

MACHINE LEARNING REDUCED 20 MODERATORS TO 9 KEY PREDICTORS

Comparing MetaForest, Two-Stage ML, and Traditional Meta-Regression



KEY TAKEAWAY: Machine learning identified a smaller set of important predictors while preserving the core findings from traditional meta-regression.

1. WHAT WE LEARNED

SHARED ACROSS ALL METHODS

- ✓ Total Sessions
- ✓ Outcome Measure
- ✓ Ethnicity

ADDITIONAL SIGNALS IDENTIFIED BY ML

- 💰 Funding Status
- 🕒 Duration (Instructional Hours)
- 📊 Frequency (Sessions per Week)



Key Predictors

ML approaches provide a principled way to reduce a large moderator set to the most consistent and influential predictors.

2. METHODS



Mathematics Fact Fluency Meta-Analysis
 $k = 35$ studies | $n = 178$ effect sizes



Robust Variance Estimation (RVE)
Tests prespecified linear relationships among moderators.



MetaForest (Random Forest)
Detects nonlinear relationships and interactions.



Two-Stage ML (Exploratory)
RF on residuals from multilevel model to identify remaining important predictors.



RVE



MetaForest



Two-Stage ML

Three complementary approaches.
Stronger evidence through convergence.

3. CHALLENGE AREA / CHALLENGE OVERCOME



THE CHALLENGE

Meta-analysts often include more candidate moderators than can be reasonably investigated using theory-driven selection alone.



WHAT WE DID

We applied two machine learning approaches to identify predictors that were stable and influential across bootstrap iterations.



THE IMPACT

ML served as a principled feature-reduction tool, highlighting variables that warrant deeper investigation in confirmatory meta-regression models.

METHODS AT A GLANCE



Mathematics Fact Fluency Meta-Analysis



$k = 35$
Studies



$n = 178$
Effect Sizes



RVE
(Robust Variance Estimation)



MetaForest
(Random Forest)



Two-Stage ML
(Exploratory)



ML FINDS WHAT MATTERS. RVE ESTIMATES HOW MUCH IT MATTERS.



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