

# Cognitive Endurance as Human Capital

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## Motivation: What does schooling do?

- Long-held views on how schooling may affect human capital  
(Dewey 1938, Morrison et al. 2019)
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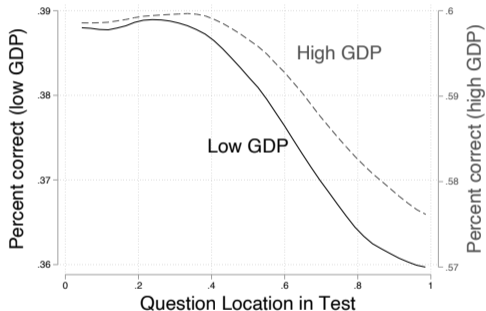
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- Nearly all of our measurement has been around the first component
- This paper:
  - Specific feature of schooling: **Effortful thinking for continuous stretches of time**
  - Investigate effects on one particular cognitive capacity: **Cognitive endurance** (aka sustained attention)
- **Contribution:** Highlight a way to measure cognitive endurance and show it can be improved through practice

## Cognitive endurance

- Ability to sustain performance over time during a cognitively effortful task
- Broad relevance
  - Productive activity often involves sustaining mental effort
  - (E.g., over many minutes in school test, or hours in work shift)

## Motivation: Large declines in performance over task

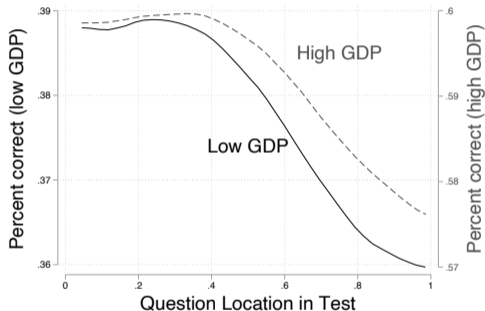
TIMSS: Administered to 4th graders, 36 mins per subject, question block order varies



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Many possible explanations → Focus on quality/type of schooling

# Outline

- ① **Experiment design**
- ② Results: Cognitive endurance
- ③ Results: Mechanisms and Confounds
- ④ Results: School performance
- ⑤ Conclusion

## Experimental Setting



- Field experiment with six private schools in Lucknow, India
- 1,650 students, grades 1-5 (ages 5-11)
- Largely low-income households (mix of urban and rural)
- Crowded classrooms, disruptive environments
- 2-4 practice problems per class, homework rarely assigned/completed

## Treatments: Introduction

- Goal: Increase time spent focusing in cognitively-challenging activity
  - Idea of "training attention" in psychology literature
- Challenges:
  - Needs to be cognitively challenging
  - But also engaging enough to retain student participation for 20 minutes

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- Our solution → Cognitively challenging tasks via tablet during the school day
  - Dynamic difficulty

# Treatments

Student level randomization to different 30-minute elective classes, administered 2-3 times a week for 6 months

- ① **Math practice:** Adaptive math problems  
Mimics "good" schooling [Pixatel imagine Math]
- ② **Games practice:** Cognitively challenging games (e.g. mazes, tangrams)  
Free of academic content (no words, numbers) – pure test of mechanism
- ③ **Control:** Traditional study hall  
5 math questions on chalkboard

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→ Do about 20 minutes of focused practice
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5 math questions on chalkboard  
→ Do about 5 minutes of focused practice

Treatment students receive on avg. additional 15 hours of focused practice

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## Performance declines (field measure)

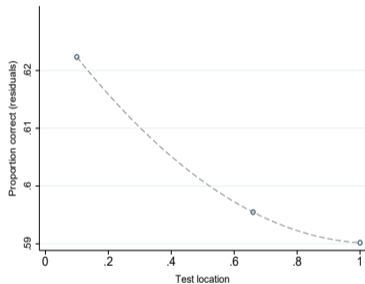
- Decline in performance over time (slope)
- Design
  - Randomize question order (question fixed effects in all analysis)
  - Plenty of time to complete tests (decline not confounded by non-completion)
- 3 diverse domains (test for broad cognitive impact)
  - Listening
  - Ravens Matrices (IQ)
  - Math

# Performance declines

## Listening

## Ravens Matrices

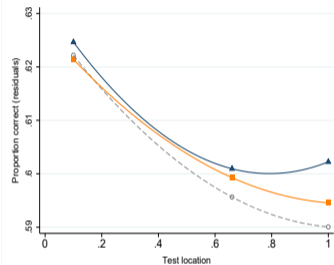
## Math



- Listen to series of short stories
- Each followed by questions
- Core input for learning
- Significant declines over time

# Performance declines

## Listening



Decline reduction: 17% (pval 0.041)

Quintile 1 effect: -0.0013 (pval 0.845)

○ Control    ■ Games Practice    ▲ Math Practice

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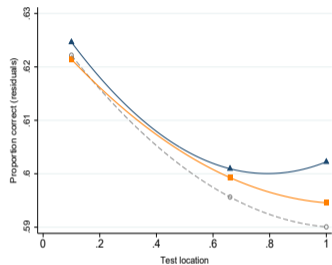
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[Regressions]

[Pooled Treatments]

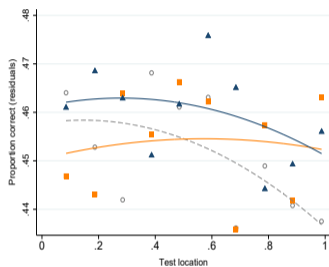
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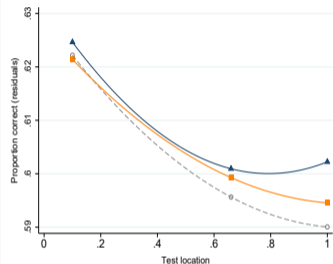
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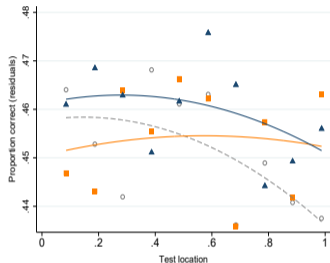
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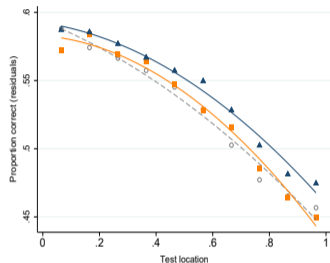
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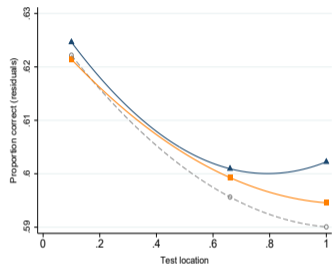
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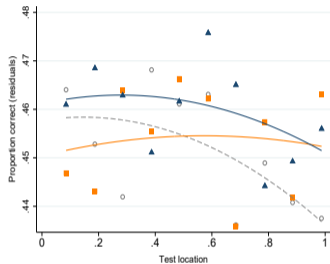
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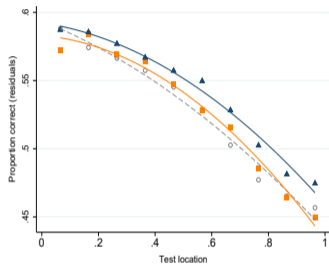
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- Effects very similar for academic and non-academic practice
- Effects persist 3-5 months later (post school vacation)

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## Channels and Confounds

- Are effects on performance declines reflecting increased motivation?
  - Other channels: Attendance? Feeling special? Parental inputs?
- Psychology: motivation and attention are interrelated  
(Chun et al. 2011, Mischel 2014, Zelazo 2016)
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- 4 pieces of evidence against other channels and 3 pieces of evidence for sustained attention channel

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### 1. No effect at the beginning of the test

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- Exploit random order of question items in test
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- No differential effect by treatment

## Evidence for sustained attention channel

Find significant effect on two out of three measures of sustained attention from psychology:

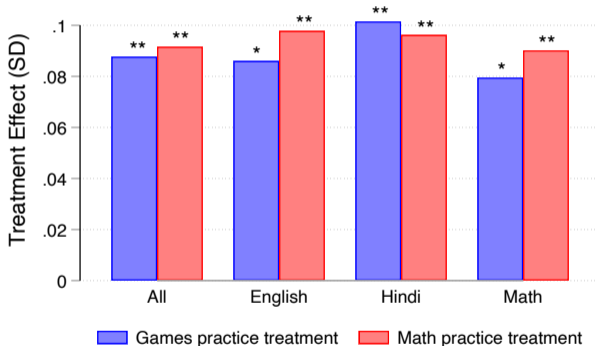
1. Sustained Attention to Response Task (SART), computer-based response to stimuli task: 0.067SD\*\* effect
2. Symbol matching task, paper-based adaptation of SART: 0.036 effect
3. Classroom observers rate using scale adapted from Vanderbilt ADHD Diagnostic Teacher Rating Scale: 0.083SD\*\*\* effect

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## Effect on school grades

Average 0.09SD effect on student grades, across subjects and treatment



Less than 1/3 of this effect is from less fatigue on the assessment itself. More than 2/3 is from students paying better attention in class and learning more

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- Cognitive endurance is malleable through external intervention.
- Complement with fuzzy RD design
  - Instrument schooling with kindergarten admission birthday cutoff
  - 5,300 9-11 year olds from 66 schools in Pakistan (Brown and Andrabi, 2021)
  - An additional year of school increases cognitive endurance by 31% for same age children
  - But only in higher quality schools (measured using CLASS classroom observation rubric).

## Takeaways

- Engaging in extended focused practice improves cognitive endurance
- This type of pedagogy is less common in poorer schools (in US and globally)
- Potential implications/areas for future work:
  - Crucial to measure wider variety of skills and understand how teaching practices impact skills
  - Forcing teachers to focus on only certain metrics (literacy and numeracy) may hinder development of other skills if it pushes teachers toward certain types of pedagogy (lecture/rote learning).