Effects of Perceived Productivity on Study Effort: Evidence from a Field Experiment

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Motivation

How often do you agree with the statement

“When I sit myself down to learn something really hard, I can learn it.”?

*Almost Never, Sometimes, Often, Almost Always*
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- Correlational evidence suggests beliefs can be significant factors in study decisions, academic achievement and labor market outcomes
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Almost Never, Sometimes, Often, Almost Always

- Correlational evidence suggests beliefs can be significant factors in study decisions, academic achievement and labor market outcomes

A student who almost always agrees with the statement
- is 2.8 times more likely to spend more time on homework
- is 3.7 times more likely to have a higher GPA.
- is 1.4 times more likely to work at a full time job
- earns 25% more

compared to a student who almost never agrees with the statement. (Calculations based on data from The Education Longitudinal Study of 2002.)
Research Question

How does effort respond to the perceived relationship between effort and rewards?
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Challenges:

▶ Measuring effort

Effort-rewards relationship is hard to estimate due to unobserved factors such as ability. Perceptions about the role of luck in determining outcomes is largely not measured. External-Internal Locus of Control: Beliefs about the determining role of luck versus personal effort in outcomes. A mediating channel between persons' desire to attain some end and the effort they exert (Findley and Cooper (1983) and McGee and McGee (2016)). Correlates with academic performance and labor market outcomes (Coleman and DeLeire (2003) and Cobb-Clark (2015)).
Research Question

How does **effort** respond to the **perceived** relationship between **effort** and **rewards**?

**Challenges:**

- Measuring effort
- Measuring rewards
Research Question

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A Field Experiment Designed to Address These Challenges
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Context:

- Intrinsically motivated students who want to learn Spanish
- Online language learning platform: Duolingo
A Field Experiment Designed to Address These Challenges

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- Online language learning platform: Duolingo
- Accurate measure of effort
A Field Experiment Designed to Address These Challenges

Context:

- Intrinsically motivated students who want to learn Spanish
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- Accurate measure of effort
- Rewards are tied to the effort and not in the far future
A Field Experiment Designed to Address These Challenges

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In this project, I
- measure the causal effort-rewards relationship by assigning students’ to different levels of effort
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- elicit the perceived effort-rewards relationship in an incentivized manner and at different points
- measure students’ *locus of control*
- exogenously manipulate students’ beliefs by assigning them to different treatments, based on the factual information
Outline

Introduction

Conceptual Framework

Experimental Design

Results

Baseline Beliefs
Change in Beliefs
Change in Effort
Change in Performance
Outline

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Conceptual Framework

Experimental Design

Results
  Baseline Beliefs
  Change in Beliefs
  Change in Effort
  Change in Performance
Conceptual Framework
Analogous to the Labor Supply Theory
Conceptual Framework
Analogous to the Labor Supply Theory

Max $U(Achievement, Leisure)$
Conceptual Framework
Analogous to the Labor Supply Theory

\[ \text{Max } U(\text{Achievement}, \text{Leisure}) \]

s.t.

\[ \text{Leisure} + \text{Study} = \text{Time} \]
Conceptual Framework
Analogous to the Labor Supply Theory

\[
\text{Max } U(\text{Achievement, Leisure})
\]
\[\text{s.t.}
\]
\[\text{Leisure + Study} = \text{Time}
\]
\[\text{Achievement} = \beta \ast \text{Study}
\]

\(\beta\): a student’s belief about how studying translates into achievement
Conceptual Framework
Analogous to the Labor Supply Theory

$$\begin{align*}
\text{Max } U(Achievement, Leisure) \\
\text{s.t.} \\
Achievement + \beta \text{Leisure} = \beta \text{Time}
\end{align*}$$
Conceptual Framework
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\(\beta\) is both the price and the opportunity cost of the leisure
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How does the optimal level of leisure change as we change \( \beta \)?
Conceptual Framework
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How does the optimal level of leisure change as we change $\beta$?
Depends on the relative magnitudes of the substitution and endowment effects
Conceptual Framework
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How does the optimal level of leisure change as we decrease \( \beta \)?
Conceptual Framework
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How does the optimal level of leisure change as we decrease $\beta$?
Substitution effect would cause an increase in leisure whereas endowment effect would cause a decrease in leisure.
Conceptual Framework
Analogous to the Labor Supply Theory

\[ \text{Max } U(\text{Achievement, Leisure}) \]
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How does the optimal level of leisure change as we decrease \( \beta \)? Substitution effect would cause an increase in leisure whereas endowment effect would cause a decrease in leisure.

- For whom, do we expect the substitution/endowment effect to dominate?
Conceptual Framework
Analogous to the Labor Supply Theory

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- For whom, do we expect the substitution/endowment effect to dominate?
  - *Internals* are more likely to attempt to control their environments (Rotter (1966) and Ryckman and Sherman (1974)) and exert control even in situations with many constraints (Bandura (1990)).
  - *Externals* are more likely to be passive ((Rotter (1992)).
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▶ \textit{Internals} are more likely to attempt to control their environments (Rotter (1966) and Ryckman and Sherman (1974)) and exert control even in situations with many constraints (Bandura (1990)).
▶ \textit{Externals} are more likely to be passive ((Rotter (1992)).
▶ \textbf{Hypothesis}: Substitution effect is stronger for \textit{internals} than \textit{externals}. 
Outline

Introduction

Conceptual Framework

Experimental Design

Results
  - Baseline Beliefs
  - Change in Beliefs
  - Change in Effort
  - Change in Performance
Subject Pool

- Intrinsically motivated individuals who want to learn Spanish online
Subject Pool

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- Recruit from large and public California Universities
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- Intrinsically motivated individuals who want to learn Spanish online
- Recruit from large and public California Universities
- **Recruitment Method**: Send emails to faculty and staff members in all departments except Spanish and related ones (17,166 emails)
Why Duolingo?

Measuring effort is tricky:
▶ Not readily observable in most of the cases
▶ Self-reports of effort can contain substantive reporting error (Stinebrickner and Stinebrickner (2004)) and can be biased due to social desirability concerns (Nederhof (1985) and Furnham (1986))
▶ Multi-dimensional: Depth vs Length

Duolingo
▶ Homogenizes the learning experience
▶ Provides an accurate and meaningful effort measure: # of lessons
▶ Keeps the depth constant so that we can focus on the amount completed
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Spanish skills

Basics 1  1/3

Phrases  0/3  Basics 2  0/4

Food  0/4  Animals  0/4
Duolingo homogenizes the learning experience

Spanish skills

Basics 1

Phrases 0/3

Basics 2 0/4

Food 0/4

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- provides an accurate and meaningful effort measure: # of lessons
Effort: # of Lessons Completed
Select translation of “chicken”

- la fruta 1
- la pasta 2
- el pollo 3
Nosotros comemos pescado.

We eat fish.
Translate “egg”

You used the wrong word.
el huevo
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Experimental Design
Experimental Design

Sign Up

Take Initial Survey (617 subjects)
Initial Survey

Locus of Control Survey (Rotter (1966))

measures individuals' beliefs on how luck affects certain outcomes in general

Forced response between statement pairs such as
Initial Survey

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Initial Survey

- **Locus of Control Survey** (Rotter (1966))
  - measures individuals’ beliefs on how luck affects certain outcomes in general
  - Forced response between statement pairs such as
    - “The idea that teachers are unfair to students is nonsense.”
    - “Most students don't realize the extent to which their grades are influenced by accidental happenings.”
Initial Survey

- Locus of Control Survey (Rotter (1966))
  - measures individuals’ beliefs on how luck affects certain outcomes in general
  - Forced response between statement pairs such as
    - “Without the right breaks one cannot be an effective leader.”
    - “Capable people who fail to become leaders have not taken advantage of their opportunities.”
Initial Survey

- Locus of Control Survey (*Rotter (1966)*)
  - measures individuals’ beliefs on how luck affects certain outcomes in general
  - Forced response between statement pairs such as
  - Score ranges between 0 (extreme internals) and 8 (extreme externals)- standardized for analysis purposes
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- A battery of survey questions assessing growth mindset (Paunesku et al. (2015)), big five personality traits (Rammstedt and John (2007)), and self control (Tangney et al. (2004)).
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- A battery of survey questions assessing **growth mindset** (Paunesku et al. (2015)), **big five personality traits** (Rammstedt and John (2007)), and **self control** (Tangney et al. (2004)).

- Language background, schooling background and demographics
Experimental Design

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Take Initial Survey (617 subjects)
Experimental Design

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Take Initial Test (491 subjects)
Spanish Assessment Test

- Test questions are directly based on Duolingo lessons
- Majority of the questions are multiple choice questions with a single or multiple correct answer
- Scoring of the test is done such that a person
  - who randomly answers questions would get a score of 0 (on average)
  - who correctly answers all questions would get a score of 1000
- Performance on the test is not incentivized
Experimental Design

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Experimental Design

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Take Initial Test (491 subjects)

Complete 6 Lessons (419 subjects)
Experimental Design

Sign Up

- Take Initial Survey (617 subjects)
- Take Initial Test (491 subjects)
- Complete 6 Lessons (419 subjects)
- Week 0 Belief Survey (394 subjects)
Belief Elicitation

Beliefs about completing lessons with Duolingo-performance in the Spanish test relationship
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- For 5 different levels of effort (*aggregated* and *averaged* for the analysis)
Belief Elicitation

Beliefs about completing lessons with Duolingo-performance in the Spanish test relationship

- For 5 different levels of effort (*aggregated and averaged* for the analysis)
- Beliefs about whom?

Details about the Pre-Experiment

- Incentivized based on accuracy using absolute deviation rule
- Beliefs about the accuracy of these beliefs are also elicited on a 5-item Likert scale
Belief Elicitation

Beliefs about completing lessons with Duolingo-performance in the Spanish test relationship

- For 5 different levels of effort (*aggregated* and *averaged* for the analysis)
- Beliefs about whom?
  - Themselves
Belief Elicitation

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- For 5 different levels of effort (aggregated and averaged for the analysis)
- Beliefs about whom?
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  - The students from a previous experiment - Designed to measure the empirical, causal relationship between Duolingo lessons and performance in the Spanish test

Details about the Pre-Experiment
Belief Elicitation

Beliefs about completing lessons with Duolingo-performance in the Spanish test relationship

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Belief Elicitation

Beliefs about completing lessons with Duolingo-performance in the Spanish test relationship

- For 5 different levels of effort (*aggregated* and *averaged* for the analysis)
- Beliefs about whom?
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Details about the Pre-Experiment

- Incentivized based on accuracy using absolute deviation rule
- Beliefs about the accuracy of these beliefs are also elicited on a 5-item Likert scale
Before Belief Elicitation

I provide information about
Before Belief Elicitation

I provide information about

- Duolingo lessons

Benchmarking: Linking test scores to college level Spanish course

Interpretation: Linking test scores to be able to do certain activities

the students from the previous experiment
Before Belief Elicitation

I provide information about

▶ Duolingo lessons
▶ how the scoring of the test is done and what test scores mean
  ▶ Benchmarking: Linking test scores to college level Spanish course
  ▶ Interpretation: Linking test scores to be able to do certain activities
Before Belief Elicitation

I provide information about

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Experimental Design

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- Week 0 Belief Survey (394 subjects)
- Randomization to Information
Information Treatments

(a) No Information (107 subjects)
(b) Full (105 subjects)
(c) Low (106 subjects)
(d) High (101 subjects)
Information Treatments

(a) No Information (107 subjects)

(b) Full (105 subjects)

- Completing 8 Duolingo lessons per week for 4 weeks led, on average, improvement of 91 points.
- Completing 16 Duolingo lessons per week for 4 weeks led, on average, improvement of 129 points.
- Completing 24 Duolingo lessons per week for 4 weeks led, on average, improvement of 167 points.

(c) Low (106 subjects)

(d) High (101 subjects)
Information Treatments

(a) No Information (107 subjects)

(b) Full (105 subjects)
- Completing 8 Duolingo lessons per week for 4 weeks led, on average, improvement of 91 points.
- Completing 16 Duolingo lessons per week for 4 weeks led, on average, improvement of 129 points.
- Completing 24 Duolingo lessons per week for 4 weeks led, on average, improvement of 167 points.

(c) Low (106 subjects)
- A participant who has an initial score similar to yours was randomly assigned to complete 12 Duolingo lessons per week (so 48 Duolingo lessons in total).
- The participant improved 50 points after completing 48 Duolingo lessons in a month.

(d) High (101 subjects)
Information Treatments

(a) No Information (107 subjects)

(b) Full (105 subjects)
- Completing 8 Duolingo lessons per week for 4 weeks led, on average, improvement of 91 points.
- Completing 16 Duolingo lessons per week for 4 weeks led, on average, improvement of 129 points.
- Completing 24 Duolingo lessons per week for 4 weeks led, on average, improvement of 167 points.

(c) Low (106 subjects)
A participant who has an initial score similar to yours was randomly assigned to complete 12 Duolingo lessons per week (so 48 Duolingo lessons in total).
The participant improved 50 points after completing 48 Duolingo lessons in a month.

(d) High (101 subjects)
A participant who has an initial score similar to yours was randomly assigned to complete 12 Duolingo lessons per week (so 48 Duolingo lessons in total).
The participant improved 237 points after completing 48 Duolingo lessons in a month.
Information Treatments

Which information treatment would work best at manipulating beliefs?
Information Treatments

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- Low and High: Anecdotal information
  - Not abstract: it is about a person students can relate
  - It is about a single individual
Information Treatments

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  - Not abstract: it is about a person students can relate
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- Full: Aggregate information
  - about different effort levels
  - based on whole sample
Information Treatments

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- Full: Aggregate information
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When and How to provide information?
Information Treatments

Which information treatment would work best at manipulating beliefs?

▶ Low and High: Anecdotal information
  ▶ Not abstract: it is about a person students can relate
  ▶ It is about a single individual

▶ Full: Aggregate information
  ▶ about different effort levels
  ▶ based on whole sample

When and How to provide information?

▶ Right after belief elicitation
▶ Storyboard format
Experimental Design

Sign Up

Take Initial Survey (617 subjects)

Take Initial Test (491 subjects)

Complete 6 Lessons (419 subjects)

Week 0 Belief Survey (394 subjects)

Randomization to Information
Experimental Design

Sign Up

Study as much as desired

Take Initial Survey (617 subjects)

Take Initial Test (491 subjects)

Complete 6 Lessons (419 subjects)

Week 0 Belief Survey (394 subjects)

Randomization to Information
Experimental Design

- Sign Up (617 subjects)
- Study as much as desired

  - Week 1
  - Week 2
  - Week 3
  - Belief Survey
  - Belief Survey
  - Belief Survey

- Take Initial Survey (617 subjects)
- Take Initial Test (491 subjects)
- Complete 6 Lessons (419 subjects)
- Week 0 Belief Survey (394 subjects)
- Randomization to Information
Experimental Design

- Sign Up
- Study as much as desired
  - Week 1: Belief Survey
  - Week 2: Belief Survey
  - Week 3: Belief Survey
  - Week 4 Belief Survey

- Week 0 Belief Survey (394 subjects)
- Complete 6 Lessons (419 subjects)
- Take Initial Test (491 subjects)
- Take Initial Survey (617 subjects)

Randomization to Information
Experimental Design

Sign Up

Study as much as desired

Week 0 Belief Survey (394 subjects)

Take Initial Survey (617 subjects)

Take Initial Test (491 subjects)

Complete 6 Lessons (419 subjects)

Week 1

Belief Survey

Week 2

Belief Survey

Week 3

Belief Survey

Week 4 Belief Survey

Take Final Test
Experimental Design

Sign Up

Study as much as desired

Week 1
Belief Survey
Take Initial Survey (617 subjects)

Week 2
Belief Survey
Take Initial Test (491 subjects)

Week 3
Belief Survey
Complete 6 Lessons (419 subjects)

Week 4 Belief Survey
Take Final Test

Randomization to Information

Take Final Survey (339 subjects)
Outline

Introduction

Conceptual Framework

Experimental Design

Results

Baseline Beliefs
Change in Beliefs
Change in Effort
Change in Performance
Initial Beliefs About the Effort-Performance Relationship
about the students from the previous experiment
Initial Beliefs About the Effort-Performance Relationship about the students from the previous experiment

There is substantial heterogeneity in initial beliefs and 63% of the subjects overestimate the returns to effort.
Do Initial Beliefs About the Previous Students Differ from Initial Beliefs About the Self?

Correlation between initial beliefs about the self and previous participants is .84 (statistically significant).

Define Difference in Beliefs = Initial Beliefs about the Previous Participants − Initial Beliefs about the Self.

Median Difference is 0, Mean Difference is -.07 (s.d. 1.17).

For 15% of the participants, Difference = 0.
Do Initial Beliefs About the Previous Students Differ from Initial Beliefs About the Self?

- Correlation between initial beliefs about the self and previous participants is .84 (statistically significant)
Do Initial Beliefs About the Previous Students Differ from Initial Beliefs About the Self?

- Correlation between initial beliefs about the self and previous participants is .84 (statistically significant).
- Define \( \text{Difference in Beliefs} = \text{Initial Beliefs about the Previous Participants} - \text{Initial Beliefs about Self} \)
- Median Difference is 0, Mean Difference is -.07 (s.d. 1.17).
- For 15% of the participants, Difference=0.
Initial Beliefs by Locus of Control

Over optimistic
Initial Beliefs by Locus of Control

Over optimistic but Not Different Across Two Groups
Confidence in Initial Beliefs

Confidence about Initial Beliefs

Density

Not Accurate  Slightly Accurate  Moderately Accurate  Very Accurate  Extremely Accurate

Internal Locus  External Locus
Confidence in Initial Beliefs

Learners with Internal Locus are more confident than learners with External Locus
### Change in Beliefs by locus of control

<table>
<thead>
<tr>
<th>Variable</th>
<th>Week 0 to Week 1</th>
<th>Week 1 to Week 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full</td>
<td>-0.914***</td>
<td>-0.920***</td>
</tr>
<tr>
<td></td>
<td>(0.301)</td>
<td>(0.313)</td>
</tr>
<tr>
<td>Low</td>
<td>-1.100***</td>
<td>-1.099***</td>
</tr>
<tr>
<td></td>
<td>(0.301)</td>
<td>(0.312)</td>
</tr>
<tr>
<td>High</td>
<td>0.435</td>
<td>0.465</td>
</tr>
<tr>
<td></td>
<td>(0.302)</td>
<td>(0.313)</td>
</tr>
<tr>
<td>Initial Beliefs</td>
<td>-0.586***</td>
<td>-0.592***</td>
</tr>
<tr>
<td></td>
<td>(0.0376)</td>
<td>(0.0393)</td>
</tr>
<tr>
<td>Constant</td>
<td>1.820***</td>
<td>8.087</td>
</tr>
<tr>
<td></td>
<td>(0.263)</td>
<td>(10.50)</td>
</tr>
<tr>
<td>Observations</td>
<td>374</td>
<td>374</td>
</tr>
<tr>
<td>No-Information Mean</td>
<td>-0.459</td>
<td>-0.408</td>
</tr>
<tr>
<td>No-Information SD</td>
<td>0.214</td>
<td>0.227</td>
</tr>
<tr>
<td>Full=Low</td>
<td>0.537</td>
<td>0.565</td>
</tr>
<tr>
<td>Full=High</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Low=High</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Joint</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Controls</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Standard errors in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.1
<table>
<thead>
<tr>
<th>VARIABLES</th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
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<td>Full</td>
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<tr>
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</tr>
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<tr>
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<td></td>
<td></td>
</tr>
<tr>
<td>Observations</td>
<td>374</td>
</tr>
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</tr>
<tr>
<td>No-Information SD</td>
<td>0.214   0.227</td>
</tr>
<tr>
<td>Full=Low</td>
<td>0.537</td>
</tr>
<tr>
<td>Full=High</td>
<td>0</td>
</tr>
<tr>
<td>Low=High</td>
<td>0</td>
</tr>
<tr>
<td>Joint</td>
<td>0</td>
</tr>
<tr>
<td>Controls</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
</tr>
</tbody>
</table>

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1
## Change in Beliefs by locus of control

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>Change in Beliefs from Week 0 to Week 1</th>
<th>Change in Beliefs from Week 1 to Week 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full</td>
<td>-0.914*** (0.301)</td>
<td>0.187 (0.280)</td>
</tr>
<tr>
<td></td>
<td>-0.920*** (0.313)</td>
<td>0.0897 (0.293)</td>
</tr>
<tr>
<td>Low</td>
<td>-1.100*** (0.301)</td>
<td>-0.161 (0.279)</td>
</tr>
<tr>
<td></td>
<td>-1.099*** (0.312)</td>
<td>-0.202 (0.290)</td>
</tr>
<tr>
<td>High</td>
<td>0.435 (0.302)</td>
<td>1.207*** (0.281)</td>
</tr>
<tr>
<td></td>
<td>0.465 (0.313)</td>
<td>1.169*** (0.297)</td>
</tr>
<tr>
<td>Initial Beliefs</td>
<td>-0.586*** (0.0376)</td>
<td>-0.216*** (0.0351)</td>
</tr>
<tr>
<td></td>
<td>-0.592*** (0.0393)</td>
<td>-0.223*** (0.0370)</td>
</tr>
<tr>
<td>Constant</td>
<td>1.820*** (0.263)</td>
<td>8.087 (10.50)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.299 (0.250)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9.600 (9.641)</td>
</tr>
</tbody>
</table>

| Observations       | 374                                     | 374                                     |
| No-Information Mean| -0.459                                  | -0.408                                  |
| No-Information SD  | 0.214                                   | 0.227                                   |
| Full=Low           | 0.537                                   | 0.565                                   |
| Full=High          | 0                                       | 0                                       |
| Low=High           | 0                                       | 0                                       |
| Joint              | 0                                       | 0                                       |
| Controls           | No                                      | Yes                                     |

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1
Summary of the results so far

Initial Beliefs

- Subjects’ initial beliefs are off: Majority of the subjects overestimate the returns to effort.
- Beliefs about the other students and about the self do not differ much
- Initial beliefs do not differ by locus of control but the confidence in initial beliefs does.
Summary of the results so far

**Initial Beliefs**
- Subjects’ initial beliefs are off: Majority of the subjects overestimate the returns to effort.
- Beliefs about the other students and about the self do not differ much.
- Initial beliefs do not differ by locus of control but the confidence in initial beliefs does.

**Change in Beliefs**
- Students update their beliefs more in the information treatments compared to the no information treatment.
- The effect of anecdotal information is as large as the effect of aggregate information.
- Changes in beliefs are similar regardless of locus of control.
How does the change in beliefs affect effort?

- Regressing effort on the changes in beliefs would not give the causal effect since
  - beliefs are measured with noise (attenuation bias)
  - effort choices might affect the change in beliefs (reverse causality)
  - a third factor, such as ability, might affect both beliefs and effort
How does the change in beliefs affect effort?

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  - effort choices might affect the change in beliefs (reverse causality)
  - a third factor, such as ability, might affect both beliefs and effort
- Use the instrumental variables (IV) approach to account for the issue of endogeneity
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- Use the instrumental variables (IV) approach to account for the issue of endogeneity

\[
\text{# of Lessons} = \alpha_1 \Delta \text{Beliefs} + \alpha_2 \Delta \text{BeliefsExternal} + \alpha_3 \text{Initial Beliefs} + \alpha_4 \text{External} + \epsilon
\]
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\[
\text{# of Lessons} = \alpha_1 \Delta \text{Beliefs} + \alpha_2 \Delta \text{Beliefs}_{\text{External}} + \alpha_3 \text{Initial Beliefs} \\
+ \alpha_4 \text{External} + \epsilon
\]

\[
\Delta \text{Beliefs} = \sum_i \gamma_{1i} \text{Treatment}_i + \sum_i \gamma_{2i} \text{Treatment}_i \text{External} \\
+ \delta_1 \text{Initial Beliefs} + \delta_2 \text{External} + \nu
\]

\[
\Delta \text{Beliefs}_{\text{External}} = \sum_i \beta_{1i} \text{Treatment}_i + \sum_i \beta_{2i} \text{Treatment}_i \text{External} \\
+ \theta_1 \text{Initial Beliefs} + \theta_2 \text{External} + \kappa
\]
Effect of Change in Beliefs on Effort (IV Approach)
Effect of Change in Beliefs on Effort (IV Approach)

Internals: Change in beliefs positively affects effort (statistically significant)
Effect of Change in Beliefs on Effort (IV Approach)

Externals: Change in beliefs negatively affects effort (not statistically significant)

1 sd ↓ in beliefs → .57 sd ↓ in effort for internals
1 sd ↓ in beliefs → .63 sd ↑ in effort for externals
Effect of Change in Beliefs on Effort by Locus of Control

When perceived effectiveness of effort decreases, internals decrease their effort more than externals.

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>New Lessons Completed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change in Beliefs</td>
<td>2.383</td>
</tr>
<tr>
<td></td>
<td>(3.165)</td>
</tr>
<tr>
<td>Change in Beliefs*Locus of Control Score</td>
<td>-9.412**</td>
</tr>
<tr>
<td></td>
<td>(3.929)</td>
</tr>
<tr>
<td>Initial Beliefs</td>
<td>0.671</td>
</tr>
<tr>
<td></td>
<td>(2.170)</td>
</tr>
<tr>
<td>Locus of Control Score</td>
<td>-12.10**</td>
</tr>
<tr>
<td></td>
<td>(5.490)</td>
</tr>
<tr>
<td>Constant</td>
<td>30.71***</td>
</tr>
<tr>
<td></td>
<td>(6.374)</td>
</tr>
<tr>
<td>Observations</td>
<td>374</td>
</tr>
<tr>
<td>First Stage F-Stat Eq. 1</td>
<td>6.803</td>
</tr>
<tr>
<td>First Stage F-Stat Eq. 2</td>
<td>2.899</td>
</tr>
<tr>
<td>Controls</td>
<td>No</td>
</tr>
</tbody>
</table>

Locus of control score is standardized, higher numbers indicate external locus of control. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1
Interpreting the results
The effect of a decrease in the perceived effectiveness of effort is

- negative and statistically significant for *internals* →
  Substitution effect dominates

- positive but not statistically significant for *externals* →
  Endowment effect dominates

What could be the mechanism behind this response?

- Duolingo is only one way of learning Spanish.

- Do subjects interpret the information relevant for learning Spanish only with Duolingo or for learning Spanish in general?

- *Internals*: Duolingo effort not being effective.

- *Externals*: Task of learning Spanish being difficult

Evidence on that internals are more likely to report using tools outside of Duolingo during study period compared to externals upon learning Duolingo effort is not as effective as they think.
Interpreting the results

The effect of a decrease in the perceived effectiveness of effort is

- negative and statistically significant for *internals* → Substitution effect dominates
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The effect of a decrease in the perceived effectiveness of effort is
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The effect of a decrease in the perceived effectiveness of effort is

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Evidence on that internals are more likely to report using tools outside of Duolingo during study period compared to externals upon learning Duolingo effort is not as effective as they think.
## Effect of Change in Beliefs on Performance by Locus of Control

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1) Improvement in Test Scores</th>
<th>(2) Test Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change in Beliefs</td>
<td>0.135</td>
<td>8.915</td>
</tr>
<tr>
<td></td>
<td>(12.20)</td>
<td>(11.18)</td>
</tr>
<tr>
<td>Change in Beliefs*Locus of Control Score</td>
<td>7.854</td>
<td>7.548</td>
</tr>
<tr>
<td></td>
<td>(14.83)</td>
<td>(14.59)</td>
</tr>
<tr>
<td>Initial Test Score</td>
<td>-0.215***</td>
<td>-0.208***</td>
</tr>
<tr>
<td></td>
<td>(0.0551)</td>
<td>(0.0577)</td>
</tr>
<tr>
<td>Locus of Control Score</td>
<td>-5.769</td>
<td>-12.69</td>
</tr>
<tr>
<td></td>
<td>(20.60)</td>
<td>(19.61)</td>
</tr>
<tr>
<td>Initial Beliefs</td>
<td>0.614</td>
<td>6.796</td>
</tr>
<tr>
<td></td>
<td>(8.114)</td>
<td>(7.295)</td>
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<tr>
<td>Constant</td>
<td>152.7***</td>
<td>-37.98</td>
</tr>
<tr>
<td></td>
<td>(32.01)</td>
<td>(108.1)</td>
</tr>
<tr>
<td>Observations</td>
<td>330</td>
<td>330</td>
</tr>
<tr>
<td>First Stage F-Stat Eq. 1</td>
<td>5.951</td>
<td>6.831</td>
</tr>
<tr>
<td>First Stage F-Stat Eq. 2</td>
<td>2.600</td>
<td>2.525</td>
</tr>
<tr>
<td>Controls</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1
Change in students’ beliefs about the effort and rewards relationship affects their effort choices, differentially by locus of control.

- In response to a decrease in the perceived effectiveness of effort, internals reduce their effort more than externals.
- Internals: Substitution effect dominates
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Summary of the results about effort and performance

- Change in students’ beliefs about the effort and rewards relationship affects their effort choices, differentially by locus of control.
  - In response to a decrease in the perceived effectiveness of effort, *internals* reduce their effort more than *externals*
  - *Internals*: Substitution effect dominates
  - *Externals*: Endowment effect dominates

- Change in students’ beliefs about the effort and rewards relationship does not affect their performance.
Conclusion and Discussion

This Project:

- A field experiment designed to understand the role of beliefs in study decisions in a realistic setting

Results:

- Students are, on average, optimistic ex ante about the effort-returns relationship
- Beliefs can be manipulated by providing information: Anecdotal information works as well as aggregate information
- A change in perceived effectiveness of studying affects effort choices for individuals with an internal locus of control but not for individuals with an external locus of control.

Next Steps:

- Do the biases in beliefs continue to exist in learning environments with a lot of feedback?
- How do the change in beliefs affect the effort choices of students in compulsory learning environments?

Thank You!
Conclusion and Discussion

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Thank You!
Links to the Literature

Research on Labor Supply

▷ Restricted by limitations on measures of effort, rewards, and beliefs.
▷ Focus on piece-rate workers (Lazear (2000) and Freeman and Kleiner (2005)) or taxi drivers (Camerer et al. (1997) and Farber (2005))

Research on the Supply of Study Effort

▷ Students exert effort due to cultural norms (Figlio et al. (2016), Bishop (2006) and Gneezy et al. (2017))
▷ Small incentives can affect study effort (Levitt et al. (2016), Barrow and Rouse (2013), Bettinger (2012), Fryer (2011), and Hirshleifer (2016))
▷ Students not know effort-rewards relation (Azmat and Iriberri (2010), Bobba and Frisancho (2016), Bandiera et al. (2015), Azmat et al. (2016))
▷ Students’ beliefs about their ability can be tied to drop-out (Stinebrickner & Stinebrickner (2012) and Stinebrickner & Stinebrickner (2014))

Psychological Research on the Role of Beliefs about Effort

▷ Carol Dweck-Growth Mindset (Dweck (2006), Paunesku et al. (2015))
▷ Angela Duckworth-Grit (Duckworth (2016), Alan et al. (2015))

Research on Locus of Control and Self Efficacy

▷ Correlates with academic performance (Heckman and Kautz (2012), Coleman and DeLeire (2003) and Mendolia and Walker (2014))
▷ Correlates with earnings and earnings growth (Cobb-Clark (2015))
ARE YOU INTERESTED IN LEARNING **SPANISH** ONLINE THIS SUMMER?

PARTICIPATE IN THIS RESEARCH STUDY!
HELP US LEARN MORE ABOUT LANGUAGE LEARNING!

LEARN SPANISH ONLINE!
GET COMPENSATION!

AM I THE RIGHT PERSON FOR THIS STUDY?

YOU ARE IF

- You don’t know any Spanish or you know very little Spanish
- You are motivated to learn (more) Spanish
- You can commit studying Spanish online for **up to 4 hours per week** for **1 month** starting from mid June
- You are at least 18 years old
- You are a student at SDSU

COMPENSATION

Upon your successful completion of the study, you will get **$50** (on average) which will be paid to you as an Amazon Gift Card.

CONTACT INFORMATION

If interested in participating, please provide your e-mail address through this survey form:

[http://tinyurl.com/startStudyingSpanish](http://tinyurl.com/startStudyingSpanish)

If you have any questions, please contact us
[start.studying.spanish@gmail.com](mailto:start.studying.spanish@gmail.com)

This research is approved by Stanford Panel on Non-Medical Human Subjects. The IRB protocol number is 36512.
List of Universities

- California Polytechnic State University-San Luis Obispo
- California State Polytechnic University-Pomona
- California State University-Fresno
- California State University-Fullerton
- California State University-Los Angeles
- California State University-Northridge
- California State University-Sacramento
- University of California-Davis
- University of California-Irvine
- University of California-Santa Barbara
- University of California-San Diego
- San Diego State University
- San Francisco State University
- San Jose State University
Design of the *Pre-Experiment*

Sign Up
Design of the *Pre-Experiment*

Sign Up

Take Initial Survey
Design of the *Pre-Experiment*

- Sign Up
  - Take Initial Survey
  - Take Initial Tests
Design of the *Pre-Experiment*

**Sign Up**

- Take Initial Survey
- Take Initial Tests

**Randomization to Classrooms:**

- 8 lessons, 12 lessons, 16 lessons,
- 20 lessons and 24 lessons per week
Design of the *Pre-Experiment*

**Sign Up**
- Take Initial Survey
- Take Initial Tests

**Study as assigned**
- Week 1
- Week 2
- Week 3
- Week 4

**Randomization to Classrooms:**
- 8 lessons, 12 lessons, 16 lessons,
- 20 lessons and 24 lessons per week
Design of the *Pre-Experiment*

- Sign Up
  - Take Initial Survey
  - Take Initial Tests

- Study as assigned
  - Week 1
  - Week 2
  - Week 3
  - Week 4
  - Take Final Tests

**Randomization to Classrooms:**
- 8 lessons, 12 lessons, 16 lessons,
- 20 lessons and 24 lessons per week
Design of the *Pre-Experiment*

**Sign Up**
- Take Initial Survey
- Take Initial Tests

**Study as assigned**
- Week 1
- Week 2
- Week 3
- Week 4
- Take Final Tests
- Take Final Survey

**Randomization to Classrooms:**
- 8 lessons, 12 lessons, 16 lessons,
- 20 lessons and 24 lessons per week
Design of the *Pre-Experiment*

**Sign Up**
- Take Initial Survey
- Take Initial Tests

**Study as assigned**
- Week 1
- Week 2
- Week 3
- Week 4
- Take Final Tests
- Take Final Survey
- Receive Payments

**Randomization to Classrooms:**
- 8 lessons, 12 lessons, 16 lessons,
- 20 lessons and 24 lessons per week
Pre-Experiment: Distribution of # of Lessons Completed by Treatment

Cumulative Dist of Completed Lessons by Treatment

- 8 lessons per week
- 16 lessons per week
- 24 lessons per week
- 12 lessons per week
- 20 lessons per week

Completed Lessons

Cumulative Frequency
Pre-Experiment: Distribution of # of Lessons Completed by Treatment

Cumulative Dist of Completed Lessons by Treatment

- 8 lessons per week
- 16 lessons per week
- 20 lessons per week
- 24 lessons per week
Pre-Experiment: Distribution of # of Lessons Completed by Treatment

Cumulative Dist of Completed Lessons by Treatment

- 8 lessons per week
- 12 lessons per week
- 16 lessons per week
- 20 lessons per week
- 24 lessons per week
Pre-Experiment: Distribution of # of Lessons Completed by Treatment

Cumulative Dist of Completed Lessons by Treatment

- 8 lessons per week
- 12 lessons per week
- 16 lessons per week
- 20 lessons per week
- 24 lessons per week
Pre-Experiment: Distribution of # of Lessons Completed by Treatment

Cumulative Dist of Completed Lessons by Treatment

- 8 lessons per week
- 12 lessons per week
- 16 lessons per week
- 20 lessons per week
- 24 lessons per week

Cumulative Frequency vs. Completed Lessons
Pre-Experiment: Improvement in Test Scores by Treatment

Average Improvement in Test Scores by Treatment

- Final Test Score: 8 Lessons per Week
- Initial Test Score:
- Improvement in Test Scores:

Bar Chart
Pre-Experiment: Improvement in Test Scores by Treatment

Average Improvement in Test Scores by Treatment

- 8 Lessons per Week
- 12 Lessons per Week

Final Test Score - Initial Test Score
- 0
- 30
- 60
- 90
- 120
- 150
- 180
Pre-Experiment: Improvement in Test Scores by Treatment
Pre-Experiment: Improvement in Test Scores by Treatment

Average Improvement in Test Scores by Treatment

Final Test Score - Initial Test Score

- 8 Lessons per Week
- 12 Lessons per Week
- 16 Lessons per Week
- 20 Lessons per Week
Pre-Experiment: Improvement in Test Scores by Treatment

Average Improvement in Test Scores by Treatment

P-values: 8 lessons vs 12 lessons: 0.682, 8 lessons vs 16 lessons: 0.376, 8 lessons vs 20 lessons: 0.210, 8 lessons vs 24 lessons: 0.060
ToT coefficient of completed lessons: 1.18 (s.e.: .0575, p-value: 0.040)
Before Belief Elicitation

Providing information about what the test scores mean: Benchmarking

Beginner Skills
(67 lessons)

Intermediate Skills
(142 lessons)

Test Scores

0

338

414

1000

Semester 1
Before Belief Elicitation
Providing information about what the test scores mean: Interpretation

0: Greet people, introduce yourself, say bye
51: Order and pay at a café
161: Talk about days of week, times of day
284: Describe objects and how they are used
450: Talk about the past
619: Make plans, talk about the future
774: Talk about recent experiences (Present Perfect)
1000:
Before Belief Elicitation
Providing background information about previous students

- Students from your university and other similar universities in California signed up for the learning Spanish research study just as you did.
- First, they took the initial assessment test.
  Average Initial Score=289 out of 1000
- They were required to complete a certain number of lessons through Duolingo for 1 month.
- After 1 month, they took the final assessment test.
<table>
<thead>
<tr>
<th>Experimental Arm:</th>
<th>All</th>
<th>No Info</th>
<th>Full</th>
<th>Low</th>
<th>High</th>
<th>P-value</th>
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<tbody>
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<td>105</td>
<td>106</td>
<td>101</td>
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</table>
Students from your university and other similar universities in California signed up for the learning Spanish research study just as you did.

First, they took the initial assessment test.

They were required to complete a certain number of lessons through Duolingo for 1 month.

After 1 month, they took the final assessment test.

A participant who has an initial score similar to yours was randomly assigned to complete 12 Duolingo lessons per week (so 48 Duolingo lessons in total).

The participant improved 50 points after completing 48 Duolingo lessons in a month.
Do Initial Beliefs About the Self Differ from Initial Beliefs About the Previous Students?

Distribution of Percentage Differences in Guesses' for Average Improvement per Lesson

(25th percentile, 75th percentile) = (-12%, +13%)
### Correlates of Locus of Control

<table>
<thead>
<tr>
<th>Variable</th>
<th>Correlation</th>
</tr>
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<tbody>
<tr>
<td>Growth Mindset</td>
<td>-0.0280</td>
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<tr>
<td>Extraversion</td>
<td>-0.0891*</td>
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<td>Agreeableness</td>
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<td>Conscientiousness</td>
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<td>Neuroticism</td>
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<tr>
<td>Openness</td>
<td>0.0232</td>
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<td>Self Control</td>
<td>-0.114*</td>
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<tr>
<td>Spanish Before</td>
<td>-0.0661</td>
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<td>Serious Learner</td>
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<td>Spanish Knowledge</td>
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<td>Female</td>
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<tr>
<td>$\delta$</td>
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</table>
Change in Beliefs by Locus of Control

The graph shows the change in beliefs by locus of control. The x-axis represents different loci of control categories: No Info Internal, Locus, No Info External, and Locus. The y-axis represents the change in beliefs, ranging from -2 to 2.

- No Info Internal: A decrease in beliefs is observed, indicated by a bar slightly below the zero line.
- Locus: The change in beliefs is close to zero, with no significant change.
- No Info External: A slight increase in beliefs is observed, indicated by a bar slightly above the zero line.
- Locus: Similar to No Info Internal, a decrease in beliefs is observed, indicated by a bar slightly below the zero line.
Information treatments are effective at changing beliefs.
Information treatments are effective at changing beliefs.
Information treatments are effective at changing beliefs, but less so for externals.
Information treatments are effective at changing beliefs, but less so for externals.
Change in Effort-Reduced Form

![Graph showing the number of lessons completed across different conditions: No Info Internal, Locus, External, Locus. The bar is significantly higher for No Info Internal compared to the others.](image-url)
Change in Effort-Reduced Form

No Info: Internal learners complete more lessons than External learners
Change in Effort-Reduced Form

Internals complete less lessons in Full & Low treatments compared to No Info treatment.
Change in Effort-Reduced Form

![Bar Chart]

- No Info Internal
- Full
- Low Locus
- High
- No Info External
- Locus

Y-axis: # of Lessons Completed
X-axis: Conditions

*Note: The chart shows the number of lessons completed under different conditions, with error bars indicating variability.*
Change in Effort-Reduced Form

Externals complete more lessons in Full & Low treatments compared to No Info treatment.
Change in Effort-Reduced Form

![Bar chart showing the number of lessons completed under different conditions.

- No Info: Blue bars
- Internal: Red bars
- Full: Green bars
- Low Locus: Orange bars
- High Locus: Purple bars

The chart illustrates the impact of information availability and locus on the completion of lessons, with error bars indicating variability.](image)
Change in Effort-Reduced Form (Overall Sample)
Change in Effort-Reduced Form (Overall Sample)

![Bar chart showing the number of lessons completed with 'No Info' and 'Full' conditions. The chart indicates a higher number of lessons completed in the 'No Info' condition compared to the 'Full' condition.](chart.png)
Change in Effort-Reduced Form (Overall Sample)
Change in Effort-Reduced Form (Overall Sample)

No difference in the number of lessons completed across treatment groups
## Effect of Change in Beliefs on Effort in the Overall Sample

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1) New Lessons Completed</th>
<th>(2) New Lessons Completed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change in Beliefs</td>
<td>2.209</td>
<td>1.535</td>
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<tr>
<td></td>
<td>(2.707)</td>
<td>(2.456)</td>
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<tr>
<td>Initial Beliefs</td>
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<td>(1.698)</td>
<td>(1.523)</td>
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<tr>
<td>Constant</td>
<td>26.46***</td>
<td>-6.639</td>
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<tr>
<td></td>
<td>(4.845)</td>
<td>(18.44)</td>
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<tr>
<td>Observations</td>
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<td>374</td>
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<tr>
<td>First Stage F-Stat</td>
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<td>Controls</td>
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</tr>
</tbody>
</table>

Standard errors in parentheses.

*** p<0.01, ** p<0.05, * p<0.1
Effect of Change in Beliefs on Performance

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1) Improvement in Test Scores</th>
<th>(2) Improvement in Test Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change in Beliefs</td>
<td>-4.008</td>
<td>1.051</td>
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<td></td>
<td>(12.80)</td>
<td>(12.15)</td>
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<td>Initial Test Score</td>
<td>-0.227***</td>
<td>-0.223***</td>
</tr>
<tr>
<td></td>
<td>(0.0555)</td>
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<td>(96.25)</td>
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<td>Observations</td>
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<tr>
<td>First Stage F-Stat</td>
<td>10.66</td>
<td>11.32</td>
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<tr>
<td>Controls</td>
<td>No</td>
<td>Yes</td>
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</table>

Standard errors in parentheses.

*** p<0.01, ** p<0.05, * p<0.1