

# Do Executive Function Skills Produce Growth in Reading Comprehension?

## A Causal Analysis



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### Introduction

Reading Comprehension (RC) is crucial for many life outcomes, yet many children struggle to perform at grade level on RC tests (NAEP, 2017). Children with RC deficits also have deficits in executive function skills, including inhibition, memory, and cognitive flexibility. We wanted to use a large sample to substantiate causal claims connecting executive functioning to reading comprehension.

### Research Question

Is there evidence to claim Executive Function (EF) skills *cause* growth in Reading Comprehension?

### Variables of Interest

740 1<sup>st</sup>- to 4<sup>th</sup>-grade students

Data collected in Fall and Spring semesters

Executive Functioning was measured using a composite score of:

- Inhibition (NEPSY inhibition subtest)
- Working Memory (TOMAL-2 letters backward)
- Cognitive Flexibility (multiple classification, Cartwright, 2002)

Student scores were standardized within grade level and then the three scores were averaged.

Outcome Variable: Change in Reading Comprehension score from fall to spring (Woodcock Johnson-IV passage comprehension subtest)

Control variables: Students' school, Grade level, English Learner (EL) status, Free- and Reduced-Price Lunch status, English Vocabulary (Woodcock Johnson-IV vocabulary subtest), Homonym understanding, and Decoding skills (Woodcock Johnson-IV Letter and Word identification).

Data were collected as part of a 3-year longitudinal study (Project LEARN).

### Methodology

We used propensity score matching, a quasi-experimental method, to test causation of executive functioning on changes to reading comprehension.

Previously, any causal interventions connecting EF to changes in RC have had very small sample sizes (*n*s ranging from 31 to 57; e.g., Cartwright et al., 2017; García-Medruza et al., 2013).

With propensity score matching, “assignment” to treatment (high EF skills) mimics randomization and reduces selection bias (Murnane & Willett, 2010). The control variables were used to predict EF assignment.

Students were matched based on predicted probability of being in the treatment group. These students would have equivalent probabilities of having high EF skills (being above the mean), even though only 1 in each pair did.

### Probit Model Predicting Propensities

	Estimate	Standard Error
English Language Learner	0.472***	.117
Inference-Making Abilities	0.021**	.008
Homonym Understanding	.066**	.022
Free- or Reduced-Price Lunch Status	-0.530***	.151
Grade	0.123*	.065
Letter/Word Decoding	0.033***	.006
Constant	-2.476***	.281
Note: The outcome variable is whether the student has high executive functioning skills. * <i>p</i> < .1 ** <i>p</i> < .05 *** <i>p</i> < .001		N=740 $\chi^2(6) = 241.87$ Pseudo- <i>R</i> <sup>2</sup> = .2363

This model indicates that the covariates significantly predict assignment to treatment group, so propensity score matching is a good fit for the data.

### Model Estimates

	Treatment Group (High EF skills)	Control Group (Low EF skills)	Difference (SE)	T Statistic
Unmatched Sample	1.828	2.789	-0.960 (0.29)	-3.27**
Matched Sample	1.828	0.528	1.3 (0.62)	2.09**

Note: Averages indicate the mean reading comprehension score.  
\*\* *p* < .05

Before matching, the “treatment group” actually had lower Reading Comprehension scores than the control group.

However, when students were appropriately matched, we observed a difference in RC scores of 1.3, which was statistically significant. Thus, we find that students who started with high EF scores improved reading comprehension by 1.3 points (0.33 standard deviations [*SD*]) *more than* students with lower initial EF scores (*p* < .05).

We ran a traditional multiple linear regression model (using all of the same variables) and found the estimated difference in RC scores between high- and low-EF students was 0.20 standard deviations, which underestimated the effect that EF had on RC.

### Conclusions

This propensity score matching model uses a large sample to provide evidence that executive functioning skills lead to increases in reading comprehension. Specifically, students with high-EF skills can expect to improve by 0.33 SD more than students with low-EF skills.

Policymakers and reading specialists can utilize this information by focusing on developing students' EF skills—memory, cognitive flexibility, and inhibition, in order to increase reading comprehension growth over time.

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