

Everything in Moderation: Using Proximal and Distal Measures to Forecast the Long-term Impacts of Math Interventions

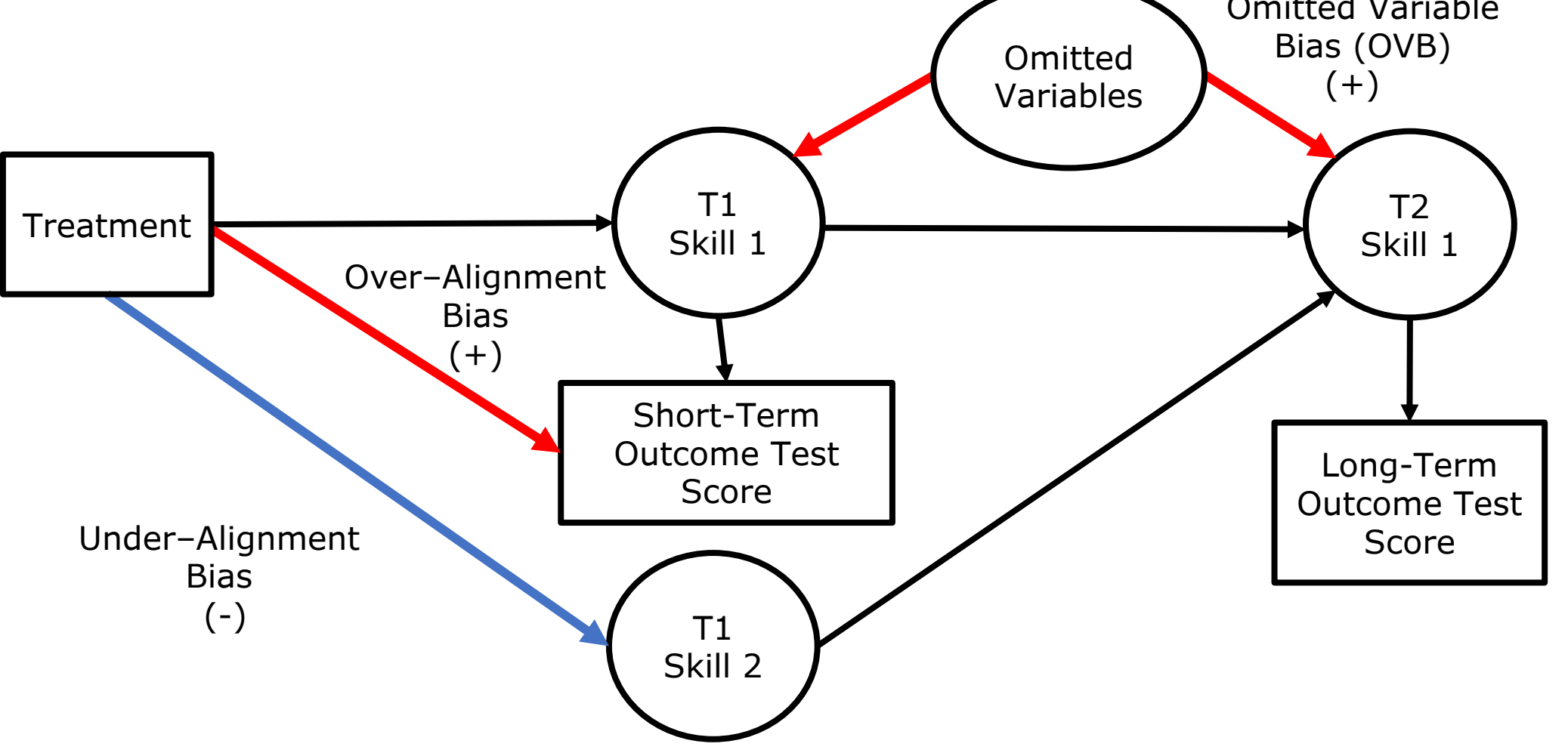
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“Biases in forecasting the long-term impacts of an intervention may be reduced by including measures of skills both proximal and distal to the intervention at the end of treatment.”

Introduction

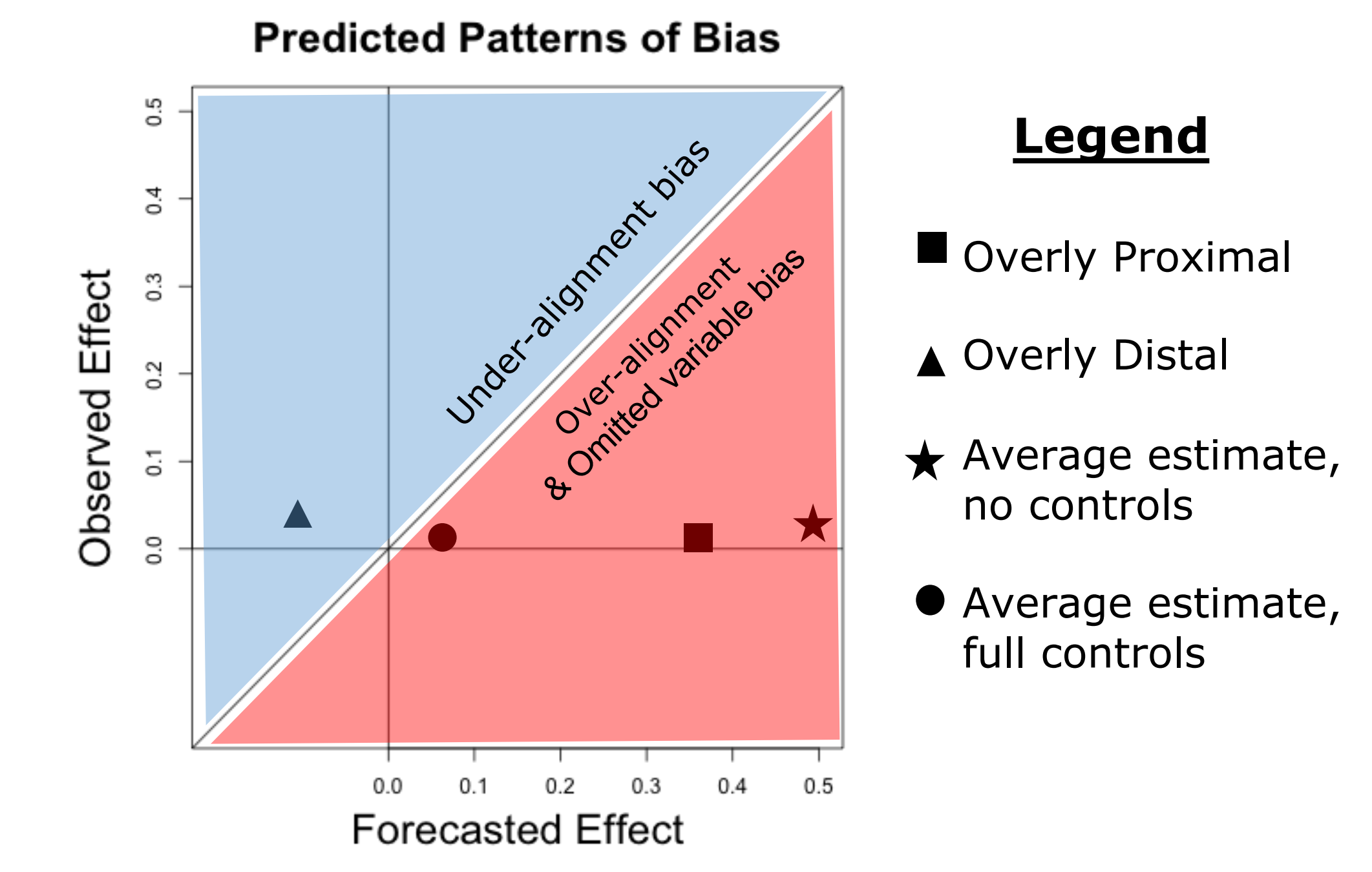
- Interventionists often justify short-term intervention targets based on their potential for long-run effects.¹
- We can forecast long-term outcomes using non-experimental data.²
- Past attempts have overestimated or underestimated these outcomes.^{2,3}

Sources of Bias in Forecasts

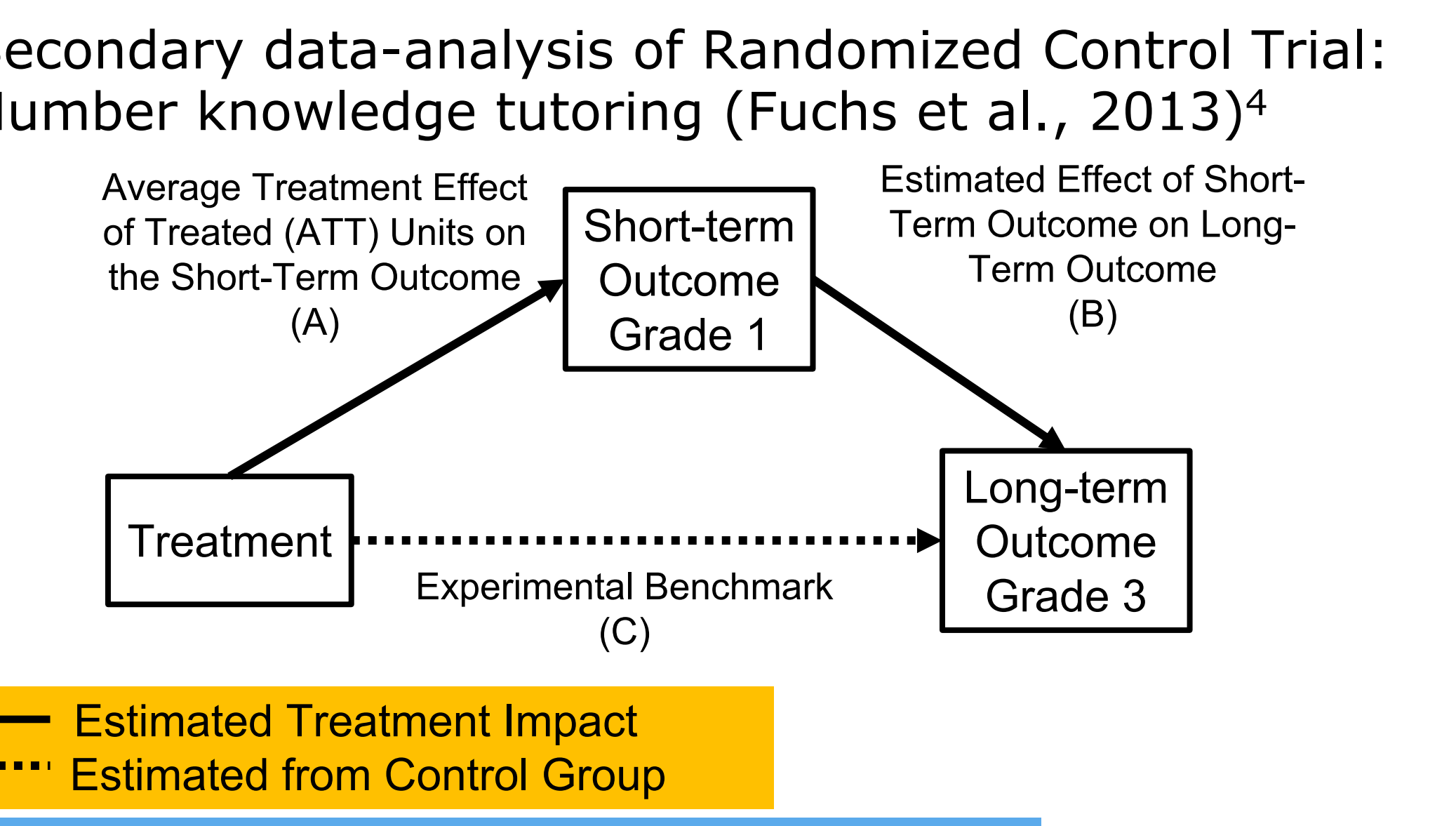


Hypotheses

- Using proximal short-term measures leads to over-estimated forecasts (over-alignment bias)
- Using distal short-term measures leads to under-estimated forecasts (under-alignment bias)
- Most measures will over-estimate forecasts due to omitted variable bias.
- Using a combination of proximal and distal short-term measures may yield a more accurate forecast



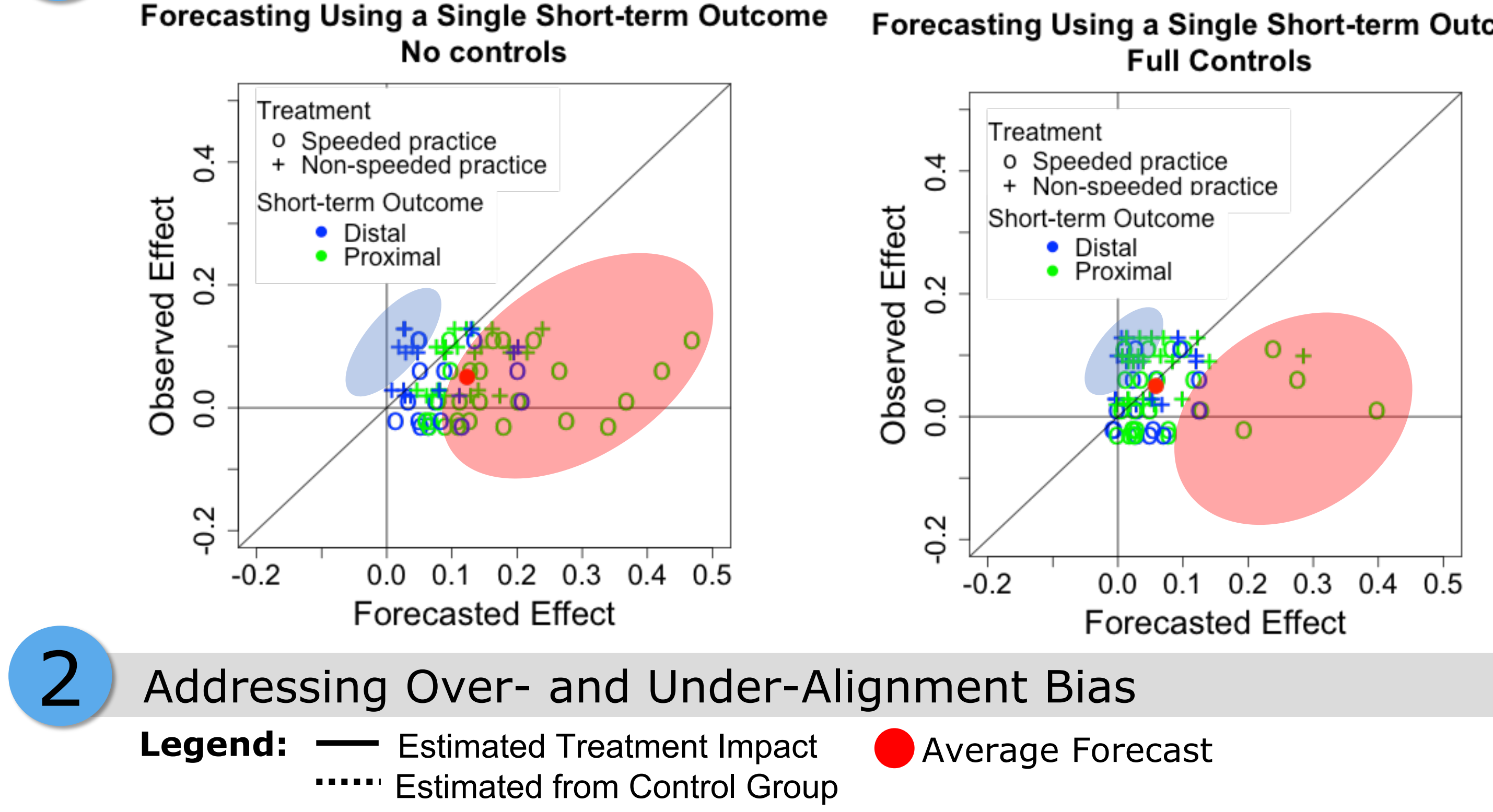
Method



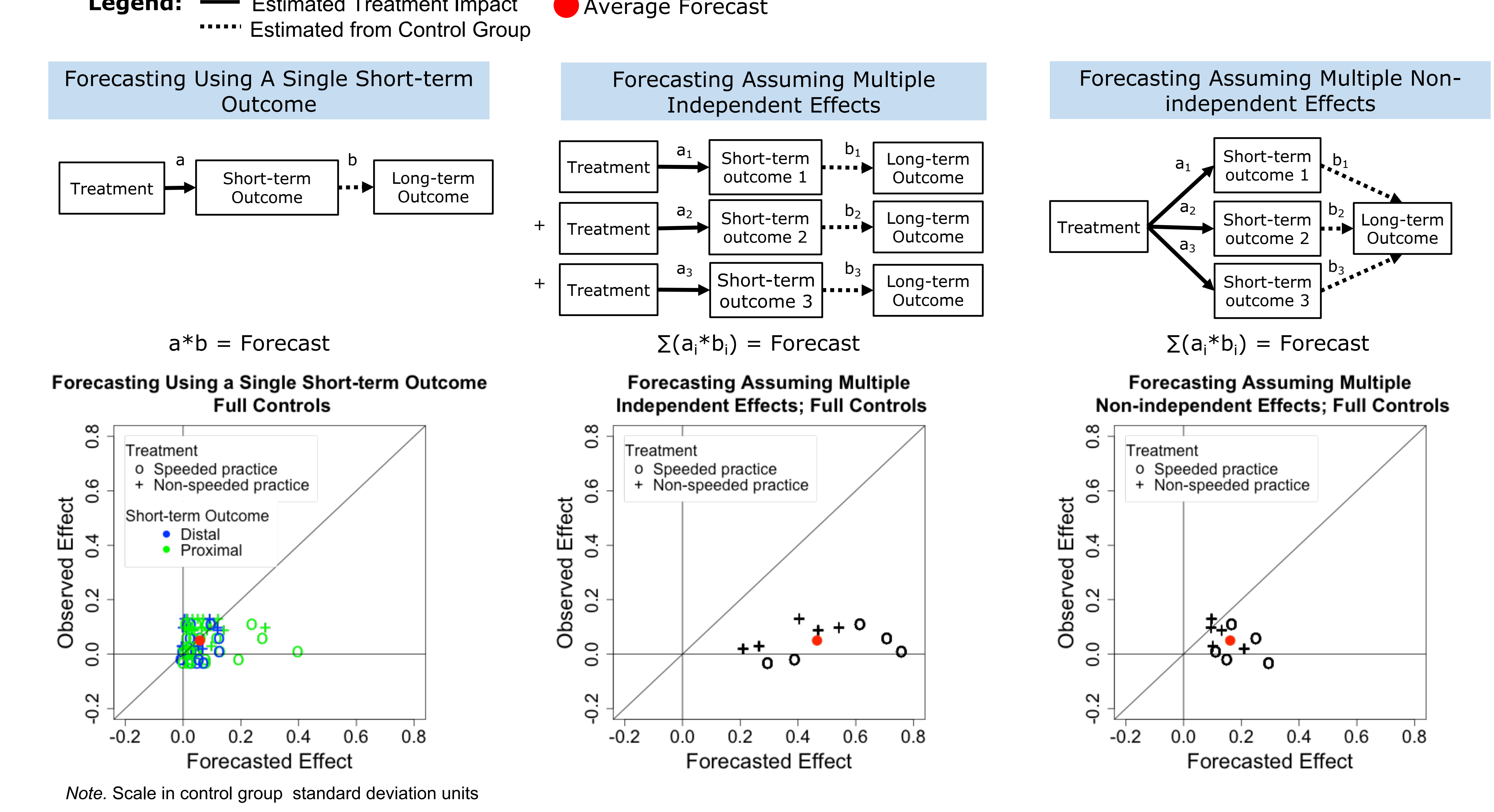
Impact (A) * Effect (B) = Forecast
 Experimental Benchmark - Forecast = Bias

Results

1 Addressing Omitted Variable Bias (OVB)

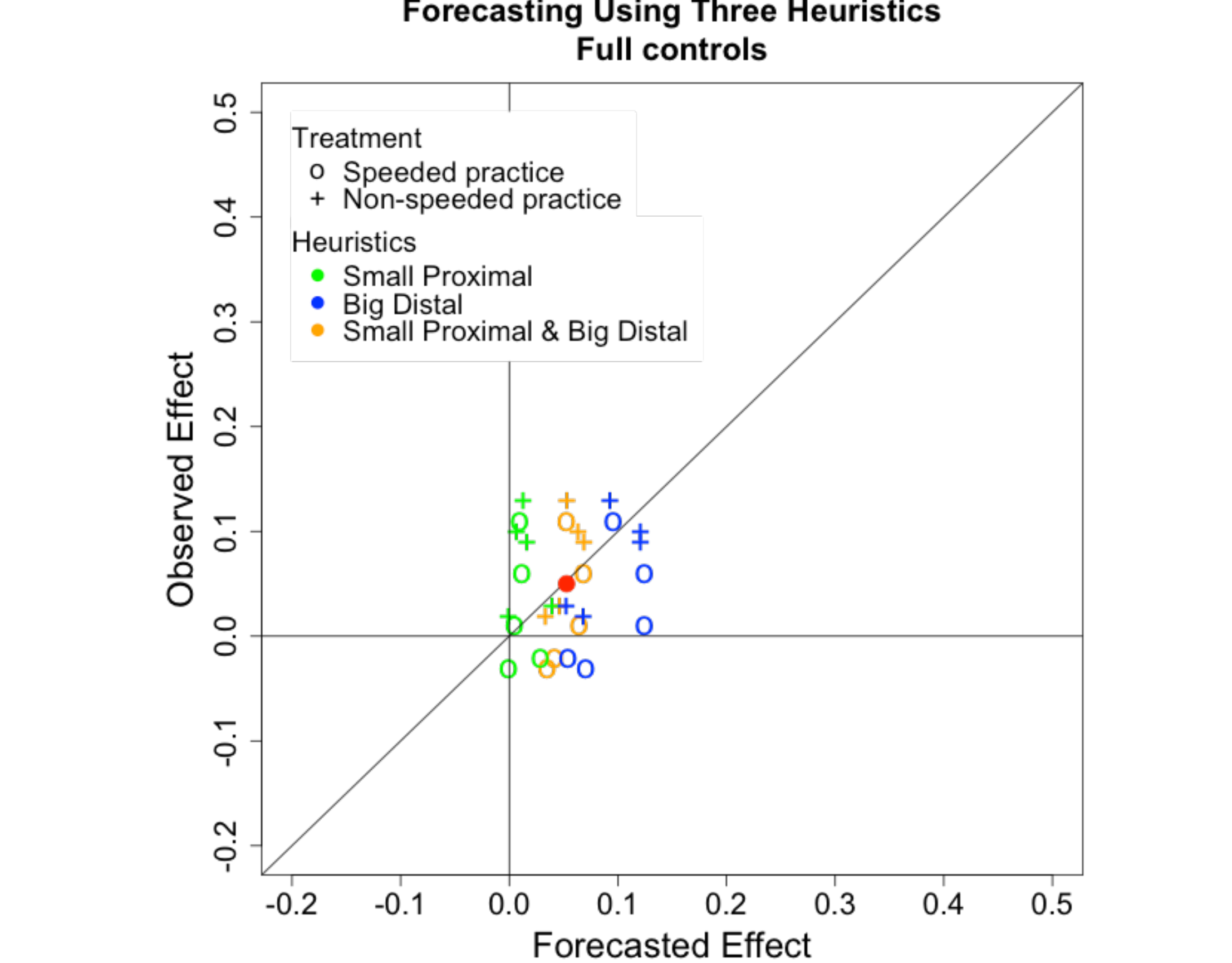


2 Addressing Over- and Under-Alignment Bias



3 Proximal and/or Distal Measures?

- Choose one proximal measure and one distal measure
- By averaging forecasts from measures that can lead to over- and under-estimation we may approximate an accurate forecast



Promising Solutions

- Use full set of pretests as controls
- Use proximal measures with small impacts and distal measures with large impacts

Poor Solutions

- Assume outcome measures have independent effects on the long-term outcome forecast

Data

Participants <ul style="list-style-type: none"> 639 students (1st - 3rd grade) 68% African American, 20% White, 7% Hispanic, 5% Other or missing, 84% Free-or-reduced price lunch 50% Female, 50% Male 	Short-term Outcome Measures (Grade 1) <ul style="list-style-type: none"> Proximal Measures: <i>Facts Correctly Retrieved, Double-Digit calculation, Story Problems, Number Sets</i> Distal Measures: <i>WRAT-arithmetic, Key-Math Numeration; Number Line Estimation</i>
Covariates <ul style="list-style-type: none"> Demographic variables: gender, free-or-reduced price lunch, English Second language learner Pretests: <i>Facts Correctly Retrieved, Double-Digit calculation, Story Problems, Number Sets, Number Line Estimation, WRAT-arithmetic, Key-Math Numeration; Number Sets</i> 	Long-term Outcome Measures (Grade 3) <ul style="list-style-type: none"> Proximal Measures: <i>Facts Correctly Retrieved, Number Sets</i> Distal Measures: <i>WRAT-arithmetic, Key-Math Numeration; Number Line Estimation</i>

Discussion

- Omitted variable, under-, and over-alignment bias are ubiquitous when estimating the magnitude of long-term relationships between skills conditional on the short-term relationships.
- Forecasting with a single short-term outcome, on average, yields an estimate that approaches the observed treatment impact.
- Forecasting with multiple non-independent short-term outcomes, on average, yields an estimate that over-estimates the observed treatment impact.
- Forecasting with multiple independent short-term outcomes, on average, yields an estimate that over-estimates the observed treatment impact.

Acknowledgements

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References: [1] Gersten, R., Jordan, N. C., & Flojo, J. R. (2005). Early identification and interventions for students with mathematics difficulties. *Journal of learning disabilities*, 38(4), 293-304. [2] Bailey, D. H., Fuchs, L. S., Gilbert, J. K., Geary, D. C., & Fuchs, D. (2018). Prevention: Necessary But Insufficient? A 2-Year Follow-Up of an Effective First-Grade Mathematics Intervention. *Child Development*. [3] Dong, N., & Lipsey, M. W. (2018). Can propensity score analysis approximate randomized experiments using pretest and demographic information in pre-k intervention research? *Evaluation Review*, 0193841X17749824. <https://doi.org/10.1177/0193841X17749824>. [4] Fuchs, L. S., Geary, D. C., Compton, D. L., Fuchs, D., Schatschneider, C., Hamlett, C. L., Changas, P. (2013). Effects of First-Grade Number Knowledge Tutoring With Contrasting Forms of Practice. *Journal of Educational Psychology*, 105(1), 58-77. <https://doi.org/10.1037/a0030127>