance* among older mothers with less support
 - Lowest among low-age high-support and high-age high-support.
 - Same conclusion from ctree and ANOVA



Fitted ctree	n	Food Avoidance Mean (SD)
[1] root	185	2.7 (0.6)
└── [2] Caregiver Age ≤ 32.9	125	2.6 (0.5)
└── [3] Caregiver Age > 32.9	60	2.9 (0.6)
└── [4] Instrumental Support T Score ≤ 54.19	30	3.1 (0.6)
└── [5] Instrumental Support T Score > 54.19	30	2.7 (0.5)

What did we learn?

Scientific

- Rich data examination in a large multicenter cohort
- Hypothesis generation for future research
- Identification of thresholds (e.g., 2.7yrs for coercive feeding)

Methodological

- Presenting and interpreting models that match the complexity of the data takes work but is worth the effort.
- Compare/contrast with linear models

Thank you!