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

Fulya Ersoy
Department of Economics, Stanford University

Job Market Paper Presentation
December 29, 2017
Acknowledgements

This project is supported by

- The Institute for Research in the Social Sciences at Stanford University
- Leonard W. Ely and Shirley R. Ely Graduate Student Fellowship through Stanford Institute for Economic Policy Research (SIEPR)
- Russell Sage Foundation
- Shultz Graduate Student Fellowship in Economic Policy through SIEPR
- Stanford Graduate Research Opportunities Fund
Motivation

How much effort to exert is one of the most important decisions students make

- Study effort is an important determinant of achievement (Costrell (1994); Stinebrickner and Stinebrickner (2008); De Fraja, Oliveria, and Zanchi (2010))
- Academic achievement is an important determinant of productivity in labor market (Becker (1964); Bishop (1989))
Motivation

- How much effort to exert is one of the most important decisions students make
  - Study effort is an important determinant of achievement (Costrell (1994); Stinebrickner and Stinebrickner (2008); De Fraja, Oliveria, and Zanchi (2010))
  - Academic achievement is an important determinant of productivity in labor market (Becker (1964); Bishop (1989))
- How do students make their study decisions?
Motivation

- How much effort to exert is one of the most important decisions students make
  - Study effort is an important determinant of achievement (Costrell (1994); Stinebrickner and Stinebrickner (2008); De Fraja, Oliveria, and Zanchi (2010))
  - Academic achievement is an important determinant of productivity in labor market (Becker (1964); Bishop (1989))

- How do students make their study decisions?
- Beliefs about the effort-rewards relationship
Motivation

- How much effort to exert is one of the most important decisions students make
  - Study effort is an important determinant of achievement (Costrell (1994); Stinebrickner and Stinebrickner (2008); De Fraja, Oliveria, and Zanchi (2010))
  - Academic achievement is an important determinant of productivity in labor market (Becker (1964); Bishop (1989))
- How do students make their study decisions?
- Beliefs about the effort-rewards relationship
  - Suggestive evidence that students might not know how effort affects performance (Fryer (2011), Bobba and Frisancho (2014), Bandiera et al. (2015))
Motivation

- How much effort to exert is one of the most important decisions students make
  - Study effort is an important determinant of achievement (Costrell (1994); Stinebrickner and Stinebrickner (2008); De Fraja, Oliveria, and Zanchi (2010))
  - Academic achievement is an important determinant of productivity in labor market (Becker (1964); Bishop (1989))

- How do students make their study decisions?
- Beliefs about the effort-rewards relationship
  - Suggestive evidence that students might not know how effort affects performance (Fryer (2011), Bobba and Frisancho (2014), Bandiera et al. (2015))
  - Change in beliefs will affect effort of different people differently
Motivation

- How much effort to exert is one of the most important decisions students make
  - Study effort is an important determinant of achievement (Costrell (1994); Stinebrickner and Stinebrickner (2008); De Fraja, Oliveria, and Zanchi (2010))
  - Academic achievement is an important determinant of productivity in labor market (Becker (1964); Bishop (1989))

- How do students make their study decisions?
- Beliefs about the effort-rewards relationship
  - Suggestive evidence that students might not know how effort affects performance (Fryer (2011), Bobba and Frisancho (2014), Bandiera et al. (2015))
  - Change in beliefs will affect effort of different people differently
  - The effect is likely to be mediated by personality traits such as
    - perception of control, growth mindset, self control
This Paper

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

Information (Experimental Variation) ⇒ Perceptions ⇒ Effort

Context: Online language learning platform: Duolingo
Subject Pool: Intrinsically motivated students who want to learn Spanish

Answer is ambiguous theoretically and it depends on the magnitude of substitution & income effects

Main Finding: Students change their study behavior upon changing their beliefs. The direction of the effect is mediated by locus of control - the extent to which individuals feel control over their outcomes.
Research Question: How does effort respond to the perceived relationship between effort and rewards?

Information (Experimental Variation) $\Rightarrow$ Perceptions $\Rightarrow$ Effort
Research Question: How does effort respond to the perceived relationship between effort and rewards?

Information (Experimental Variation) ⇒ Perceptions ⇒ Effort

Context: Online language learning platform: Duolingo
**Research Question:** How does effort respond to the perceived relationship between effort and rewards?

Information (Experimental Variation) ⇒ Perceptions ⇒ Effort

**Context:** Online language learning platform: Duolingo

**Subject Pool:** Intrinsically motivated students who want to learn Spanish
This Paper

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

Information (Experimental Variation) ⇒ Perceptions ⇒ Effort

**Context:** Online language learning platform: Duolingo

**Subject Pool:** Intrinsically motivated students who want to learn Spanish

**Answer** is ambiguous theoretically and it depends on the magnitude of substitution & income effects
**Research Question:** How does effort respond to the perceived relationship between effort and rewards?

Information (Experimental Variation) $\Rightarrow$ Perceptions $\Rightarrow$ Effort

**Context:** Online language learning platform: Duolingo

**Subject Pool:** Intrinsically motivated students who want to learn Spanish

**Answer** is ambiguous theoretically and it depends on the magnitude of substitution & income effects

**Main Finding:** Students change their study behavior upon changing their beliefs. The direction of the effect is mediated by *locus of control* - the extent to which individuals feel control over their outcomes.
Challenges
How does effort respond to the perceived relationship between effort and rewards?
Challenges
How does effort respond to the perceived relationship between effort and rewards?

- Measuring effort
Challenges

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

▶ Measuring effort

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

- Measuring effort

- Measuring rewards

- Effort-rewards relationship is hard to estimate due to unobserved factors such as ability
Challenges

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

▶ Measuring effort

▶ Measuring rewards

▶ Effort-rewards relationship is hard to estimate due to unobserved factors such as ability

▶ Beliefs about the effort-rewards relation are largely unmeasured and might correlate with unobserved factors
Challenges

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

- Measuring effort

- Measuring rewards

- Effort-rewards relationship is hard to estimate due to unobserved factors such as ability

- Beliefs about the effort-rewards relation are largely unmeasured and might correlate with unobserved factors

- Personality traits are largely not measured
A Field Experiment Designed to Address These Challenges

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

- Measuring effort
  - Accurate measure of effort
- Measuring rewards

- Effort-rewards relationship is hard to estimate due to unobserved factors such as ability

- Beliefs about the effort-rewards relation are largely unmeasured and might correlate with unobserved factors

- Personality traits are largely not measured
A Field Experiment Designed to Address These Challenges

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

- Measuring effort
  - Accurate measure of effort
- Measuring rewards
  - Rewards are closely tied to the effort
- Effort-rewards relationship is hard to estimate due to unobserved factors such as ability

- Beliefs about the effort-rewards relation are largely unmeasured and might correlate with unobserved factors
- Personality traits are largely not measured
A Field Experiment Designed to Address These Challenges
How does effort respond to the perceived relationship between effort and rewards?

- Measuring effort
  - Accurate measure of effort
- Measuring rewards
  - Rewards are closely tied to the effort
- Effort-rewards relationship is hard to estimate due to unobserved factors such as ability
  - Measure the causal effort-rewards relationship by experimentally manipulating students’ effort
- Beliefs about the effort-rewards relation are largely unmeasured and might correlate with unobserved factors

- Personality traits are largely not measured
A Field Experiment Designed to Address These Challenges

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

- Measuring effort
  - Accurate measure of effort
- Measuring rewards
  - Rewards are closely tied to the effort
- Effort-rewards relationship is hard to estimate due to unobserved factors such as ability
  - Measure the causal effort-rewards relationship by experimentally manipulating students’ effort
- Beliefs about the effort-rewards relation are largely unmeasured and might correlate with unobserved factors
  - Elicit the perceived effort-rewards relationship in an incentivized manner and at different points
  - Exogenously manipulate students’ beliefs by assigning them to different treatments, based on factual information
- Personality traits are largely not measured
A Field Experiment Designed to Address These Challenges

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

▶ Measuring effort
  ▶ Accurate measure of effort

▶ Measuring rewards
  ▶ Rewards are closely tied to the effort

▶ Effort-rewards relationship is hard to estimate due to unobserved factors such as ability
  ▶ Measure the causal effort-rewards relationship by experimentally manipulating students’ effort

▶ Beliefs about the effort-rewards relation are largely unmeasured and might correlate with unobserved factors
  ▶ Elicit the perceived effort-rewards relationship in an incentivized manner and at different points
  ▶ Exogenously manipulate students’ beliefs by assigning them to different treatments, based on factual information

▶ Personality traits are largely not measured
  ▶ Measure students’ personality traits
Outline

Introduction

Conceptual Framework

Experimental Design

Results

Conclusion

Literature
Outline

Introduction

Conceptual Framework

Experimental Design

Results

Conclusion
Max \( U \) (Consumption, Leisure) = Consumption + wage \times Leisure = wage \times Time
Conceptual Framework

Canonical Model of Labor Supply
Canonical Model of Labor Supply

\[ \text{Max } U(\text{Consumption}, \text{Leisure}) \]
Conceptual Framework

Canonical Model of Labor Supply

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

\[
s.t.
\]

\[
\text{Leisure} + \text{Work Hours} = \text{Time}
\]
Canonical Model of Labor Supply

Max $U(\text{Consumption}, \text{Leisure})$

s.t.

$\text{Leisure} + \text{Work Hours} = \text{Time}$

$\text{Consumption} = \text{wage} \times \text{Work Hours}$
Conceptual Framework

Canonical Model of Labor Supply

Max $U(\text{Consumption}, \text{Leisure})$

s.t.

Leisure + Work Hours = Time

Consumption = wage \times Work Hours

Max $U(\text{Consumption}, \text{Leisure})$

s.t.

Consumption + wage \times Leisure = wage \times Time
Conceptual Framework

Canonical Model of Labor Supply

Max $U(\text{Consumption}, \text{Leisure})$

s.t.

$\text{Leisure} + \text{Work Hours} = \text{Time}$

$\text{Consumption} = \text{wage} \times \text{Work Hours}$

Max $U(\text{Consumption}, \text{Leisure})$

s.t.

$\text{Consumption} + \text{wage} \times \text{Leisure} = \text{wage} \times \text{Time}$

What happens to hours of work when the wage decreases?
Conceptual Framework

Canonical Model of Labor Supply

Max $U(\text{Consumption}, \text{Leisure})$

s.t.

Leisure + Work Hours = Time

Consumption = wage * Work Hours

Max $U(\text{Consumption}, \text{Leisure})$

s.t.

Consumption + wage * Leisure = wage * Time

What happens to hours of work when the wage decreases?

- Substitution Effect → Reduction in hours of work
Conceptual Framework

Canonical Model of Labor Supply

\[ \text{Max } U(\text{Consumption, Leisure}) \]
\[ \text{s.t.} \]
\[ \text{Leisure} + \text{Work Hours} = \text{Time} \]
\[ \text{Consumption} = \text{wage} \times \text{Work Hours} \]

\[ \text{Max } U(\text{Consumption, Leisure}) \]
\[ \text{s.t.} \]
\[ \text{Consumption} + \text{wage} \times \text{Leisure} = \text{wage} \times \text{Time} \]

What happens to hours of work when the wage decreases?

- Substitution Effect → Reduction in hours of work
- Income Effect → Increase in hours of work
Conceptual Framework
Backward Bending Supply Curve

Wage rate

Hours worked

W1, W2, W3

L1, L2, L3
Conceptual Framework

Analogous to the Labor Supply Theory
Conceptual Framework

Analogous to the Labor Supply Theory

\[ \text{Max } U(\text{Achievement}, \text{Leisure}) \]
Conceptual Framework
Analogous to the Labor Supply Theory

$$\text{Max } U(\text{Achievement, Leisure})$$

s.t.

$$\text{Leisure + Study } = \text{Time}$$
Conceptual Framework

Analogous to the Labor Supply Theory

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

s.t.

\[ \text{Leisure} + \text{Study} = \text{Time} \]

\[ \text{Achievement} = \beta \ast \text{Study} \]

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

Max $U(Achievement, Leisure)$

s.t.

$Achievement + \beta Leisure = \beta Time$
Conceptual Framework
Analogous to the Labor Supply Theory

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

\[ \text{s.t.} \]

\[ \text{Achievement} + \beta \text{Leisure} = \beta \text{Time} \]

$\beta$ is both the price and the opportunity cost of the leisure
Conceptual Framework
Analogous to the Labor Supply Theory

\[
\begin{align*}
\text{Max } U(\text{Achievement, Leisure}) \\
\text{s.t.} \\
\text{Achievement} + \beta \text{Leisure} = \beta \text{Time}
\end{align*}
\]

\(\beta\) is both the price and the opportunity cost of the leisure.

How does the optimal level of effort change as we change \(\beta\)?
Conceptual Framework

Analogous to the Labor Supply Theory

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

\( \beta \) is both the price and the opportunity cost of the leisure

How does the optimal level of effort change as we change \( \beta \)?
Depends on the relative magnitudes of the substitution and income effects
Conceptual Framework
Analogous to the Labor Supply Theory

\[
\begin{align*}
\text{Max } U(\text{Achievement}, \text{Leisure}) \\
s.t. \\
\text{Achievement} + \beta \text{Leisure} = \beta \text{Time}
\end{align*}
\]

\(\beta\) is both the price and the opportunity cost of the leisure

How does the optimal level of effort change as we change \(\beta\)?

Depends on the relative magnitudes of the substitution and income effects

- ↓ perceived effectiveness of effort
Conceptual Framework

Analogous to the Labor Supply Theory

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

s.t.

\[
\text{Achievement} + \beta \text{Leisure} = \beta \text{Time}
\]

\(\beta\) is both the price and the opportunity cost of the leisure

**How does the optimal level of effort change as we change \(\beta\)?**

Depends on the relative magnitudes of the substitution and income effects

- \(\downarrow\) perceived effectiveness of effort
- Substitution effect would cause \(\downarrow\) effort
Conceptual Framework

Analogous to the Labor Supply Theory

Max $U(Achievement, Leisure)$

$s.t.$

$Achievement + \beta Leisure = \beta Time$

$\beta$ is both the price and the opportunity cost of the leisure

How does the optimal level of effort change as we change $\beta$?

Depends on the relative magnitudes of the substitution and income effects

- $\downarrow$ perceived effectiveness of effort
- Substitution effect would cause $\downarrow$ effort
- Income effect would cause $\uparrow$ effort
Conceptual Framework

Analogous to the Labor Supply Theory

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

\[ s.t. \]

\[ \text{Achievement} + \beta \text{Leisure} = \beta \text{Time} \]

\( \beta \) is both the price and the opportunity cost of the leisure

**How does the optimal level of effort change as we change \( \beta \)?**

Depends on the relative magnitudes of the substitution and income effects

- ▶ ‪↓ ‬perceived effectiveness of effort
- ▶ Substitution effect would cause ‪↓ ‬effort
- ▶ Income effect would cause ‪↑ ‬effort

**Personality traits might mediate for whom the substitution/income effect dominates.**
Outline

Introduction

Conceptual Framework

Experimental Design

Results

Conclusion
Subject Pool

- Motivated individuals who want to learn Spanish online
Subject Pool

- Motivated individuals who want to learn Spanish online
- Recruit from large and public California Universities
Subject Pool

List

13 / 90
Subject Pool

- Motivated individuals who want to learn Spanish online
- Recruit from large and public California Universities
Subject Pool

- 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 (Emails sent to 17,166 individuals)
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
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
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
Duolingo homogenizes the learning experience
Duolingo homogenizes the learning experience

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

Animals 0/4
Duolingo homogenizes the learning experience

Spanish skills

- Basics 1
- Phrases
- Basics 2
- Food 0/4
- Animals 0/4
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
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
Effort: # of Lessons Completed
Select translation of “chicken”

- la fruta 1
- la pasta 2
- el pollo 3
Translate this text

Nosotros comemos pescado.

We eat fish.
Translate “egg”

You used the wrong word.

el huevo

Report a problem
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
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
Experimental Design

Sign Up
Experimental Design

Sign Up

Take Initial Survey
Initial Survey

Example Questions

- Locus of Control Survey (Rotter (1966))
- Growth Mindset Survey (Paunesku et al. (2015))
- Self Control Survey (Tangney et al. (2004))
- Big five personality traits (Rammstedt and John (2007))
Initial Survey

Example Questions

- Locus of Control Survey (Rotter (1966))
- Growth Mindset Survey (Paunesku et al. (2015))
- Self Control Survey (Tangney et al. (2004))
- Big five personality traits (Rammstedt and John (2007))
- Language background, schooling background and demographics
Experimental Design

Sign Up

Take Initial Survey
Experimental Design

Sign Up

Take Initial Survey

Take Initial Test
Spanish Assessment Test

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

Sign Up

Take Initial Survey

Take Initial Test
Experimental Design

Sign Up

Take Initial Survey

Take Initial Test

Complete 6 Lessons
Experimental Design

Sign Up

Take Initial Survey

Take Initial Test

Complete 6 Lessons

Week 0 Belief Survey
Belief Elicitation

Beliefs about how Duolingo lessons affect the performance in the Spanish test
Belief Elicitation

Beliefs about how Duolingo lessons affect the performance in the Spanish test

- For 5 different levels of effort (*aggregated* and *averaged* for the analysis)
Belief Elicitation

Beliefs about how Duolingo lessons affect the performance in the Spanish test

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

**Randomization to Classrooms:**
- 8 lessons, 12 lessons, 16 lessons,
- 20 lessons and 24 lessons per week

**Take Final Tests**
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

Study as assigned

<table>
<thead>
<tr>
<th>Week 1</th>
<th>Week 2</th>
<th>Week 3</th>
<th>Week 4</th>
</tr>
</thead>
</table>

Take Initial Survey

Take Initial Tests

**Randomization to Classrooms:**

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

Take Final Tests

Take Final Survey

Receive Payments
Pre-Experiment: Distribution of # of Lessons Completed by Treatment

Cumulative Dist of Completed Lessons by Treatment

Completed Lessons

Cumulative Frequency

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

Average Improvement in Test Scores by Treatment

<table>
<thead>
<tr>
<th>Final Test Score - Initial Test Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 30 60 90 120 150 180</td>
</tr>
</tbody>
</table>

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

Average Improvement in Test Scores by Treatment

<table>
<thead>
<tr>
<th>Lessons per Week</th>
<th>Final Test Score - Initial Test Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>12</td>
<td>30</td>
</tr>
<tr>
<td>16</td>
<td>60</td>
</tr>
<tr>
<td>20</td>
<td>90</td>
</tr>
</tbody>
</table>
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)
Belief Elicitation

Beliefs about how Duolingo lessons affect the performance in the Spanish test

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

Beliefs about how Duolingo lessons affect the performance in the Spanish test

▶ For 5 different levels of effort (aggregated and averaged for the analysis)
▶ Beliefs about whom?
  ▶ Themselves
  ▶ The students from a previous experiment - Designed to measure the empirical, causal relationship between Duolingo lessons and performance in the Spanish test
    ▶ Incentivized based on accuracy using absolute deviation rule
Before Belief Elicitation

I provide information about
Before Belief Elicitation

I provide information about

- Duolingo lessons
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

- 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
- The students from the previous experiment
Experimental Design

Sign Up

Take Initial Survey

Take Initial Test

Complete 6 Lessons

Week 0 Belief Survey
Experimental Design

Sign Up

Take Initial Survey

Take Initial Test

Complete 6 Lessons

Week 0 Belief Survey

Randomization to Information
(a) No Information (107 subjects)    (b) Average (105 subjects)

(c) Low (106 subjects)    (d) High (101 subjects)
Information Treatments

(a) No Information (107 subjects)

(b) Average (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) Average (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)

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.
Information Treatments

(a) No Information (107 subjects)

(b) Average (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

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
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
- Average: Information about average improvement
  - About different effort levels
  - Based on whole sample
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
- Average: Information about average improvement
  - About different effort levels
  - Based on whole sample

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
- Average: Information about average improvement
  - 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
- Take Initial Test
- Complete 6 Lessons
- Week 0 Belief Survey
- Randomization to Information
Experimental Design

Sign Up

Study as much as desired

Take Initial Survey

Take Initial Test

Complete 6 Lessons

Week 0 Belief Survey

Randomization to Information
Experimental Design

Sign Up

Study as much as desired

Week 1
Belief Survey
Take Initial Survey
Take Initial Test
Complete 6 Lessons

Week 2
Belief Survey
Week 3
Belief Survey

Week 0 Belief Survey
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

**Take Initial Survey**

**Take Initial Test**

**Complete 6 Lessons**

**Week 0 Belief Survey**

**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

Take Initial Survey

Take Initial Test

Complete 6 Lessons

Week 0 Belief Survey

Randomization to Information

Take Final Test
Experimental Design

**Sign Up**

**Study as much as desired**

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

- Take Initial Survey
- Take Initial Test
- Complete 6 Lessons
- Week 0 Belief Survey
- Week 4 Belief Survey
- Take Final Test
- Take Final Survey

Randomization to Information
Outline

Introduction

Conceptual Framework

Experimental Design

Results

Conclusion
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).

\[ \text{Difference in Beliefs} = \text{Initial Beliefs about the Previous Participants} - \text{Initial Beliefs about Self} \]

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

For 15% of the participants, Difference=0.
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 Difference in Beliefs = Initial Beliefs about the Previous Participants − Initial Beliefs about Self.
- Median Difference is 0, Mean Difference is −.07 (s.d. 1.17).
- For 15% of the participants, Difference = 0.
## Change in Beliefs about the Previous Participants

<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></td>
<td>Average</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>-0.973***</td>
<td>-1.224***</td>
</tr>
<tr>
<td></td>
<td>(0.318)</td>
<td>(0.318)</td>
</tr>
<tr>
<td></td>
<td>-0.980***</td>
<td>-1.199***</td>
</tr>
<tr>
<td></td>
<td>(0.335)</td>
<td>(0.333)</td>
</tr>
<tr>
<td></td>
<td>Initial Belief</td>
<td>Initial Belief</td>
</tr>
<tr>
<td></td>
<td>-0.641***</td>
<td>-0.672***</td>
</tr>
<tr>
<td></td>
<td>(0.0396)</td>
<td>(0.0422)</td>
</tr>
<tr>
<td></td>
<td>-0.334</td>
<td>-0.296</td>
</tr>
<tr>
<td>Observations</td>
<td>374</td>
<td>374</td>
</tr>
<tr>
<td>No-Information Mean</td>
<td>-0.334</td>
<td>-0.296</td>
</tr>
<tr>
<td>No-Information SD</td>
<td>0.225</td>
<td>0.242</td>
</tr>
<tr>
<td>Full=Low</td>
<td>0.430</td>
<td>0.508</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
## Change in Beliefs about the Previous Participants

<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>Average</td>
<td>-0.973*** (0.318)</td>
<td>0.147 (0.282)</td>
</tr>
<tr>
<td></td>
<td>-0.980*** (0.335)</td>
<td>0.0797 (0.298)</td>
</tr>
<tr>
<td>Low</td>
<td>-1.224*** (0.318)</td>
<td>-0.405 (0.281)</td>
</tr>
<tr>
<td></td>
<td>-1.199*** (0.333)</td>
<td>-0.502* (0.295)</td>
</tr>
<tr>
<td>High</td>
<td>0.614* (0.319)</td>
<td>1.065*** (0.282)</td>
</tr>
<tr>
<td></td>
<td>0.692** (0.334)</td>
<td>0.909*** (0.302)</td>
</tr>
<tr>
<td>Initial Belief</td>
<td>-0.641*** (0.0396)</td>
<td>-0.150*** (0.0355)</td>
</tr>
<tr>
<td></td>
<td>-0.672*** (0.0422)</td>
<td>-0.155*** (0.0380)</td>
</tr>
<tr>
<td>Constant</td>
<td>2.123*** (0.274)</td>
<td>0.143 (0.248)</td>
</tr>
<tr>
<td></td>
<td>8.789 (11.22)</td>
<td>13.97 (9.810)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Observations</th>
<th>374</th>
<th>374</th>
</tr>
</thead>
<tbody>
<tr>
<td>No-Information Mean</td>
<td>-0.334 (0.274)</td>
<td>-0.296 (11.22)</td>
</tr>
<tr>
<td>No-Information SD</td>
<td>0.225 (0.274)</td>
<td>0.242 (11.22)</td>
</tr>
<tr>
<td>Full=Low</td>
<td>0.430 (0.274)</td>
<td>0.0500 (11.22)</td>
</tr>
<tr>
<td>Full=High</td>
<td>0 (0.274)</td>
<td>0.00100 (11.22)</td>
</tr>
<tr>
<td>Low=High</td>
<td>0 (0.274)</td>
<td>0 (11.22)</td>
</tr>
<tr>
<td>Joint</td>
<td>0 (0.274)</td>
<td>0 (11.22)</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 Beliefs about the Previous Participants

<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></td>
<td>Average: -0.973*** (0.318)</td>
<td>-0.980*** (0.335)</td>
</tr>
<tr>
<td></td>
<td>Low: -1.224*** (0.318)</td>
<td>-1.199*** (0.333)</td>
</tr>
<tr>
<td></td>
<td>High: 0.614* (0.319)</td>
<td>0.692** (0.334)</td>
</tr>
<tr>
<td></td>
<td>Initial Belief: -0.641*** (0.0396)</td>
<td>-0.672*** (0.0422)</td>
</tr>
<tr>
<td></td>
<td>Constant: 2.123*** (0.274)</td>
<td>8.789 (11.22)</td>
</tr>
<tr>
<td>Observations</td>
<td>374</td>
<td>374</td>
</tr>
<tr>
<td>No-Information Mean</td>
<td>-0.334</td>
<td>-0.296</td>
</tr>
<tr>
<td>No-Information SD</td>
<td>0.225</td>
<td>0.242</td>
</tr>
<tr>
<td>Full=Low</td>
<td>0.430</td>
<td>0.508</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

Change in beliefs about the self looks surprisingly similar!
Change in Effort-Reduced Form
Change in Effort-Reduced Form

![Bar chart showing the number of lessons completed with 'No Info' category.]
Change in Effort-Reduced Form

The bar chart shows the comparison of the number of lessons completed between 'No Info' and 'Avg' conditions. The chart indicates that participants in the 'No Info' condition completed a higher number of lessons compared to those in the 'Avg' condition.
Change in Effort-Reduced Form

![Bar chart showing the number of lessons completed with different levels of information: No Info, Avg, Low.](chart.png)
Change in Effort-Reduced Form

No difference in the number of lessons completed across treatment groups
## Effect of Change in Beliefs on Effort (IV Approach)

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1) New Lessons Completed</th>
<th>(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change in Beliefs</td>
<td>2.209</td>
<td>1.535</td>
</tr>
<tr>
<td></td>
<td>(2.707)</td>
<td>(2.456)</td>
</tr>
<tr>
<td>Initial Beliefs</td>
<td>1.812</td>
<td>1.002</td>
</tr>
<tr>
<td></td>
<td>(1.698)</td>
<td>(1.523)</td>
</tr>
<tr>
<td>Constant</td>
<td>26.46***</td>
<td>-6.639</td>
</tr>
<tr>
<td></td>
<td>(4.845)</td>
<td>(18.44)</td>
</tr>
<tr>
<td>Observations</td>
<td>374</td>
<td>374</td>
</tr>
<tr>
<td>First Stage F-Stat</td>
<td>11.84</td>
<td>12.81</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
What do we learn so far?

- Information treatments are very effective at changing beliefs
What do we learn so far?

- Information treatments are very effective at changing beliefs
- Information treatments have no effect on effort on average

So, changes in beliefs seem to have no effect on effort on average. These results suggest income effect is stronger for some people and substitution effect is stronger for the others. Who responds in which direction? Personality traits: Locus of Control, Growth Mindset, Self Control.
What do we learn so far?

- Information treatments are very effective at changing beliefs
- Information treatments have no effect on effort on average
- So, changes in beliefs seem to have no effect on effort on average
What do we learn so far?

- Information treatments are very effective at changing beliefs.
- Information treatments have no effect on effort on average.
- So, changes in beliefs seem to have no effect on effort on average.
- These results suggest income effect is stronger for some people and substitution effect is stronger for the others.
What do we learn so far?

- Information treatments are very effective at changing beliefs.
- Information treatments have no effect on effort on average.
- So, changes in beliefs seem to have no effect on effort on average.
- These results suggest income effect is stronger for some people and substitution effect is stronger for the others.
- Who responds in which direction?
  - Personality traits: Locus of Control, Growth Mindset, Self Control.
Heterogeneity of the Results by Personality Traits (IV Approach)
Heterogeneity of the Results by Personality Traits (IV Approach)

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>New Lessons Completed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change in Beliefs</td>
<td>2.367 (2.832)</td>
</tr>
<tr>
<td>Change in Beliefs * Locus of Control</td>
<td>9.520** (4.050)</td>
</tr>
<tr>
<td>Change in Beliefs * Growth Mindset</td>
<td></td>
</tr>
<tr>
<td>Change in Beliefs * Self Control</td>
<td></td>
</tr>
<tr>
<td>Locus of Control</td>
<td>12.52** (5.315)</td>
</tr>
<tr>
<td>Growth Mindset</td>
<td>2.390 (2.276)</td>
</tr>
<tr>
<td>Self-Control</td>
<td>5.266** (2.612)</td>
</tr>
<tr>
<td>Constant</td>
<td>-4.950 (31.89)</td>
</tr>
</tbody>
</table>

Observations 374
Controls Yes

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Higher locus of control score indicates internal. All personality variables are standardized.
Heterogeneity of the Results by Personality Traits (IV Approach)

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>New Lessons Completed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change in Beliefs</td>
<td>2.367 (2.832)</td>
</tr>
<tr>
<td></td>
<td>1.853 (2.619)</td>
</tr>
<tr>
<td>Change in Beliefs * Locus of Control</td>
<td>9.520** (4.050)</td>
</tr>
<tr>
<td>Change in Beliefs * Growth Mindset</td>
<td>0.531 (3.407)</td>
</tr>
<tr>
<td>Change in Beliefs * Self Control</td>
<td></td>
</tr>
<tr>
<td>Locus of Control</td>
<td>12.52** (5.315)</td>
</tr>
<tr>
<td></td>
<td>1.355 (1.773)</td>
</tr>
<tr>
<td>Growth Mindset</td>
<td>2.390 (2.276)</td>
</tr>
<tr>
<td></td>
<td>1.189 (2.492)</td>
</tr>
<tr>
<td>Self-Control</td>
<td>5.266** (2.612)</td>
</tr>
<tr>
<td></td>
<td>5.450** (2.117)</td>
</tr>
<tr>
<td>Constant</td>
<td>-4.950 (31.89)</td>
</tr>
<tr>
<td></td>
<td>-6.683 (25.68)</td>
</tr>
<tr>
<td>Observations</td>
<td>374</td>
</tr>
<tr>
<td>Controls</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
</tr>
</tbody>
</table>

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Higher locus of control score indicates internal. All personality variables are standardized.
Heterogeneity of the Results by Personality Traits (IV Approach)

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>New Lessons Completed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change in Beliefs</td>
<td>2.367 1.853 2.013</td>
</tr>
<tr>
<td></td>
<td>(2.832) (2.619) (2.331)</td>
</tr>
<tr>
<td>Change in Beliefs * Locus of Control</td>
<td>9.520** (4.050)</td>
</tr>
<tr>
<td>Change in Beliefs * Growth Mindset</td>
<td>0.531 (3.407)</td>
</tr>
<tr>
<td>Change in Beliefs * Self Control</td>
<td>0.657 (2.494)</td>
</tr>
<tr>
<td>Locus of Control</td>
<td>12.52** 1.355 1.290</td>
</tr>
<tr>
<td></td>
<td>(5.315) (1.773) (1.737)</td>
</tr>
<tr>
<td>Growth Mindset</td>
<td>2.390 1.189 0.891</td>
</tr>
<tr>
<td></td>
<td>(2.276) (2.492) (1.740)</td>
</tr>
<tr>
<td>Self-Control</td>
<td>5.266** 5.450** 5.940**</td>
</tr>
<tr>
<td></td>
<td>(2.612) (2.117) (2.758)</td>
</tr>
<tr>
<td>Constant</td>
<td>-4.950 -6.683 -8.970</td>
</tr>
<tr>
<td></td>
<td>(31.89) (25.68) (27.22)</td>
</tr>
<tr>
<td>Observations</td>
<td>374 374 374</td>
</tr>
<tr>
<td>Controls</td>
<td>Yes Yes Yes</td>
</tr>
</tbody>
</table>

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Higher locus of control score indicates internal. All personality variables are standardized.
Heterogeneity of the Results by Personality Traits (IV Approach)

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>New Lessons Completed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change in Beliefs</td>
<td>2.367</td>
</tr>
<tr>
<td></td>
<td>(2.832)</td>
</tr>
<tr>
<td>Change in Beliefs * Locus of Control</td>
<td>9.520**</td>
</tr>
<tr>
<td></td>
<td>(4.050)</td>
</tr>
<tr>
<td>Change in Beliefs * Growth Mindset</td>
<td>0.531</td>
</tr>
<tr>
<td></td>
<td>(3.407)</td>
</tr>
<tr>
<td>Change in Beliefs * Self Control</td>
<td>0.657</td>
</tr>
<tr>
<td></td>
<td>(2.494)</td>
</tr>
<tr>
<td>Locus of Control</td>
<td>12.52**</td>
</tr>
<tr>
<td></td>
<td>(5.315)</td>
</tr>
<tr>
<td>Growth Mindset</td>
<td>2.390</td>
</tr>
<tr>
<td></td>
<td>(2.276)</td>
</tr>
<tr>
<td>Self-Control</td>
<td>5.266**</td>
</tr>
<tr>
<td></td>
<td>(2.612)</td>
</tr>
<tr>
<td>Constant</td>
<td>-4.950</td>
</tr>
<tr>
<td></td>
<td>(31.89)</td>
</tr>
</tbody>
</table>

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Higher locus of control score indicates internal. All personality variables are standardized.
A median split on the locus of control score

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

$1 \text{ sd} \downarrow$ in beliefs $\rightarrow$ $.57 \text{ sd} \downarrow$ in effort for internals

$1 \text{ sd} \downarrow$ in beliefs $\rightarrow$ $.63 \text{ sd} \uparrow$ in effort for externals

Correlates of Locus of Control
A median split on the locus of control score

*Internals*: Change in beliefs positively affects effort (statistically significant)
A median split on the locus of control score

*Externals*: Change in beliefs negatively affects effort (not statistically significant)
A median split on the locus of control score

When perceived effectiveness of effort decreases, internals decrease their effort more than externals.
A median split on the locus of control score

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

1 sd ↓ in beliefs → .57 sd ↓ in effort for internals
1 sd ↓ in beliefs → .63 sd ↑ in effort for externals
Change in Effort-Reduced Form
Change in Effort-Reduced Form

![Bar chart showing the number of lessons completed for different options: No Info, Internal, Locus, External, and Locus. The chart indicates that the highest number of lessons completed is for the No Info option.](image-url)
Change in Effort-Reduced Form

No Info: *Internals* complete more lessons than *Externals*
Change in Effort-Reduced Form

*Internals* complete less lessons in the Average treatment compared to No Info.
Change in Effort-Reduced Form

*Externals* complete more lessons in the Average treatment compared to No Info.
Change in Effort-Reduced Form

*Internals* complete less lessons in the Low treatment compared to No Info.
Change in Effort-Reduced Form

*Externals* complete more lessons in the Low treatment compared to No Info.
Change in Effort-Reduced Form

![Bar chart showing the number of lessons completed for different conditions and loci. The chart compares 'No Info Internal', 'Avg Internal', 'Low Locus', 'High Locus', 'No Info External', 'Avg External', and 'Low Locus'.]
Change in Effort-Reduced Form

![Graph showing the number of lessons completed under different conditions. The graph compares the number of lessons completed between 'No Info Internal', 'Avg Locus', 'High Locus', 'No Info External', 'Avg Locus', 'Low Locus', and 'High Locus'. The y-axis represents the number of lessons completed, ranging from 10 to 50. The x-axis represents the different conditions. The bars indicate the average number of lessons completed, and the error bars represent the variability.](image-url)
Locus of Control seems to matter a lot

Locus of control - the extent to which individuals feel control over their life
Locus of Control seems to matter a lot

Locus of control - the extent to which individuals feel control over their life

- predicts the direction of the effort response

By which channels may locus of control affect the outcomes?

- predicts the direction of the effort response
Locus of Control seems to matter a lot

Locus of control - the extent to which individuals feel control over their life

- predicts the direction of the effort response
- is one of the most frequently studied concepts in psychology
Locus of Control seems to matter a lot

Locus of control - the extent to which individuals feel control over their life

- predicts the direction of the effort response
- is one of the most frequently studied concepts in psychology
- correlates with academic performance and labor market outcomes (Findley and Cooper (1983), Cobb-Clark (2015))
  - is more strongly correlated with academic achievement than all the school-related factors (Coleman Report (1966))
Locus of Control seems to matter a lot

Locus of control - the extent to which individuals feel control over their life

- predicts the direction of the effort response
- is one of the most frequently studied concepts in psychology
- correlates with academic performance and labor market outcomes (Findley and Cooper (1983), Cobb-Clark (2015))
  - is more strongly correlated with academic achievement than all the school-related factors (Coleman Report (1966))

By which channels may locus of control affect the outcomes?
Locus of Control seems to matter a lot

Locus of control - the extent to which individuals feel control over their life

▶ predicts the direction of the effort response
▶ is one of the most frequently studied concepts in psychology
▶ correlates with academic performance and labor market outcomes (Findley and Cooper (1983), Cobb-Clark (2015))
  ▶ is more strongly correlated with academic achievement than all the school-related factors (Coleman Report (1966))

By which channels may locus of control affect the outcomes? through its effect on

▶ perceived returns to education (Coleman and DeLeire (2003))
▶ perceived costs of education (Piatek and Pinger (2010))
▶ perceived riskiness of returns (Salamanca et al. (2015))
Interpreting the results

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

- negative and statistically significant for *internals*
- positive but not statistically significant for *externals*
Interpreting the results

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

- negative and statistically significant for *internals*
- positive but not statistically significant for *externals*

What could be the mechanism behind this response?
Interpreting the results

The effect of a decrease in the perceived effectiveness of effort is
- negative and statistically significant for *internals*
- positive but not statistically significant for *externals*

**What could be the mechanism behind this response?**
- Do Initial Beliefs differ by Locus of Control?
Do Initial Beliefs differ by Locus of Control?

Dist of Initial Beliefs by LOC
Dist of Difference by LOC
Correlates of LOC
Confidence in Initial Beliefs by LOC
Do Initial Beliefs differ by Locus of Control?

Over optimistic

Dist of Initial Beliefs by LOC  Dist of Difference by LOC  Correlates of LOC

Confidence in Initial Beliefs by LOC
Do Initial Beliefs differ by Locus of Control? NO!

Over optimistic but Not Different Across Two Groups

Dist of Initial Beliefs by LOC  Dist of Difference by LOC  Correlates of LOC

Confidence in Initial Beliefs by LOC
Interpreting the results

The effect of a decrease in the perceived effectiveness of effort is
▶ negative and statistically significant for internals
▶ positive but not statistically significant for externals

What could be the mechanism behind this response?
▶ Do Initial Beliefs differ by Locus of Control?
Interpreting the results

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

- negative and statistically significant for *internals*
- positive but not statistically significant for *externals*

**What could be the mechanism behind this response?**

- Do Initial Beliefs differ by Locus of Control? NO!
Interpreting the results

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

- negative and statistically significant for *internals*
- positive but not statistically significant for *externals*

**What could be the mechanism behind this response?**

- Do Initial Beliefs differ by Locus of Control? NO!
- Do Changes in Beliefs about Duolingo differ by Locus of Control?
Do Changes in Beliefs differ by Locus of Control?
Do Changes in Beliefs differ by Locus of Control?

![Graph showing change in beliefs for different loci of control. The graph indicates that changes are not significantly different between the loci of control.](image)
Do Changes in Beliefs differ by Locus of Control?
Do Changes in Beliefs differ by Locus of Control?
Do Changes in Beliefs differ by Locus of Control?

![Bar chart showing changes in beliefs for different loci of control and information conditions. The x-axis represents the loci of control (Internal, Locus, and External), and the y-axis represents the change in beliefs. The chart indicates that changes in beliefs do not differ by locus of control.](chart.png)
Do Changes in Beliefs differ by Locus of Control?

![Bar chart showing changes in beliefs across different loci of control categories: No Info Internal, Avg Internal, Low Locus, No Info External, Avg External, Locus. Each bar represents the change in beliefs with error bars indicating variability.]
Do Changes in Beliefs differ by Locus of Control?

The graph shows changes in beliefs for different conditions: No Info, Internal, Avg, Low Locus, No Info, External, Avg, Low Locus. The x-axis represents these conditions, and the y-axis represents the change in beliefs with error bars indicating variability.
Do Changes in Beliefs differ by Locus of Control?

The diagram illustrates the change in beliefs across different loci of control and information conditions. The x-axis represents the different loci of control (Low, High, No Info, Average) and information conditions (Internal, Average, External, Low). The y-axis shows the change in beliefs, ranging from -3 to 3. Standard errors are indicated by the error bars.
Do Changes in Beliefs differ by Locus of Control? NO!

Information treatments are effective at changing beliefs, similarly by locus of control
Interpreting the results

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

- negative and statistically significant for *internals*
- positive but not statistically significant for *externals*

**What could be the mechanism behind this response?**

- Do Initial Beliefs differ by Locus of Control? NO!
- Do Changes in Beliefs about Duolingo differ by Locus of Control?
Interpreting the results

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

- negative and statistically significant for *internals*
- positive but not statistically significant for *externals*

What could be the mechanism behind this response?

- Do Initial Beliefs differ by Locus of Control? NO!
- Do Changes in Beliefs about Duolingo differ by Locus of Control? NO!
Interpreting the results

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

- negative and statistically significant for internals
- positive but not statistically significant for externals

What could be the mechanism behind this response?

- Do Initial Beliefs differ by Locus of Control? NO!
- Do Changes in Beliefs about Duolingo differ by Locus of Control? NO!
- Do subjects interpret the information relevant for learning Spanish only with Duolingo or for learning Spanish in general?
Interpreting the results

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

- negative and statistically significant for *internals*
- positive but not statistically significant for *externals*

What could be the mechanism behind this response?

- Do Initial Beliefs differ by Locus of Control? NO!
- Do Changes in Beliefs about Duolingo differ by Locus of Control? NO!
- Do subjects interpret the information relevant for learning Spanish only with Duolingo or for learning Spanish in general?
  - Do Changes in Beliefs about other learning platforms differ by Locus of Control?
Do Changes in Beliefs about the Returns to Learning Spanish in a Classroom differ by Locus of Control?
Do Changes in Beliefs about the Returns to Learning Spanish in a Classroom differ by Locus of Control? NO!

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>Change in General Beliefs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>-85.97***</td>
</tr>
<tr>
<td></td>
<td>(24.27)</td>
</tr>
<tr>
<td>Low</td>
<td>-128.6***</td>
</tr>
<tr>
<td></td>
<td>(24.09)</td>
</tr>
<tr>
<td>High</td>
<td>32.65</td>
</tr>
<tr>
<td></td>
<td>(24.46)</td>
</tr>
<tr>
<td>Average * Locus of Control Score</td>
<td>5.989</td>
</tr>
<tr>
<td></td>
<td>(25.03)</td>
</tr>
<tr>
<td>Low * Locus of Control Score</td>
<td>-9.707</td>
</tr>
<tr>
<td></td>
<td>(23.48)</td>
</tr>
<tr>
<td>High * Locus of Control Score</td>
<td>22.48</td>
</tr>
<tr>
<td></td>
<td>(25.35)</td>
</tr>
<tr>
<td>Locus of Control Score</td>
<td>-11.40</td>
</tr>
<tr>
<td></td>
<td>(17.65)</td>
</tr>
<tr>
<td>Initial Belief</td>
<td>-0.795***</td>
</tr>
<tr>
<td></td>
<td>(0.0433)</td>
</tr>
<tr>
<td>Observations</td>
<td>342</td>
</tr>
<tr>
<td>No-Information Mean</td>
<td>-40.48</td>
</tr>
<tr>
<td>No-Information SD</td>
<td>17.25</td>
</tr>
<tr>
<td>Controls</td>
<td>No</td>
</tr>
</tbody>
</table>

Locus of control score is standardized, higher numbers indicate internal locus.

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*
- positive but not statistically significant for *externals*

**What could be the mechanism behind this response?**

- Do Initial Beliefs differ by Locus of Control? NO!
- Do Changes in Beliefs about Duolingo differ by Locus of Control? NO!
- Do subjects interpret the information relevant for learning Spanish only with Duolingo or for learning Spanish in general?
  - Do Changes in Beliefs about other learning platforms differ by Locus of Control?
Interpreting the results

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

- negative and statistically significant for *internals*
- positive but not statistically significant for *externals*

What could be the mechanism behind this response?

- Do Initial Beliefs differ by Locus of Control? NO!
- Do Changes in Beliefs about Duolingo differ by Locus of Control? NO!
- Do subjects interpret the information relevant for learning Spanish only with Duolingo or for learning Spanish in general?
  - Do Changes in Beliefs about other learning platforms differ by Locus of Control? NO!
Interpreting the results

The effect of a decrease in the perceived effectiveness of effort is
- negative and statistically significant for *internals*
- positive but not statistically significant for *externals*

**What could be the mechanism behind this response?**
- Do Initial Beliefs differ by Locus of Control? NO!
- Do Changes in Beliefs about Duolingo differ by Locus of Control? NO!
- Do subjects interpret the information relevant for learning Spanish only with Duolingo or for learning Spanish in general?
  - Do Changes in Beliefs about other learning platforms differ by Locus of Control? NO!
  - Do Changes in beliefs affect the usage of other platforms differently by Locus of Control?
Do Changes in Beliefs affect the Usage of Other Platforms differently by Locus of Control?
Do Changes in Beliefs affect the Usage of Other Platforms differently by Locus of Control? NO!

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(Reported) Usage of Other Tools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change in Beliefs</td>
<td>-0.0345</td>
</tr>
<tr>
<td></td>
<td>(0.0295)</td>
</tr>
<tr>
<td>Change in Beliefs * Locus of Control Score</td>
<td>0.00491</td>
</tr>
<tr>
<td></td>
<td>(0.0360)</td>
</tr>
<tr>
<td>Initial Beliefs</td>
<td>-0.0249</td>
</tr>
<tr>
<td></td>
<td>(0.0194)</td>
</tr>
<tr>
<td>Locus of Control Score</td>
<td>-0.000532</td>
</tr>
<tr>
<td></td>
<td>(0.0500)</td>
</tr>
<tr>
<td>Constant</td>
<td>0.209***</td>
</tr>
<tr>
<td></td>
<td>(0.0573)</td>
</tr>
<tr>
<td>Observations</td>
<td>326</td>
</tr>
<tr>
<td>First Stage F-Stat Eq. 1</td>
<td>5.640</td>
</tr>
<tr>
<td>First Stage F-Stat Eq. 2</td>
<td>2.493</td>
</tr>
<tr>
<td>Controls</td>
<td>No</td>
</tr>
</tbody>
</table>

Locus of control score is standardized, higher numbers indicate internal 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*
▶ positive but not statistically significant for *externals*

**What could be the mechanism behind this response?**

▶ Do Initial Beliefs differ by Locus of Control? NO!
▶ Do Changes in Beliefs about Duolingo differ by Locus of Control? NO!

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

▶ Do Changes in Beliefs about other learning platforms differ by Locus of Control? NO!
▶ Do Changes in beliefs affect the usage of other platforms differently by Locus of Control?
Interpreting the results

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

▶ negative and statistically significant for *internals*
▶ positive but not statistically significant for *externals*

**What could be the mechanism behind this response?**

▶ Do Initial Beliefs differ by Locus of Control? NO!
▶ Do Changes in Beliefs about Duolingo differ by Locus of Control? NO!
▶ Do subjects interpret the information relevant for learning Spanish only with Duolingo or for learning Spanish in general?
  ▶ Do Changes in Beliefs about other learning platforms differ by Locus of Control? NO!
  ▶ Do Changes in beliefs affect the usage of other platforms differently by Locus of Control? NO!
Interpreting the results

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

- negative and statistically significant for internals
- positive but not statistically significant for externals

What could be the mechanism behind this response?

- Do Initial Beliefs differ by Locus of Control? NO!
- Do Changes in Beliefs about Duolingo differ by Locus of Control? NO!
- Do subjects interpret the information relevant for learning Spanish only with Duolingo or for learning Spanish in general?
  - Do Changes in Beliefs about other learning platforms differ by Locus of Control? NO!
  - Do Changes in beliefs affect the usage of other platforms differently by Locus of Control? NO!

No evidence from the data about the mechanisms → a theoretical model of locus of control
A model of Locus of Control

Formal Model

Assumption: If a bad event happens, internals believe they can reap the benefits they accrue from restorative action, whereas externals believe no such action can be taken and benefits will be lost.

Prediction: Internals increase their effort more than externals when there is an increase in returns to effort.

Intuition:
- As returns to effort in terms of performance increase, restorative action increases for internals.
- As the restorative action increases, the probability of recovering the benefits increases.
- As the probability of recovering the benefits increases, optimal effort increases for internals.
A model of Locus of Control

Assumption:
If a bad event happens, internals believe they can reap the benefits they accrue from restorative action, whereas externals believe no such action can be taken and benefits will be lost.

Prediction:
Internals increase their effort more than externals when there is an increase in returns to effort.

Intuition:
▶ As returns to effort in terms of performance increase, restorative action increase for internals.
▶ As the restorative action increases, the probability of recovering the benefits increases.
▶ As the probability of recovering the benefits increases, optimal effort increases for internals.
Assumption: If a bad event happens, internals believe they can reap the benefits they accrue restorative action, whereas externals believe no such action can be taken and benefits will be lost.
Assumption: If a bad event happens, internals believe they can reap the benefits they accrue restorative action, whereas externals believe no such action can be taken and benefits will be lost.

Prediction: Internals increase their effort more than externals when there is an increase in returns to effort.
**Assumption:** If a bad event happens, internals believe they can reap the benefits they accrue restorative action, whereas externals believe no such action can be taken and benefits will be lost.

**Prediction:** Internals increase their effort more than externals when there is an increase in returns to effort.

**Intuition:**

- As returns to effort in terms of performance increase, restorative action increase for internals.
- As the restorative action increases, the probability of recovering the benefits increases.
- As the probability of recovering the benefits increases, optimal effort increases for internals.
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 average information
- Effort is malleable through changing beliefs and perception of control plays an important role in predicting the direction of the effect

Implications:
Programs manipulating effort through changes in beliefs should be careful about the heterogeneous response

Next Steps:
- Compulsory learning environments?
- Beliefs of students from different SES?
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 average information
- Effort is malleable through changing beliefs and perception of control plays an important role in predicting the direction of the effect

Implications:
Programs manipulating effort through changes in beliefs should be careful about the heterogeneous response

Next Steps:
- Compulsory learning environments?
- Beliefs of students from different SES?
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 average information
- Effort is malleable through changing beliefs and perception of control plays an important role in predicting the direction of the effect

Implications: Programs manipulating effort through changes in beliefs should be careful about the heterogenous response

Next Steps:
- Compulsory learning environments?
- Beliefs of students from different SES?
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 average information
▶ Effort is malleable through changing beliefs and perception of control plays an important role in predicting the direction of the effect

Implications: Programs manipulating effort through changes in beliefs should be careful about the heterogenous response

Next Steps:
▶ Compulsory learning environments?
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 average information
- Effort is malleable through changing beliefs and perception of control plays an important role in predicting the direction of the effect

Implications: Programs manipulating effort through changes in beliefs should be careful about the heterogenous response

Next Steps:
- Compulsory learning environments?
- Beliefs of students from different SES?
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 average information
► Effort is malleable through changing beliefs and perception of control plays an important role in predicting the direction of the effect

Implications: Programs manipulating effort through changes in beliefs should be careful about the heterogenous response

Next Steps:
► Compulsory learning environments?
► Beliefs of students from different SES?

Thank You!
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

If you have any questions, please contact us
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-Averageerton
- 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
Example Questions

**Locus of Control**
“The idea that teachers are unfair to students is nonsense.” vs “Most students don’t realize the extent to which their grades are influenced by accidental happenings.”
8 forced response pairs

**Growth Mindset**
No matter how much intelligence you have, you can always change it a good deal.
8 statements with a scale of 1: Disagree a lot and 6: Agree a lot

**Self Control**
I am good at resisting temptation.
13 statements with a scale of 1: Not at all and 6: Very much
Belief Elicitation Details

Belief Question
On average, how much improvement in test scores do you think results from completing \( X \) lessons per week for 4 weeks (\( X \times 4 \) lessons in total)?

- \( X = 8, 12, 16, 20, 24 \) lessons

On average, how much improvement in test scores do you think results from completing \( 24 \) lessons per week for \( 4 \) weeks (\( 96 \) lessons in total)?

By improvement, we mean the difference between the final test score and the initial test score. (Please only type in numbers, no words or blanks!)

(If one of these questions is randomly chosen for payment, we will discount $0.50 from your bonus payment for each point by which your guess and the correct answer to the question chosen differs.)
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

<table>
<thead>
<tr>
<th>Test Scores</th>
<th>0</th>
<th>51</th>
<th>161</th>
<th>284</th>
<th>450</th>
<th>619</th>
<th>774</th>
<th>1000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activities</td>
<td>Greet people, introduce yourself, say bye</td>
<td>Order and pay at a café</td>
<td>Talk about days of week, times of day</td>
<td>Describe objects and how they are used</td>
<td>Talk about the past</td>
<td>Make plans, talk about the future</td>
<td>Talk about recent experiences (Present Perfect)</td>
<td></td>
</tr>
</tbody>
</table>
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.
## Balance Across Treatment Arms

<table>
<thead>
<tr>
<th>Experimental Arm:</th>
<th>All</th>
<th>No Info</th>
<th>Average</th>
<th>Low</th>
<th>High</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Demographics:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td>23.16</td>
<td>23.76</td>
<td>23.25</td>
<td>23.03</td>
<td>22.57</td>
<td>.407</td>
</tr>
<tr>
<td><strong>Female</strong></td>
<td>.71</td>
<td>.73</td>
<td>.67</td>
<td>.73</td>
<td>.7</td>
<td>.738</td>
</tr>
<tr>
<td><strong>Asian</strong></td>
<td>.43</td>
<td>.34</td>
<td>.5</td>
<td>.44</td>
<td>.45</td>
<td>.121</td>
</tr>
<tr>
<td><strong>Caucasian</strong></td>
<td>.36</td>
<td>.46</td>
<td>.31</td>
<td>.3</td>
<td>.35</td>
<td>.07</td>
</tr>
<tr>
<td><strong>Education:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>GPA</strong></td>
<td>3.42</td>
<td>3.45</td>
<td>3.41</td>
<td>3.42</td>
<td>3.39</td>
<td>.739</td>
</tr>
<tr>
<td><strong>Mother’s Education</strong></td>
<td>14.64</td>
<td>14.45</td>
<td>14.48</td>
<td>15.09</td>
<td>14.55</td>
<td>.716</td>
</tr>
<tr>
<td><strong>Father’s Education</strong></td>
<td>14.66</td>
<td>14.95</td>
<td>14.8</td>
<td>14.58</td>
<td>14.3</td>
<td>.052</td>
</tr>
<tr>
<td><strong>Personality:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Locus of Control</strong></td>
<td>3.57</td>
<td>3.57</td>
<td>3.71</td>
<td>3.43</td>
<td>3.54</td>
<td>.634</td>
</tr>
<tr>
<td><strong>Growth Mindset</strong></td>
<td>28.86</td>
<td>29.65</td>
<td>28.54</td>
<td>28.31</td>
<td>28.94</td>
<td>.03</td>
</tr>
<tr>
<td><strong>Neuroticism</strong></td>
<td>5.96</td>
<td>5.86</td>
<td>5.9</td>
<td>6.13</td>
<td>5.96</td>
<td>.722</td>
</tr>
<tr>
<td><strong>Self Control</strong></td>
<td>44.56</td>
<td>45.04</td>
<td>44.63</td>
<td>44.7</td>
<td>43.83</td>
<td>.756</td>
</tr>
<tr>
<td><strong>Observations</strong></td>
<td>506</td>
<td>107</td>
<td>105</td>
<td>106</td>
<td>101</td>
<td>-</td>
</tr>
</tbody>
</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?

$(-12\%, +13\%)$
## Change in Beliefs about the Self

<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><strong>Average</strong></td>
<td>-0.914***</td>
<td>0.187</td>
</tr>
<tr>
<td></td>
<td>(0.301)</td>
<td>(0.280)</td>
</tr>
<tr>
<td><strong>Low</strong></td>
<td>-1.100***</td>
<td>-0.161</td>
</tr>
<tr>
<td></td>
<td>(0.301)</td>
<td>(0.279)</td>
</tr>
<tr>
<td><strong>High</strong></td>
<td>0.435</td>
<td>1.207***</td>
</tr>
<tr>
<td></td>
<td>(0.302)</td>
<td>(0.281)</td>
</tr>
<tr>
<td><strong>Initial Beliefs</strong></td>
<td>-0.586***</td>
<td>-0.216***</td>
</tr>
<tr>
<td></td>
<td>(0.0376)</td>
<td>(0.0351)</td>
</tr>
<tr>
<td><strong>Constant</strong></td>
<td>1.820***</td>
<td>0.299</td>
</tr>
<tr>
<td></td>
<td>(0.263)</td>
<td>(0.250)</td>
</tr>
<tr>
<td><strong>Observations</strong></td>
<td>374</td>
<td>374</td>
</tr>
<tr>
<td><strong>No-Information Mean</strong></td>
<td>-0.459</td>
<td>-0.543</td>
</tr>
<tr>
<td><strong>No-Information SD</strong></td>
<td>0.214</td>
<td>0.199</td>
</tr>
<tr>
<td><strong>Average=Low</strong></td>
<td>0.537</td>
<td>0.211</td>
</tr>
<tr>
<td><strong>Average=High</strong></td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Low=High</strong></td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Joint</strong></td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Controls</strong></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 Performance-Reduced Form

No difference in the improvement in performance across treatment groups
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?

- 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
- Use the instrumental variables (IV) approach to account for the issue of endogeneity
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
- Use the instrumental variables (IV) approach to account for the issue of endogeneity

\[
\# \text{ of Lessons} = \alpha_1 \Delta \text{Beliefs} + \alpha_2 \text{Initial Beliefs} + \epsilon
\]

\[
\Delta \text{Beliefs} = \sum_i \gamma_{1i} \text{Treatment}_i + \delta_1 \text{Initial Beliefs} + \nu
\]
## Effect of Change in Beliefs on Performance (IV Approach)

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1) Improvement in Test Scores</th>
<th>(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change in Beliefs</td>
<td>-4.008</td>
<td>1.051</td>
</tr>
<tr>
<td></td>
<td>(12.80)</td>
<td>(12.15)</td>
</tr>
<tr>
<td>Initial Test Score</td>
<td>-0.227***</td>
<td>-0.223***</td>
</tr>
<tr>
<td></td>
<td>(0.0555)</td>
<td>(0.0566)</td>
</tr>
<tr>
<td>Initial Beliefs</td>
<td>-2.749</td>
<td>1.389</td>
</tr>
<tr>
<td></td>
<td>(8.223)</td>
<td>(7.707)</td>
</tr>
<tr>
<td>Constant</td>
<td>164.9***</td>
<td>-37.94</td>
</tr>
<tr>
<td></td>
<td>(32.62)</td>
<td>(96.25)</td>
</tr>
<tr>
<td>Observations</td>
<td>330</td>
<td>330</td>
</tr>
<tr>
<td>First Stage F-Stat</td>
<td>10.66</td>
<td>11.32</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
Heterogeneity of the Results by Purpose of Learning

Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>t-statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Lessons Completed</td>
<td>2.086</td>
<td>0.911</td>
<td>3.125</td>
<td>0.002</td>
</tr>
<tr>
<td>Change in Beliefs</td>
<td>0.337</td>
<td>0.953</td>
<td>5.264</td>
<td>0.000</td>
</tr>
<tr>
<td>Initial Beliefs</td>
<td>1.857</td>
<td>0.990</td>
<td>1.795</td>
<td>0.075</td>
</tr>
<tr>
<td>Serious Learner</td>
<td>-1.688</td>
<td>1.942</td>
<td>5.664</td>
<td>0.000</td>
</tr>
<tr>
<td>Constant</td>
<td>27.20</td>
<td>38.15</td>
<td>6.372</td>
<td>0.000</td>
</tr>
<tr>
<td>Controls</td>
<td>No</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Observations: 374

First Stage F-Stat Eq. 1: 6.158
First Stage F-Stat Eq. 2: 3.352

Standard errors in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.1.

Serious learners want to learn Spanish for work or living abroad purposes.

No evidence of heterogeneity of the results by purpose of learning!
<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>New Lessons Completed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change in Beliefs</td>
<td>2.086</td>
</tr>
<tr>
<td></td>
<td>(3.125)</td>
</tr>
<tr>
<td>Change in Beliefs * Serious Learner</td>
<td>0.337</td>
</tr>
<tr>
<td></td>
<td>(5.264)</td>
</tr>
<tr>
<td>Initial Beliefs</td>
<td>1.857</td>
</tr>
<tr>
<td></td>
<td>(1.795)</td>
</tr>
<tr>
<td>Serious Learner</td>
<td>-1.688</td>
</tr>
<tr>
<td></td>
<td>(5.664)</td>
</tr>
<tr>
<td>Constant</td>
<td>27.20***</td>
</tr>
<tr>
<td></td>
<td>(6.372)</td>
</tr>
<tr>
<td>Observations</td>
<td>374</td>
</tr>
<tr>
<td>First Stage F-Stat Eq. 1</td>
<td>6.158</td>
</tr>
<tr>
<td>First Stage F-Stat Eq. 2</td>
<td>3.352</td>
</tr>
<tr>
<td>Controls</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
</tr>
</tbody>
</table>

Observations: 374
First Stage F-Stat Eq. 1: 6.158, 6.330
First Stage F-Stat Eq. 2: 3.352, 3.772
Controls: No, Yes

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Serious learners want to learn Spanish for work or living abroad purposes.
Heterogeneity of the Results by Purpose of Learning

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>New Lessons Completed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change in Beliefs</td>
<td>2.086</td>
</tr>
<tr>
<td></td>
<td>(3.125)</td>
</tr>
<tr>
<td>Change in Beliefs * Serious Learner</td>
<td>0.337</td>
</tr>
<tr>
<td></td>
<td>(5.264)</td>
</tr>
<tr>
<td>Initial Beliefs</td>
<td>1.857</td>
</tr>
<tr>
<td></td>
<td>(1.795)</td>
</tr>
<tr>
<td>Serious Learner</td>
<td>-1.688</td>
</tr>
<tr>
<td></td>
<td>(5.664)</td>
</tr>
<tr>
<td>Constant</td>
<td>27.20***</td>
</tr>
<tr>
<td></td>
<td>(6.372)</td>
</tr>
</tbody>
</table>

Observations: 374 374
First Stage F-Stat Eq. 1: 6.158 6.330
First Stage F-Stat Eq. 2: 3.352 3.772
Controls: No Yes

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.
Serious learners want to learn Spanish for work or living abroad purposes.

No evidence of heterogeneity of the results by purpose of learning!
Why do you want to learn Spanish?
(Please rank the following items. 1 indicates the most important reason and 7 indicates the least important one.)

- To improve employment opportunities
- To expand options for studying, living and working abroad
- To make international friends
- To sharpen cognitive skills
- To make travel more feasible and enjoyable
- Just for fun
- To connect with current or prospective family members
How does the change in beliefs affect effort by personality traits?

- 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
- Use the instrumental variables (IV) approach to account for the issue of endogeneity
How does the change in beliefs affect effort by personality traits?

- 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
- Use the instrumental variables (IV) approach to account for the issue of endogeneity

\[
\text{# of Lessons} = \alpha_1 \Delta \text{Beliefs} + \alpha_2 \Delta \text{Beliefs} \times \text{Personality}
\]
\[
+ \alpha_3 \text{Initial Beliefs} + \alpha_4 \times \text{Personality} + \epsilon
\]
How does the change in beliefs affect effort by personality traits?

- 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
- Use the instrumental variables (IV) approach to account for the issue of endogeneity

\[
\text{\# of Lessons} = \alpha_1 \Delta \text{Beliefs} + \alpha_2 \Delta \text{Beliefs} \times \text{Personality} \\
+ \alpha_3 \text{Initial Beliefs} + \alpha_4 \times \text{Personality} + \epsilon
\]

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

\[
\Delta \text{Beliefs} \times \text{Personality} = \sum_i \beta_{1i} \text{Treatment}_i + \sum_i \beta_{2i} \text{Treatment}_i \times \text{Personality}
\]
Distribution of Locus of Control Score

Frequency

Locus of Control Score (External-Internal)

0 1 2 3 4 5 6 7 8

Back
A quartile split on the locus of control score
Effect of Change in Beliefs on Effort by Locus of Control

![Graph showing the effect of change in beliefs on effort by locus of control. The x-axis represents the Locus of Control (External-Internal), and the y-axis represents the Effect of a Positive Change in Beliefs on Effort. The graph includes a trend line and error bars.]
# Correlates of External Locus of Control

<table>
<thead>
<tr>
<th>Variable</th>
<th>Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Growth Mindset</td>
<td>-0.0280</td>
</tr>
<tr>
<td>Extraversion</td>
<td>-0.0891*</td>
</tr>
<tr>
<td>Agreeableness</td>
<td>-0.167***</td>
</tr>
<tr>
<td>Conscientiousness</td>
<td>-0.0383</td>
</tr>
<tr>
<td>Neuroticism</td>
<td>0.211***</td>
</tr>
<tr>
<td>Openness</td>
<td>0.0232</td>
</tr>
<tr>
<td>Self Control</td>
<td>-0.114*</td>
</tr>
<tr>
<td>Spanish Before</td>
<td>-0.0661</td>
</tr>
<tr>
<td>Learning for Work</td>
<td>0.0127</td>
</tr>
<tr>
<td>Age</td>
<td>-0.0846</td>
</tr>
<tr>
<td>Female</td>
<td>0.123**</td>
</tr>
<tr>
<td>Asian</td>
<td>-0.00186</td>
</tr>
<tr>
<td>Years of Education</td>
<td>-0.0367</td>
</tr>
<tr>
<td>Engineering &amp; Sciences</td>
<td>-0.0689</td>
</tr>
<tr>
<td>Father Education</td>
<td>-0.0203</td>
</tr>
<tr>
<td>Mother Education</td>
<td>0.00697</td>
</tr>
<tr>
<td>GPA</td>
<td>0.121**</td>
</tr>
<tr>
<td>Standardized Test</td>
<td>0.0556</td>
</tr>
</tbody>
</table>
## 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>
</tr>
<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>

Locus of control score is standardized, higher numbers indicate internal locus of control. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1
Distribution of Initial Beliefs by Locus of Control

![Graph showing the distribution of initial beliefs by locus of control. The graph plots Week 0 Guesses against a scale from 0 to 15 on the x-axis and a scale from 0 to 1 on the y-axis. The data points are differentiated by circles for internal locus of control and diamonds for external locus of control. There is a benchmark line at Week 0.]
Do Initial Beliefs About the Self Differ from Initial Beliefs About the Previous Students by Locus of Control?
Do Confidence in Initial Beliefs differ by Locus of Control?
Do Confidence in Initial Beliefs differ by Locus of Control?

*Internals* are more confident than *Externals*
## 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>Average</td>
<td>-0.941*** (-0.302)</td>
<td>0.211 (-0.282)</td>
</tr>
<tr>
<td>Low</td>
<td>-1.113*** (-0.301)</td>
<td>-0.163 (-0.281)</td>
</tr>
<tr>
<td>High</td>
<td>0.461 (0.301)</td>
<td>1.196*** (0.282)</td>
</tr>
<tr>
<td>Average*Locus</td>
<td>0.125 (0.316)</td>
<td>-0.185 (0.295)</td>
</tr>
<tr>
<td>Low*Locus</td>
<td>-0.247 (0.300)</td>
<td>0.0418 (0.276)</td>
</tr>
<tr>
<td>High*Locus</td>
<td>0.400 (0.321)</td>
<td>-0.162 (0.297)</td>
</tr>
<tr>
<td>Locus</td>
<td>0.0929 (0.229)</td>
<td>-0.0380 (0.210)</td>
</tr>
<tr>
<td>Initial Beliefs</td>
<td>-0.588*** (0.0376)</td>
<td>-0.218*** (0.0354)</td>
</tr>
<tr>
<td>Constant</td>
<td>1.825*** (0.263)</td>
<td>10.10 (9.659)</td>
</tr>
</tbody>
</table>

### Observations
- 374
- 374
- 337
- 337

### No-Information Mean
- -0.453
- -0.416
- -0.546
- -0.531

### No-Information SD
- 0.213
- 0.226
- 0.200
- 0.215

### Controls
- No
- Yes
- No
- Yes

Locus of control score is standardized, higher numbers indicate internal locus. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1
Do Change in Beliefs differ by Locus of Control?
Do Change in Beliefs differ by Locus of Control?

The graph shows the change in beliefs for different loci of control:

- **No Info**
- **Internal**
- **Locus**
- **External**
- **Locus**

The change in beliefs is indicated by the bar graph, with the internal locus showing a significant change compared to the other loci.
Do Change in Beliefs differ by Locus of Control?
Do Change in Beliefs differ by Locus of Control?

The graph shows the change in beliefs for different conditions. The x-axis represents the locus of control: 'No Info Internal', 'Avg', 'Locus', 'No Info External', and 'Locus'. The y-axis represents the change in beliefs, ranging from -3 to 1. The bars indicate the average change with error bars showing the variability.
Do Change in Beliefs differ by Locus of Control?

The graph shows the change in beliefs for different conditions, including 'No Info Internal', 'Avg Internal', 'Locus', 'No Info External', and 'Avg External'. The y-axis represents the change in beliefs, while the x-axis categorizes the conditions.
Do Change in Beliefs differ by Locus of Control?

![Bar chart showing change in beliefs for different loci of control.]

- No Info Internal
- Avg Internal
- Low Locus
- No Info External
- Avg External
- Locus
Do Change in Beliefs differ by Locus of Control?
Do Change in Beliefs differ by Locus of Control?

[Bar chart showing changes in beliefs for different loci of control]
Do Change in Beliefs differ by Locus of Control? NO!

Information treatments are effective at changing beliefs, similarly by locus of control.
Model of Locus of Control

Setup

- Effort: \( E \)
- Cost of Effort: \( \gamma \)
- Perceived Achievement: \( A = \alpha E \)
- Benefit: \( u(A) = \ln(A) \)
- Perceived Effectiveness of Effort: \( \alpha \)
- Pr(bad event): \( 1 - p \)
- When bad event occurs, benefits are not realized
- Restorative Action: \( r \)
- Cost of \( r \): \( \delta \)
- Pr(restoring benefits): \( f(r) \) where \( f'(r) > 0 \) and \( f''(r) < 0 \)
Model of Locus of Control

Setup

- Effort: $E$, Cost of Effort: $\gamma$
- Perceived Achievement: $A = \alpha E$, Benefit: $u(A) = \ln(A)$
- Perceived Effectiveness of Effort: $\alpha$

Pr(bad event): $1 - p$

When bad event occurs, benefits are not realized

Restorative Action: $r$, Cost of $r$: $\delta$

Pr(restoring benefits): $f(r)$ where $f'(r) > 0$ and $f''(r) < 0$
Model of Locus of Control

Setup

- Effort: $E$, Cost of Effort: $\gamma$
- Perceived Achievement: $A = \alpha E$, Benefit: $u(A) = \ln(A)$
- Perceived Effectiveness of Effort: $\alpha$
- $\Pr(\text{bad event}): 1 - p$
- When bad event occurs, benefits are not realized
Model of Locus of Control

Setup

- Effort: $E$, Cost of Effort: $\gamma$
- Perceived Achievement: $A = \alpha E$, Benefit: $u(A) = \ln(A)$
- Perceived Effectiveness of Effort: $\alpha$
- $\Pr(\text{bad event}): 1 - p$
- When bad event occurs, benefits are not realized

- **Externals** believe that they cannot do anything about the bad event
- **Internals** believe that they can compensate for the bad event
Model of Locus of Control: Externals’ Problem

Setup

- Effort: $E$, Cost of Effort: $\gamma$
- Perceived Achievement: $A = \alpha E$, Benefit: $u(A) = \ln(A)$
- Perceived Effectiveness of Effort: $\alpha$
- $\Pr(\text{bad event}): 1 - p$
- When bad event occurs, benefits are not realized

Externals’ Problem

$$\max_E p \ln(\alpha E) - \gamma E$$

$$E_E^* = \frac{p}{\gamma}$$
Model of Locus of Control: Externals’ Problem

Setup

- Effort: $E$, Cost of Effort: $\gamma$
- Perceived Achievement: $A = \alpha E$, Benefit: $u(A) = \ln(A)$
- Perceived Effectiveness of Effort: $\alpha$
- $\Pr(\text{bad event})$: $1 - p$
- When bad event occurs, benefits are not realized

Externals’ Problem

$$\max_E p \ln(\alpha E) - \gamma E$$

$$E^*_E = \frac{p}{\gamma}$$

Result: $E^*_E$ is invariant to $\alpha$. 
Model of Locus of Control: Internals’ Problem

Setup

- Effort: $E$, Cost of Effort: $\gamma$
- Perceived Achievement: $A = \alpha E$, Benefit: $u(A) = \ln(A)$
- Perceived Effectiveness of Effort: $\alpha$
- $\Pr(\text{bad event}): 1 - p$
- When bad event occurs, benefits are not realized
- Restorative Action: $r$, Cost of $r$: $\delta$
- $\Pr(\text{restoring benefits}): f(r)$ where $f'(r) > 0$ and $f''(r) < 0$

Internals’ Problem: Two-Step
Model of Locus of Control: Internals’ Problem

Setup

- Effort: $E$, Cost of Effort: $\gamma$
- Perceived Achievement: $A = \alpha E$, Benefit: $u(A) = \ln(A)$
- Perceived Effectiveness of Effort: $\alpha$
- $\Pr(\text{bad event}): 1 - p$
- When bad event occurs, benefits are not realized
- Restorative Action: $r$, Cost of $r$: $\delta$
- $\Pr(\text{restoring benefits}): f(r)$ where $f'(r) > 0$ and $f''(r) < 0$

Internals’ Problem: Two-Step

Step 2: Choosing the Restorative Action

$$\max_r f(r)\ln(\alpha E) - \delta r$$

$$f'(r^*) = \frac{\delta}{\ln(\alpha E)}$$
Model of Locus of Control: Internals’ Problem

**Setup**

- **Effort:** $E$, Cost of Effort: $\gamma$
- **Perceived Achievement:** $A = \alpha E$, Benefit: $u(A) = \ln(A)$
- **Perceived Effectiveness of Effort:** $\alpha$
- **$Pr$ (bad event):** $1 - p$
- **When bad event occurs, benefits are not realized**
- **Restorative Action:** $r$, Cost of $r$: $\delta$
- **$Pr$ (restoring benefits):** $f(r)$ where $f'(r) > 0$ and $f''(r) < 0$

**Internals’ Problem: Two-Step**

Step 2: Choosing the Restorative Action

$$\max_r f(r)\ln(\alpha E) - \delta r$$

$$f'(r^*) = \frac{\delta}{\ln(\alpha E)}$$

The optimal restorative action is **increasing** in achievement.
Model of Locus of Control: Internals’ Problem

Setup

▶ Effort: $E$, Cost of Effort: $\gamma$
▶ Perceived Achievement: $A = \alpha E$, Benefit: $u(A) = \ln(A)$
▶ Perceived Effectiveness of Effort: $\alpha$
▶ $\Pr(\text{bad event}): 1 - p$
▶ When bad event occurs, benefits are not realized
▶ Restorative Action: $r$, Cost of $r$: $\delta$
▶ $\Pr(\text{restoring benefits}): f(r)$ where $f'(r) > 0$ and $f''(r) < 0$

Internals’ Problem: Two-Step

Step 1: Choosing the Effort

$$\max_E \, p\ln(\alpha E) + (1 - p)[f(r^*)\ln(\alpha E) - \delta r^*] - \gamma E$$

$$E_i^* = \frac{p + (1 - p)f(r^*)}{\gamma} > \frac{p}{\gamma} = E_E^*$$
Choice of Restorative Action: \( f'(r^*) = \frac{\delta}{\ln(\alpha E)} \)

Choice of Effort: \( E_i^* = \frac{p + (1-p)f(r^*)}{\gamma} \)

How does the optimal level of effort internals exert change when the perceived effectiveness of effort changes?

\[
\frac{dE_i^*}{d\alpha} > 0 = \frac{dE_i^*}{d\alpha}
\]

Intuition:
\begin{itemize}
  \item As \( \alpha \) increases, \( r^* \) increases.
  \item As \( r^* \) increases, \( f(r^*) \) increases.
  \item As \( f(r^*) \) increases, \( E_i^* \) increases.
\end{itemize}

Prediction: Substitution effect is stronger for internals than externals.
Model of Locus of Control: Internals’ Problem

Choice of Restorative Action: \( f'(r^*) = \frac{\delta}{\ln(\alpha E)} \)

Choice of Effort: \( E^*_I = \frac{p+(1-p)f(r^*)}{\gamma} \)

How does the optimal level of effort internals exert change when the perceived effectiveness of effort changes?
Choice of Restorative Action: \( f'(r^*) = \frac{\delta}{\ln(\alpha E)} \)

Choice of Effort: \( E_i^* = \frac{p + (1-p)f(r^*)}{\gamma} \)

How does the optimal level of effort internals exert change when the perceived effectiveness of effort changes?

\[
\frac{dE_i^*}{d\alpha} > 0 = \frac{dE^*_E}{d\alpha}
\]
Choice of Restorative Action:  
\[ f'(r^*) = \frac{\delta}{\ln(\alpha E)} \]

Choice of Effort:  
\[ E_i^* = \frac{p+(1-p)f(r^*)}{\gamma} \]

How does the optimal level of effort internals exert change when the perceived effectiveness of effort changes?

\[ \frac{dE_i^*}{d\alpha} > 0 = \frac{dE_E^*}{d\alpha} \]

Intuition:

▷ As \( \alpha \) increases, \( r^* \) increases.
▷ As \( r^* \) increases, \( f(r^*) \) increases.
▷ As \( f(r^*) \) increases, \( E_i^* \) increases.
Model of Locus of Control: Internals’ Problem

Choice of Restorative Action:  
\[ f'(r^*) = \frac{\delta}{\ln(\alpha E)} \]

Choice of Effort:  
\[ E_i^* = \frac{p+(1-p)f(r^*)}{\gamma} \]

How does the optimal level of effort internals exert change when the perceived effectiveness of effort changes?

\[ \frac{dE_i^*}{d\alpha} > 0 = \frac{dE_E^*}{d\alpha} \]

Intuition:

- As \( \alpha \) increases, \( r^* \) increases.
- As \( r^* \) increases, \( f(r^*) \) increases.
- As \( f(r^*) \) increases, \( E_i^* \) increases.

Prediction: Substitution effect is stronger for internals than externals.