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SPSP 2018 | SOCIETY FOR PERSONALITY AND SOCIAL PSYCHOLOGY

Uncovering Hidden Moderators with Machine Learning

Alexander Danvers

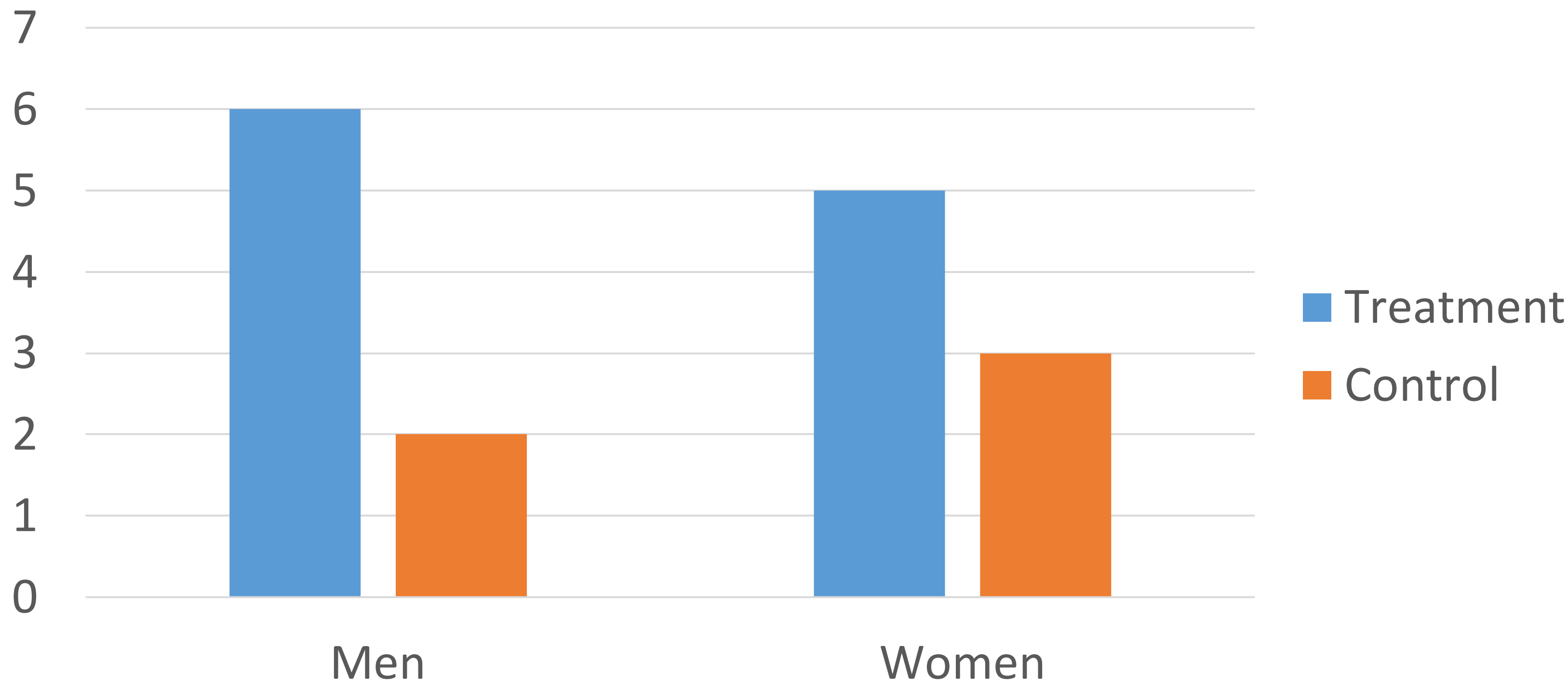
David Lovis-McMahon

Hidden Moderators

- Moderators change an effect size, but we may not know all moderators ahead of time
- Failures to replicate effects may be the result of not accounting for crucial (but unknown) moderators
- Identifying hidden moderators can also help us determine if interventions work better for some people (see Imai & Strauss, 2011; Imai & Ratkovic, 2013)
- We want a ***test*** to determine if there are hidden (not predicted) moderators

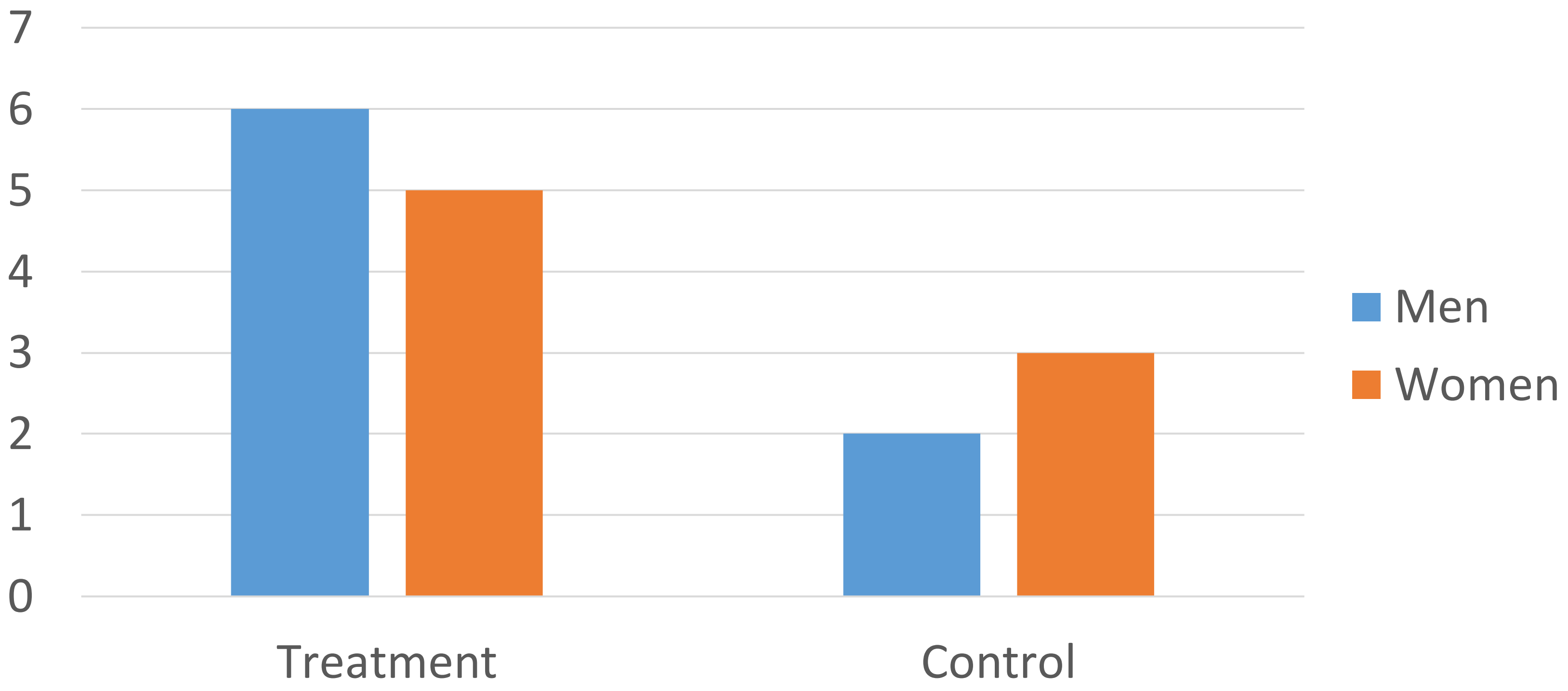
What is a Moderator?

A variable that ***changes*** an effect size



What is a Moderator?

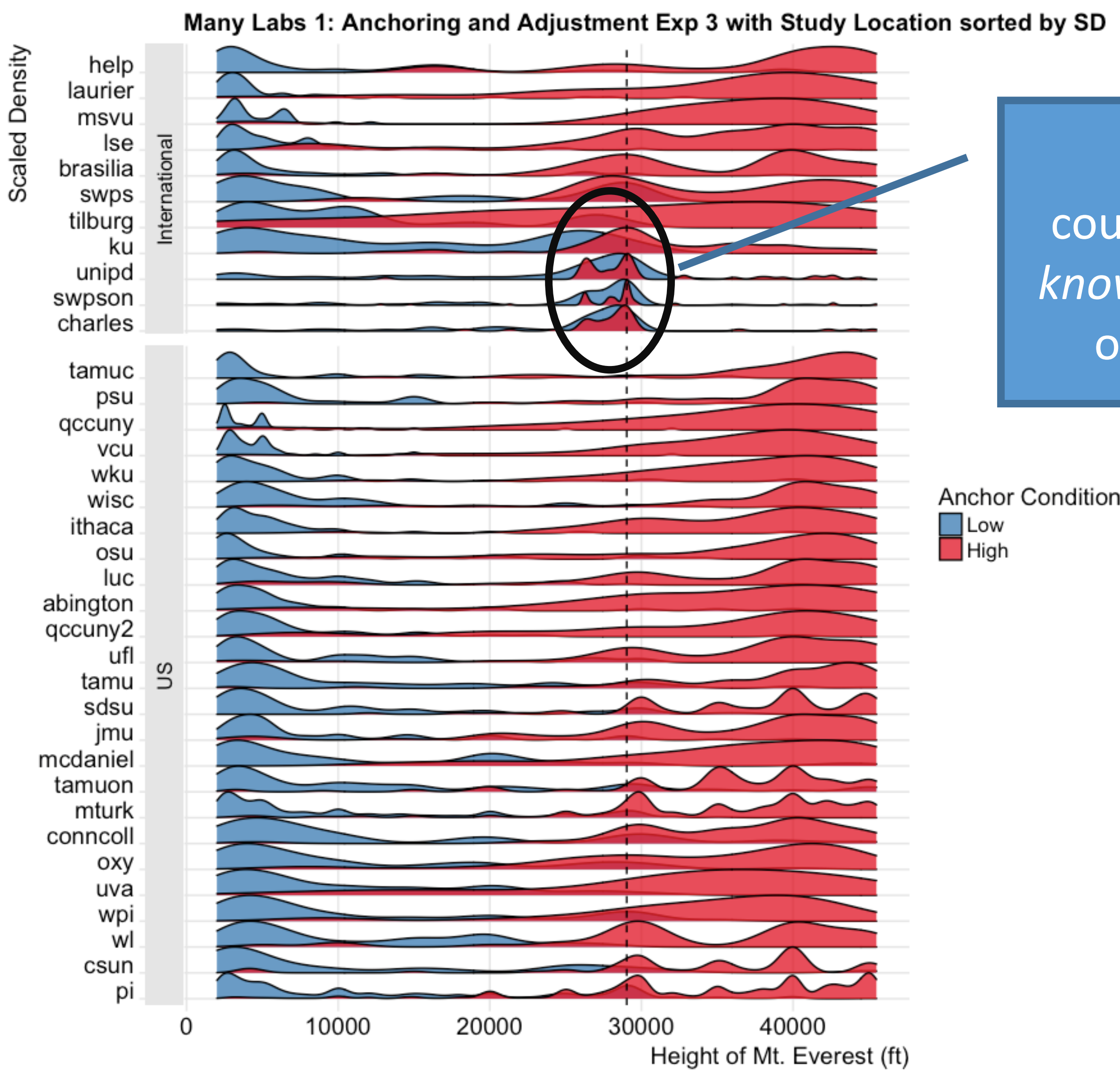
A ***covariate*** with different effects across groups



The Many Labs 1 Data

- 15 experiments, all involving two conditions
  - 10 of these were analyzed for the current project
  - Excluded studies with binary outcomes (for now)
- 36 data samples, with 6,344 participants
- Previous analysis used U.S./non-U.S. and Lab/Online as moderators, in a GLM framework
  - US/non-U.S. moderated 5 effects
  - Lab/online moderated 6 effects

Finding Hidden Moderators the Old Fashioned Way



In some countries, they *know* the height of Everest!

#SPSP2

Finding Hidden Moderators the Regression Way

- Regression analysis can be used to test whether a specific moderating effect is significant (Aiken & West, 1994)
- A special interaction term is created, and the significance of the regression coefficient is tested

$$\hat{Y} = b_0 + b_1 X + b_2 M + b_3 X * M$$

Limitations to the Regression Approach

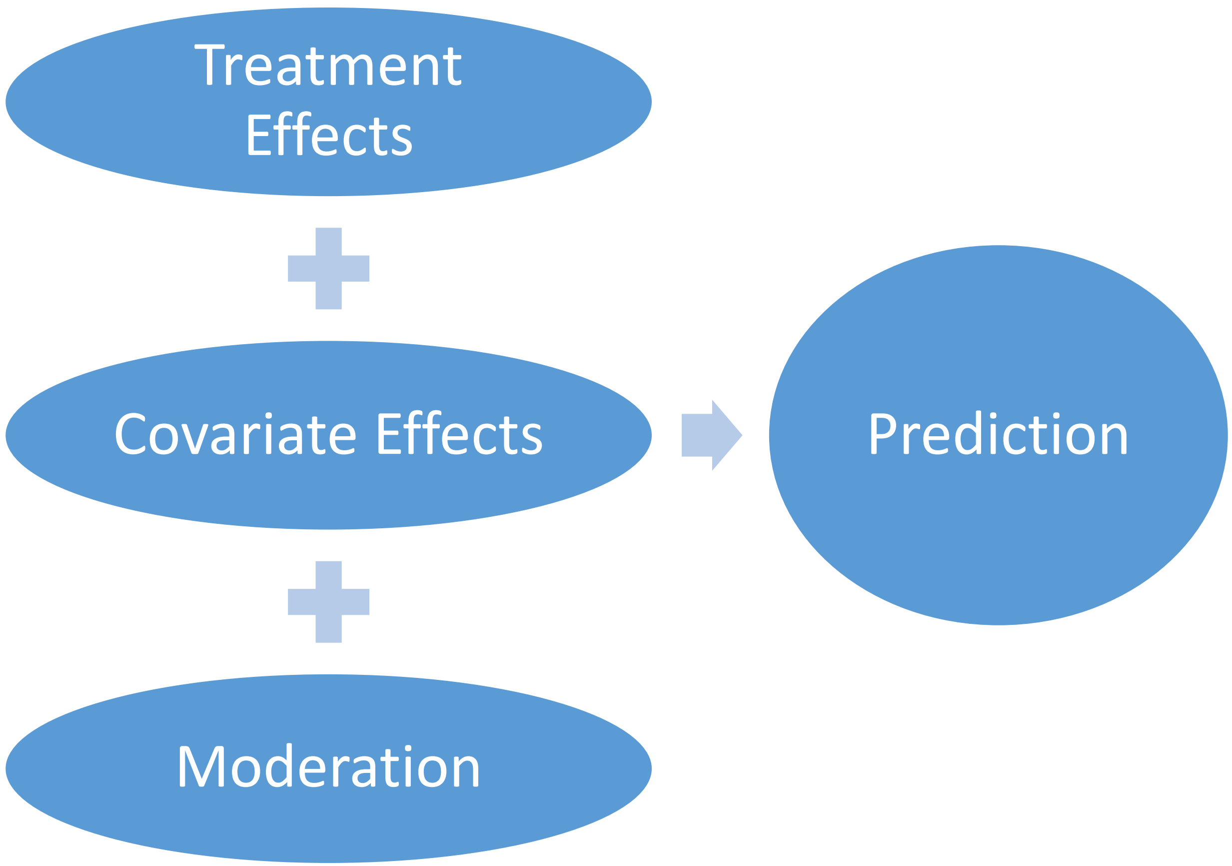
- New terms need to be constructed for each potential moderator
- What if there are higher order interactions?
  - The effect is different not just for men and women, but according to ethnicity (intersectionality in moderators)

What if we could test all of the possible moderating relationships in one step?

Machine Learning

- Emphasize accurate prediction of the overall model, without testing specific predictors
  - "Success" is based on accurate prediction of *new data*
  - Not based on a significance test or p-value
- Flexible algorithms allow for nonlinearity and interactions between variables to be discovered bottom-up
- Typically require larger data sets to reliably identify complex patterns

Types of Effects



Types of Effects

Treatment Effects → Mean difference between groups

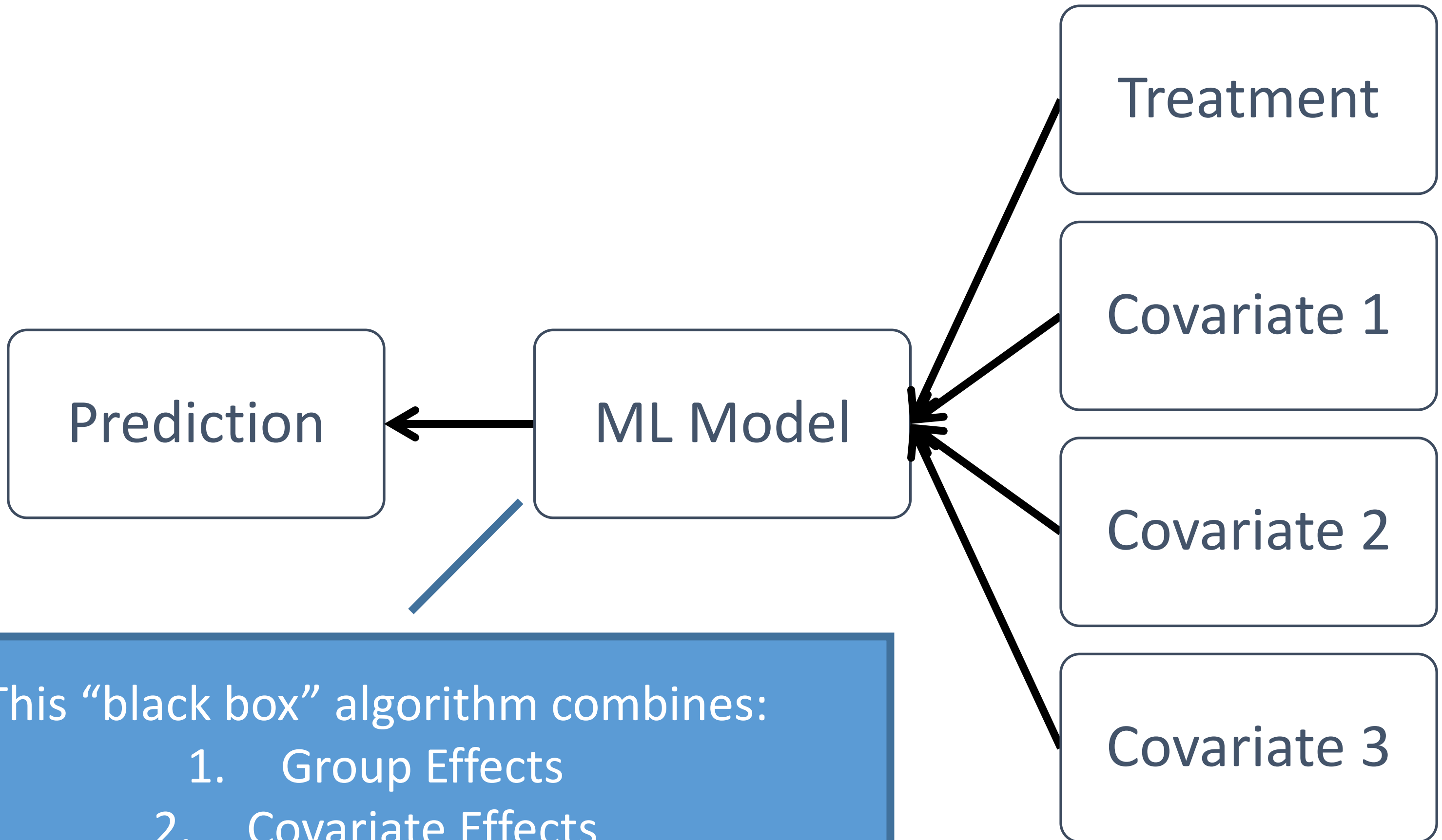
\+

Covariate Effects → Complex, nonlinear interactions between covariates

\+

Moderation → Complex, nonlinear interactions of covariates with treatment

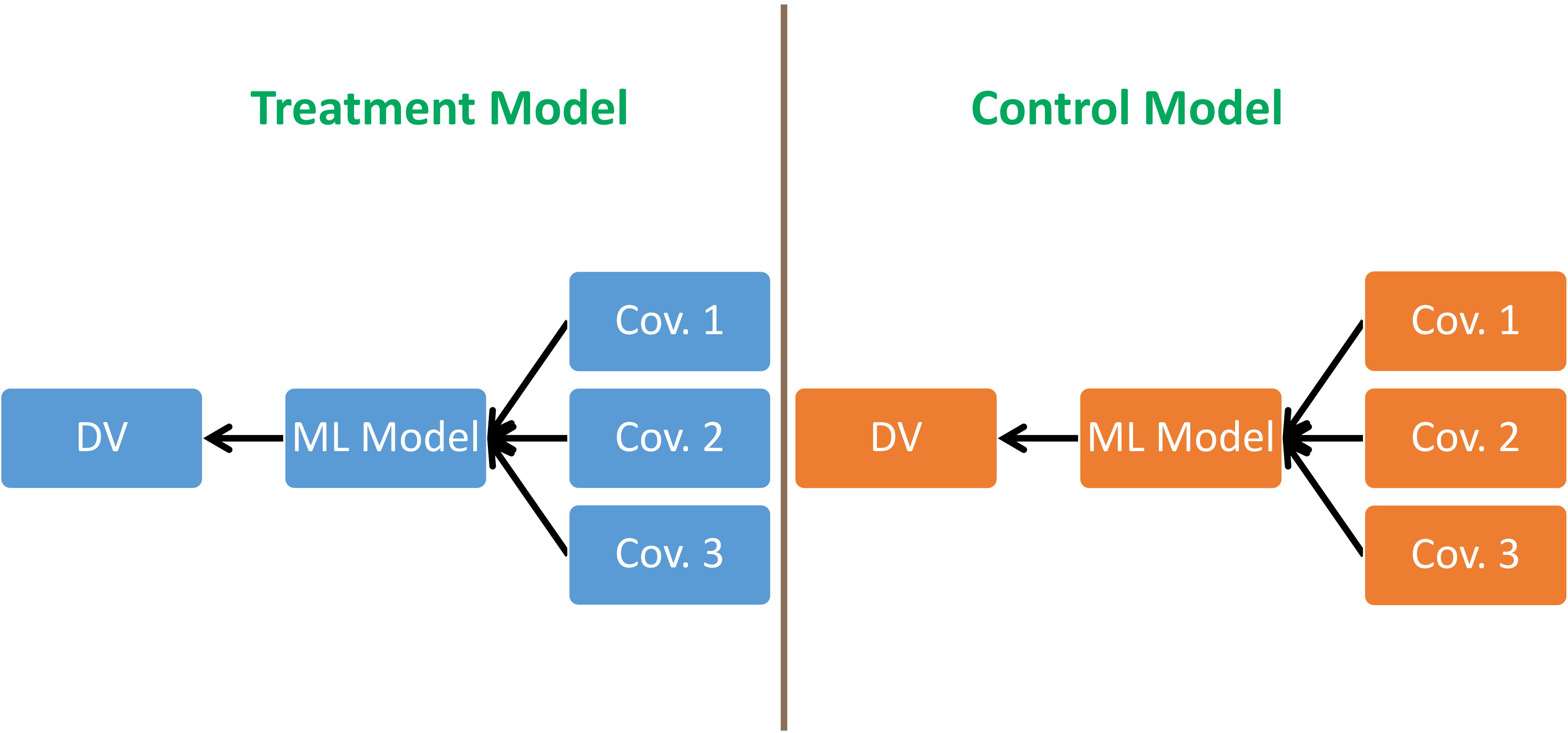
Simple Predictive Model



This "black box" algorithm combines:

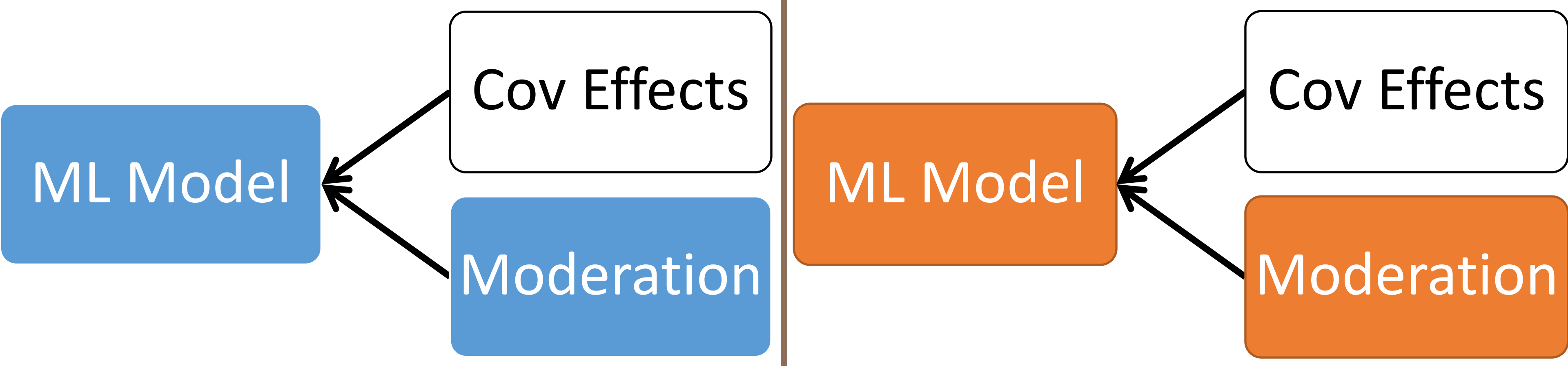
1. Group Effects
2. Covariate Effects
3. Moderation Effects

Separate Models for Conditions



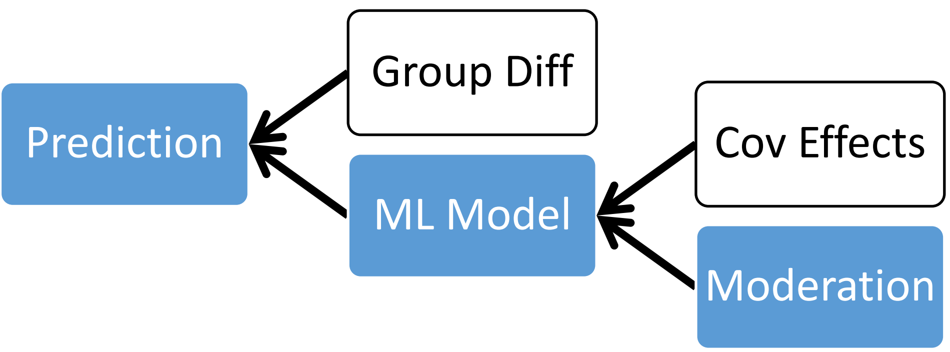
Differences Between the Algorithms

Treatment | **Control**

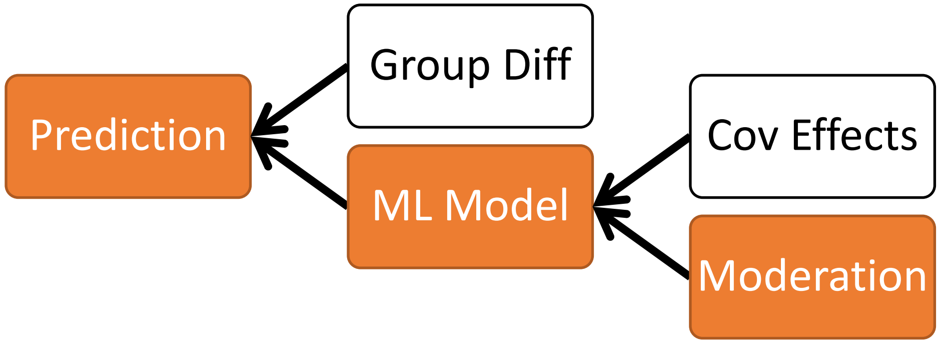


Counterfactual Thinking

Prediction from Treatment Model

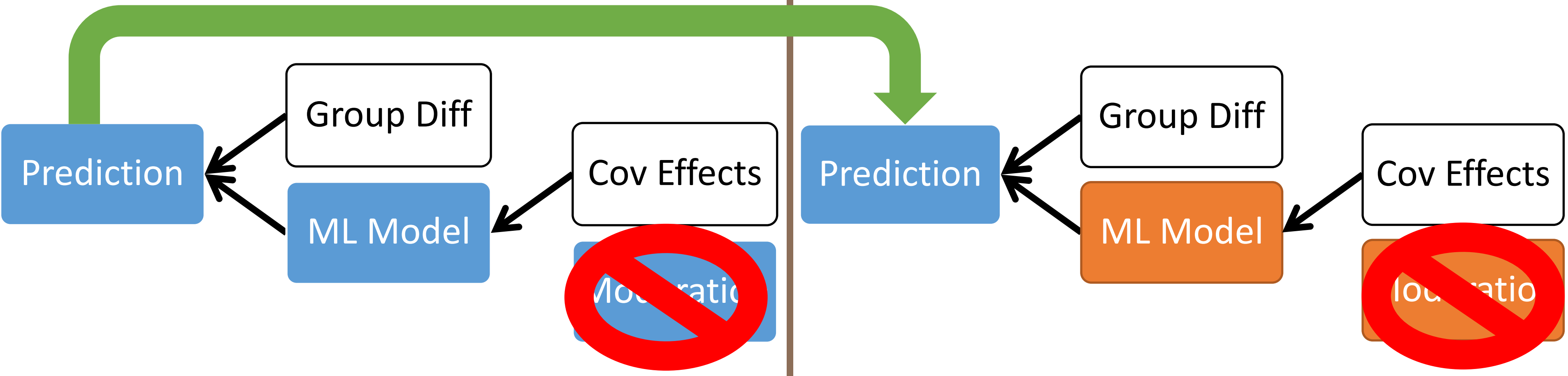


Prediction from Control Model



No Moderation

Prediction from Treatment Model | **Prediction from Control Model**



Our Approach

1. Divide the data into two groups, according to who was in the ***treatment*** and who was in the ***control*** group
2. Train ***random forest models*** on each group separately, including all potential moderators.
3. Examine the ***difference in predictive accuracy*** for each model

Simulation Results

- 300 Ps randomly assigned to treatment or control
- 3 potential moderators
- Conditions:
  - 0, 1, 2, or all 3 are actually moderators
  - There are 1, 2, or 3 two-way multiplicative interactions between moderators and the effect
- Qs:
  - Can we identify whether hidden moderators are present?

Are Moderators Present?

- A *t*-test of differences in prediction error for treatment vs control

Condition	Proportion of Sig *t*-tests	
	p < .05	*p* < .01
No mods	8.5%	2.5%
1 mod	94.6%	85.4%
2 mod	99.8%	99.2%
3 mod	100.0%	100.0%
1 2way	100.0%	100.0%
2 2way	100.0%	100.0%
3 2way	100.0%	100.0%

Many Labs 1: Moderators

- U.S. or International Sample
- Whether participants were together or separate
- Order of presentation for the study
- Participant gender
- Participant age
- Participant race
- What day the study was conducted
- What time of day the study was conducted
- How long the participant took completing the survey

Many Labs 1: Results

Study	Group Diff	Error Diff	*t*	*p*-value
Anchoring: Baby	**1.476**	**0.041**	**11.777**	**<.001**
Anchoring: Chicago	**1.331**	**0.046**	**8.682**	**<.001**
Anchoring: Mt. Everest	**1.510**	**0.098**	**15.488**	**<.001**
Anchoring: NYC	**1.006**	**0.046**	**8.096**	**<.001**
Currency Priming	-0.019	-0.006	-1.371	.170
Flag Priming	**0.029**	**-0.009**	**-2.237**	**.025**
Imagined Contact	0.130	0.004	0.761	.446
Quote Attribution	0.317	0.006	1.249	.212
Rev. Gambler's Fal	**0.597**	**0.066**	**12.892**	**<.001**
Sunk Cost	-0.272	-0.004	-0.970	.332

Can we identify specific moderators?

Short answer: No

Long answer: Maybe

- Random Forest Models include measures of "variable importance" based on how much a particular variable improved prediction.
- We can compare the ***ratio*** of variable importance in the treatment model to that of the control model

Simulation: Which Moderators Are Important?

	No mods	1 mod	2 mod	3 mod	1 2 way	2 2 way	3 2 way
M1 LM	0.00	**0.87**	**0.87**	**0.86**	**4.34**	**7.82**	**7.79**
M1 RF*	0.03	**2.58**	**2.57**	**2.53**	**66.20**	**207.60**	**207.35**
M2 LM	0.00	0.00	**0.87**	**0.86**	**4.33**	**4.35**	**7.82**
M2 RF*	0.03	0.06	**2.55**	**2.54**	**66.09**	**69.53**	**210.11**
M3 LM	0.00	0.00	0.00	**0.87**	**0.87**	**4.35**	**7.81**
M3 RF*	0.02	0.04	0.01	**2.56**	**5.52**	**69.81**	**207.45**

*Ratios of variable importance measures

Many Labs 1: Which Moderators are Important?

Study	Order	Sex	Age	Race	US/In	Sep?	Day	T.O.D	Time
Anchoring: Baby	**6.22**	**4.89**	**5.75**	**7.14**	**6.35**	**6.50**	**5.98**	**5.50**	**5.13**
Anchoring: Chicago	**1.93**	**0.51**	**1.32**	**1.87**	**1.40**	**1.64**	**1.70**	**1.93**	**1.94**
Anchoring: Mt. Everest	0.87	**0.62**	0.83	**0.66**	**0.55**	**0.58**	**0.79**	0.82	0.90
Anchoring: NYC	**1.81**	**1.79**	**1.81**	**1.63**	1.14	**1.51**	**1.67**	**1.69**	**1.72**
Currency Priming	0.97	0.94	1.04	1.08	1.06	1.01	0.98	0.95	0.97
Flag Priming	1.04	1.07	1.01	0.96	0.98	1.07	1.02	1.06	1.04
Imagined Contact	0.91	0.81	0.91	0.89	0.94	0.95	0.92	0.92	0.94
Quote Attribution	1.19	**1.48**	**1.22**	1.01	**1.21**	**1.31**	1.17	1.17	1.19
Rev. Gambler's Fal	**2.12**	**2.57**	**2.40**	**2.37**	**3.06**	**1.96**	**2.03**	**1.98**	**1.96**
Sunk Cost	**1.47**	**1.38**	1.11	**1.57**	**1.50**	**1.47**	**1.37**	**1.43**	**1.42**

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Limitations

- Favors prediction over interpretability.
  - Allows for systems of interacting variables
- Promising simulation results so far, but more tests needed.
  - Wider range of effect sizes, categorical moderators, exponential and higher order polynomials as moderators
- Results suggest new hypotheses to test. They do not definitively prove the presence of moderators.

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