We are grateful to NIH/NIA for financial support (R21-AG037741, R01-AG040787, R01-AG020717-07, P01-AG026571, T32-AG00186), and to Mike Gideon for helpful early conversations.
Longstanding concern that Americans may not be investing appropriately for retirement. (e.g., Benartzi and Thaler, 1999)

- May want to give advice about asset allocation.
- Or use policy tools, such as defaults.

“Good” asset allocation for an individual depends on risk aversion.

Usual approach to measuring: infer from real or hypothetical choices.

But such untutored choices may not accurately reflect preferences:

- Investment choices themselves are the cause of concern.
- Even simplified gambles unfamiliar and cognitively challenging.
- Often violate seemingly compelling axioms of expected utility (EU).

Models of non-EU behavior are descriptive, and consistent with pref. or systematic-mistake interpretation. (e.g., Beshears et al., 2008; Bernheim and Rangel, 2009)

How to measure individual’s risk aversion for normative purposes?
We develop a two-stage survey procedure to measure risk aversion:

1. **Untutored choices**: Standard elicitation of choices over risky lotteries.

2. **Reconsidered choices**:
   a. We confront participants with *inconsistencies* in their untutored choices (i.e., framing effects). Different behavior when the “same” choice (according to standard axioms) is framed differently.
   b. We ask participants whether their untutored choices were mistaken, and if so, how they would like to revise.

Major potential concern: experimenter demand effects.
- We address in a range of ways, discussed later.

We demonstrate our procedure in a sample of 601 Cornell students.
- Make hypothetical choices about investing for retirement.
Our key assumption: Reconsidered choices more closely reflect the individual’s true preferences.

- Substantive psychological assumption; does not follow from principle of revealed preferences. (Bernheim and Rangel, 2009)
- Builds on ancient tradition in moral philosophy and more recent tradition in decision analysis. (e.g., Raiffa, 1968)
  - Discover own preferences by identifying and resolving internal inconsistencies.
- This assumption underlies a traditional defense of EU axioms as normative. (e.g., Morgenstern, 1979)
- Most reasonable for abstract choices in deliberative state of mind. (cf. Giné, Goldberg, Silverman, and Yang, 2016)

Under this assumption:
- Can identify mistakes separately from deliberate axiom violations.
- Can get better measure of risk aversion for normative purposes.
Compare choices in risky lottery framed as “lives saved,” “lives lost,” or both frames together. (McNeil, Pauker, and Tversky, 1988; Druckman, 2001)

- Risk averse in gain frame, risk-seeking in loss frame.
- With both frames together, behavior is intermediate.
- McNeil et al.: the mixed frame may be helpful because it calls attention to both positive and negative aspects of the outcomes.

When provided with arguments for and against expected discounted value (EDV) of cash flows, participants more likely to maximize EDV. (Loewenstein and Sicherman, 1991)

Measure “financial competence” as discrepancy in investment choices across frames. (Ambuehl, Bernheim, and Lusardi, 2016)

Our paper builds on and differs from prior work in:
- Prompting people to reconsider their own inconsistent choices and introspect about their reasons.
- Systematically examining endorsement of a range of axioms comprising EU.
1. Introduction
2. *Experiment Sample and Set-Up*
3. Results
4. Conclusion
601 Cornell subject pool participants: 90% undergrads, 65% female.
Sessions scheduled for 2 hours.
Mean survey completion time: 68 minutes.
Paid $40 for participation.
Of Wave 1+2 sample, 87% \((N = 246)\) returned for wave 2.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Dates</th>
<th>(N)</th>
<th>Differences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wave 1 sample</td>
<td>Jul-Dec 2013</td>
<td>317</td>
<td>Questions about why a person updated choices as they did were open-ended.</td>
</tr>
<tr>
<td>Wave 1+2 sample</td>
<td>Apr-May 2014</td>
<td>284</td>
<td>Questions about why a person updated as they did were multiple choice.</td>
</tr>
</tbody>
</table>

Invited back for a 2\(^{nd}\) wave.
5 possible plans: A, BCE, BCF, BDE, BDF (safest to riskiest by CRRA)
Pre-test

Training
  - Reviewed basic rules of probability
  - Taught symbols and figures
  - Reviewed background assumptions for choices
  - Could not continue until passed each quiz

Main Body
  1. Untutored risky choices
  2. Reconsidered risky choices
     - Inconsistency reconsiderations
     - Intransitivity reconsiderations

Personality and cognitive batteries

Post-experiment questionnaire
36 risky choices derived from the master decision tree.

Choices between the 5 investment plans framed 7 ways.
Note: 2 such questions (C vs. D and E vs. F).
Frame: Single Action with Backdrop

Note: 2 such questions (C vs. D and E vs. F).
36 risky choices derived from the master decision tree.

Choices between the 5 investment plans framed 7 ways.

Frames chosen such that:

- Adjacent frames define a normative axiom (according to which the “same” choice should be made across frames).
- Argument for equivalence across adjacent frames is self-evident.
Axiom: Irrelevance of Background Counterfactuals

In one question you chose C over D, but in another question you chose D over C.

Do you think the two situations are different enough that it makes sense to have different choices, or should they be the same?

- at age 50
  - C or D?
- from age 65 on
  - Conservative
    - $47,000/yr
  - $44,000/yr
  - $70,500/yr

You chose C:

- at age 35
- at age 50
- from age 65 on
- Conservative
  - $56,000/yr
  - $47,000/yr
  - $44,000/yr
  - $70,500/yr

You chose D:

- at age 35
  - B
  - C or D?
- at age 50
  - Conservative
    - $56,000/yr
    - $47,000/yr
    - $44,000/yr
    - $70,500/yr
    - $112,500/yr

- It makes sense to have the same choice in both questions.
- It makes sense to have different choices.
Frames and Axioms

- 36 risky choices derived from the master decision tree.
  - Choices between the 5 investment plans framed 7 ways.
- Frames chosen such that:
  - Adjacent frames define a normative axiom (according to which the “same” choice should be made across frames).
  - Argument for equivalence across adjacent frames is self-evident.
  - Consequently, participants never asked to understand a complex chain of reasoning.
# List of Frames and Axioms

<table>
<thead>
<tr>
<th>(Normative) Axiom</th>
<th>Frame 1</th>
<th>Frame 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrelevance of Counterfactual Choices</td>
<td>Two Contingent Actions with Backdrop [1]</td>
<td>Complete Contingent Action Plan</td>
</tr>
<tr>
<td>Fusion + Shift from Nodewise to Pairwise</td>
<td>Complete Contingent Action Plan [1]</td>
<td>Pairwise Choices Between Complete Strategies</td>
</tr>
<tr>
<td>Complete Strategies = Implied Lotteries</td>
<td>Pairwise Choices Between Complete Strategies [10]</td>
<td>Pairwise Choices Between Compound Lotteries</td>
</tr>
<tr>
<td>Reduction of Compound Lotteries</td>
<td>Pairwise Choices Between Compound Lotteries [10]</td>
<td>Pairwise Choices Between Reduced Simple Lotteries [10]</td>
</tr>
</tbody>
</table>
### List of Frames and Axioms

<table>
<thead>
<tr>
<th>(Normative) Axiom</th>
<th>Frame 1</th>
<th>Frame 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fusion + Shift from Nodewise to Pairwise</td>
<td>Complete Contingent Action Plan [1]</td>
<td>Pairwise Choices Between Complete Strategies</td>
</tr>
<tr>
<td>Complete Strategies = Implied Lotteries</td>
<td>Pairwise Choices Between Complete Strategies [10]</td>
<td>Pairwise Choices Between Compound Lotteries</td>
</tr>
<tr>
<td>Reduction of Compound Lotteries</td>
<td>Pairwise Choices Between Compound Lotteries [10]</td>
<td>Pairwise Choices Between Reduced Simple Lotteries [10]</td>
</tr>
</tbody>
</table>
36 risky choices derived from the master decision tree.
Choices between the 5 investment plans framed 7 ways.

Frames chosen such that:
- Adjacent frames define a normative axiom (according to which the “same” choice should be made across frames).
- Argument for equivalence across adjacent frames is self-evident.
- Consequently, participants never asked to understand a complex chain of reasoning.

In addition to Indep. Axiom sub-axioms, we study transitivity axiom.
“Our research project depends on understanding your choices in a deep way. Now, we’re going to ask you about some of the choices you’ve made so far.”

Algorithm:

1. **Inconsistencies**: all current inconsistencies + ¼ of the consistent choices (placebos), randomly selected. (~5+5 total.)
   a. Ask whether or not they want to update one or both choices.
   b. Ask why they did or did not update.
2. **Intransitivities**: all current pairwise-frame choices. (~1 total.)
Axiom: Irrelevance of Background Counterfactuals

In one question you chose C over D, but in another question you chose D over C.

Do you think the two situations are different enough that it makes sense to have different choices, or should they be the same?

- It makes sense to have the same choice in both questions.
- It makes sense to have different choices.
Inconsistencies:
“In one question you chose C over D, but in another question you chose D over C. Do you think the two situations are different enough that it makes sense to have different choices, or should they be the same?”

Placebo inconsistencies:
“In these two questions, you chose C over D. Do you think the two situations are different enough that it makes sense to have different choices, or should they be the same?”
I changed my mind: I realized that it does make sense to have different choices in these two situations. I would like to keep my current choices (10%).

Which better represents your preference: your choice of [Option 1] over [Option 2], or your choice of [2] over [1]?

Option 1 over 2 (43%)  Option 2 over 1 (47%)

I changed my mind: I realized that it does make sense to have different choices in these two situations. I would like to change *both* of my choices (10%).

Why do you want to make different choices in these two situations?

The two situations are different enough that I want different choices (57%).
Some of the options are equally good to me, so it doesn't matter which one I choose (25%).
I chose how I thought the experimenters wanted me to choose (3%).
I don't know which options I prefer (6%).
I don't know or am confused (4%).
Other __________ (2%).

Is this what you wanted your choices to be changed to?

Yes

Why did you want to change your choices as you did?

I made a mistake when I first chose (45%).
Answering all of these questions made me change what I want (36%).
Some of the options are equally good to me, so it doesn't matter which one I choose (12%).

Why do you want to make different choices in these two situations?

The two situations are different enough that I want different choices (57%).
Some of the options are equally good to me, so it doesn't matter which one I choose (25%).
I chose how I thought the experimenters wanted me to choose (3%).
I don't know which options I prefer (6%).
I don't know or am confused (4%).
Other __________ (2%).
Participants may infer that they should, or experimenter wants them, to revise their earlier choice.

To minimize:

- We always offered options of keeping both choices the same and of switching both choices, making intent less obvious.
- “Placebo inconsistencies”: Asked participants to reconsider ¼ of choice pairs that were consistent with normative axiom.
  - Roughly as frequent as inconsistency reconsiderations.
  - Further masked intentions, and obtained placebo measure of how often participants update when prompted to do so.
  - Kept choices the same 98% of the time.
- Directly offered participants option to select “I chose how I thought the experimenters wanted me to choose.”
  - Selected more often when participants didn’t revise an inconsistency (3%) than when they did (1%).
“Our research project depends on understanding your choices in a deep way. Now, we’re going to ask you about some of the choices you’ve made so far.”

Algorithm:

1. **Inconsistencies**: all current inconsistencies + $\frac{1}{4}$ of the consistent choices (placebos), randomly selected. (~5+5 total.)
   a. Ask whether or not they want to update one or both choices.
   b. Ask why they did or did not update.
2. **Intransitivities**: all current pairwise-frame choices. (~1 total.)
   - Could be 3-way, 4-way, or 5-way (since 5 investment plans).
“Our research project depends on understanding your choices in a deep way. Now, we’re going to ask you about some of the choices you’ve made so far.”

**Algorithm:**

1. **Inconsistencies**: all current inconsistencies + ¼ of the consistent choices (placebos), randomly selected. (~5+5 total.)
   a. Ask whether or not they want to update one or both choices.
   b. Ask why they did or did not update.

2. **Intransitivities**: all current pairwise-frame choices. (~1 total.)
   - Could be 3-way, 4-way, or 5-way (since 5 investment plans).

Algorithm then repeated a 2nd time.
Outline

1. Introduction
2. Experiment Sample and Set-Up
3. Results
4. Conclusion
Reassuringly, virtually no updating in “placebo inconsistencies.”
Yet substantial reductions in intransitivities and inconsistencies.
Number of Intransitivities Over the Experiment

Wave 1
- Untutored
- After 1st incon.
- After 1st intrans.
- After 2nd incon.
- After 2nd intrans.

Wave 2
- Untutored
- After 1st incon.
- After 1st intrans.
- After 2nd incon.
- After 2nd intrans.

N = 214.
Number of Inconsistencies Over the Experiment

Wave 1

- Untutored
- After 1st incons.
- After 1st intrans.
- After 2nd incons.
- After 2nd intrans.

Wave 2

- Untutored
- After 1st incons.
- After 1st intrans.
- After 2nd incons.
- After 2nd intrans.

N = 214.
Reassuringly, virtually no updating in “placebo inconsistencies.”
Yet substantial reductions in intransitivities and inconsistencies.
  Implies that reconsideration is not in a random direction.
When *didn’t* revise inconsistencies, usually because the two frames were considered “different situations” (or because indifferent).
  Consistent with rejecting the axiom.
## Why Not Revise Inconsistent Choices (By Axiom)

<table>
<thead>
<tr>
<th>Axiom</th>
<th>Different Situations</th>
<th>Indiff.</th>
<th>Expt'er Demand</th>
<th>IDK</th>
<th>Confused</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrelevance of Background Counterfactuals</td>
<td>57%</td>
<td>21%</td>
<td>2%</td>
<td>9%</td>
<td>9%</td>
<td>2%</td>
<td>91</td>
</tr>
<tr>
<td>Simple Actions = State-Contingent Actions</td>
<td>74%</td>
<td>17%</td>
<td>2%</td>
<td>2%</td>
<td>4%</td>
<td>1%</td>
<td>116</td>
</tr>
<tr>
<td>Irrelevance of Counterfactual Choices</td>
<td>56%</td>
<td>25%</td>
<td>2%</td>
<td>9%</td>
<td>3%</td>
<td>5%</td>
<td>116</td>
</tr>
<tr>
<td>Fusion + Shift from Nodewise to Pairwise</td>
<td>63%</td>
<td>21%</td>
<td>2%</td>
<td>7%</td>
<td>4%</td>
<td>4%</td>
<td>244</td>
</tr>
<tr>
<td>Complete Strategies = Implied Lotteries</td>
<td>56%</td>
<td>25%</td>
<td>3%</td>
<td>7%</td>
<td>3%</td>
<td>6%</td>
<td>689</td>
</tr>
<tr>
<td>Reduction of Compound Lotteries</td>
<td>55%</td>
<td>28%</td>
<td>3%</td>
<td>5%</td>
<td>4%</td>
<td>6%</td>
<td>873</td>
</tr>
<tr>
<td>Overall</td>
<td>57%</td>
<td>25%</td>
<td>3%</td>
<td>6%</td>
<td>4%</td>
<td>5%</td>
<td>2129</td>
</tr>
</tbody>
</table>
Reassuringly, virtually no updating in “placebo inconsistencies.” Yet substantial reductions in intransitivities and inconsistencies.

- Implies that reconsideration is not in a random direction.

When *didn’t* revise inconsistencies, usually because the two frames were considered “different situations” (or because indifferent).

- Consistent with rejecting the axiom.

When revised inconsistencies, usually reported “made a mistake” or “change[d] what I want” (or indifferent).

- Consistent with endorsing the axiom.
### Why Revised Inconsistent Choices (By Axiom)

<table>
<thead>
<tr>
<th>Axiom</th>
<th>Mistake</th>
<th>Learned</th>
<th>Indiff.</th>
<th>Expt'er Demand</th>
<th>IDK</th>
<th>Confused</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrelevance of Background Counterfactuals</td>
<td>48%</td>
<td>34%</td>
<td>12%</td>
<td>1%</td>
<td>1%</td>
<td>1%</td>
<td>2%</td>
<td>91</td>
</tr>
<tr>
<td>Simple Actions = State-Contingent Actions</td>
<td>36%</td>
<td>38%</td>
<td>18%</td>
<td>0%</td>
<td>3%</td>
<td>2%</td>
<td>3%</td>
<td>61</td>
</tr>
<tr>
<td>Fusion + Shift from Nodewise to Pairwise</td>
<td>47%</td>
<td>32%</td>
<td>13%</td>
<td>1%</td>
<td>4%</td>
<td>2%</td>
<td>0%</td>
<td>166</td>
</tr>
<tr>
<td>Complete Strategies = Implied Lotteries</td>
<td>46%</td>
<td>35%</td>
<td>10%</td>
<td>1%</td>
<td>5%</td>
<td>1%</td>
<td>2%</td>
<td>678</td>
</tr>
<tr>
<td>Reduction of Compound Lotteries</td>
<td>45%</td>
<td>37%</td>
<td>12%</td>
<td>1%</td>
<td>2%</td>
<td>1%</td>
<td>2%</td>
<td>926</td>
</tr>
<tr>
<td>Overall</td>
<td>45%</td>
<td>36%</td>
<td>12%</td>
<td>1%</td>
<td>3%</td>
<td>1%</td>
<td>2%</td>
<td>1922</td>
</tr>
</tbody>
</table>
Reassuringly, virtually no updating in “placebo inconsistencies.”
Yet substantial reductions in intransitivities and inconsistencies.
  Implies that reconsideration is not in a random direction.
When *didn’t* revise inconsistencies, usually because the two frames were considered “different situations” (or because indifferent).
  Consistent with rejecting the axiom.
When revised inconsistencies, usually reported “made a mistake” or “change[d] what I want” (or indifferent).
  Consistent with endorsing the axiom.
Reconsidered choices on average were somewhat more risk tolerant.
Participants often revised *away* from the choice they made in the frame “Pairwise Choices Between Reduced Simple Lotteries.”
  May be evidence against presumption that it elicits normative preferences.
% Choosing F (the risky option) over E

Note: For Pairwise frames, data from the 2 questions BCE vs. BCF and BDE vs. BDF are used.
Note: For Pairwise frames, data from the 2 questions BCE vs. BCF and BDE vs. BDF are used.
By end of wave 2, almost no intransitivities remain.

Consistent with recent literature finding little evidence for intransitivity. (e.g., Regenwetter, Dana, and Davis-Stober, 2011; cf., Tversky, 1969)

Most inconsistencies driven by relatively few participants.

- 35% have 0, 55% have ≤1, and 68% have ≤2; only 14% have >5.

With one exception, inconsistency rate is ≤11% for all axioms.

Not high inconsistency rate for Reduction of Compound Lotteries.

- Consistent with axiom violations as reasoning/math errors.

Exception is “Irrelevance of Counterfactual Choices” axioms.
## Mean Inconsistency Rates

<table>
<thead>
<tr>
<th>Axiom</th>
<th>U1</th>
<th>R1</th>
<th>U2</th>
<th>R2</th>
<th>$P$-value U1-R1</th>
<th>$P$-value U1-U2</th>
<th>$P$-value U2-R2</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrelevance of Background Counterfactuals</td>
<td>13%</td>
<td>6%</td>
<td>8%</td>
<td>4%</td>
<td>&lt;0.0005</td>
<td>0.0345</td>
<td>0.0008</td>
<td>236</td>
</tr>
<tr>
<td>Simple Actions = State-Contingent Actions</td>
<td>12%</td>
<td>9%</td>
<td>6%</td>
<td>6%</td>
<td>0.0218</td>
<td>0.0025</td>
<td>1</td>
<td>236</td>
</tr>
<tr>
<td>Irrelevance of Counterfactual Choices</td>
<td>14%</td>
<td>17%</td>
<td>12%</td>
<td>15%</td>
<td>0.0781</td>
<td>0.3713</td>
<td>0.1393</td>
<td>221</td>
</tr>
<tr>
<td>Fusion + Shift from Nodewise to Pairwise</td>
<td>25%</td>
<td>15%</td>
<td>18%</td>
<td>11%</td>
<td>&lt;0.0005</td>
<td>0.0036</td>
<td>&lt;0.0005</td>
<td>225</td>
</tr>
<tr>
<td>Complete Strategies = Implied Lotteries</td>
<td>22%</td>
<td>10%</td>
<td>14%</td>
<td>8%</td>
<td>&lt;0.0005</td>
<td>&lt;0.0005</td>
<td>&lt;0.0005</td>
<td>232</td>
</tr>
<tr>
<td>Reduction of Compound Lotteries</td>
<td>26%</td>
<td>11%</td>
<td>18%</td>
<td>9%</td>
<td>&lt;0.0005</td>
<td>&lt;0.0005</td>
<td>&lt;0.0005</td>
<td>231</td>
</tr>
<tr>
<td>Overall</td>
<td>23%</td>
<td>11%</td>
<td>15%</td>
<td>8%</td>
<td>&lt;0.0005</td>
<td>&lt;0.0005</td>
<td>&lt;0.0005</td>
<td>214</td>
</tr>
</tbody>
</table>

**Note:** $P$-values are from two-sided t-test. Irrelevance of Counterfactual Choices adjusted by 2/3.
### Mean Inconsistency Rates

<table>
<thead>
<tr>
<th>Axiom</th>
<th>U1</th>
<th>R1</th>
<th>U2</th>
<th>R2</th>
<th>P-value</th>
<th>P-value</th>
<th>P-value</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrelevance of Background</td>
<td>13%</td>
<td>6%</td>
<td>8%</td>
<td>4%</td>
<td>&lt;0.0005</td>
<td>0.0345</td>
<td>0.0008</td>
<td>236</td>
</tr>
<tr>
<td>Counterfactuals</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Simple Actions = State-</td>
<td>12%</td>
<td>9%</td>
<td>6%</td>
<td>6%</td>
<td>0.0218</td>
<td>0.0025</td>
<td>1</td>
<td>236</td>
</tr>
<tr>
<td>Contingent Actions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Irrelevance of Counterfactual</td>
<td>14%</td>
<td>17%</td>
<td>12%</td>
<td>15%</td>
<td>0.0781</td>
<td>0.3713</td>
<td>0.1393</td>
<td>221</td>
</tr>
<tr>
<td>Choices</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fusion + Shift from Nodewise to</td>
<td>25%</td>
<td>15%</td>
<td>18%</td>
<td>11%</td>
<td>&lt;0.0005</td>
<td>0.0036</td>
<td>&lt;0.0005</td>
<td>225</td>
</tr>
<tr>
<td>Pairwise</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Complete Strategies = IMPLIED</td>
<td>22%</td>
<td>10%</td>
<td>14%</td>
<td>8%</td>
<td>&lt;0.0005</td>
<td>&lt;0.0005</td>
<td>&lt;0.0005</td>
<td>232</td>
</tr>
<tr>
<td>LOTTERIES</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduction of Compound</td>
<td>26%</td>
<td>11%</td>
<td>18%</td>
<td>9%</td>
<td>&lt;0.0005</td>
<td>&lt;0.0005</td>
<td>&lt;0.0005</td>
<td>231</td>
</tr>
<tr>
<td>LOTTERIES</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall</td>
<td>23%</td>
<td>11%</td>
<td>15%</td>
<td>8%</td>
<td>&lt;0.0005</td>
<td>&lt;0.0005</td>
<td>&lt;0.0005</td>
<td>214</td>
</tr>
</tbody>
</table>

**Note:** P-values are from two-sided t-test.
Results: Reconsidered Choices

By end of wave 2, almost no intransitivities remain.
- Consistent with recent literature finding little evidence for intransitivity. (e.g., Regenwetter, Dana, and Davis-Stober, 2011; cf., Tversky, 1969)

Most inconsistencies driven by relatively few participants.
- 35% have 0, 55% have \( \leq 1 \), and 68% have \( \leq 2 \); only 14% have >5.

With one exception, inconsistency rate is \( \leq 11\% \) for all axioms.
- *Not* high inconsistency rate for Reduction of Compound Lotteries.
  - Consistent with axiom violations as reasoning/math errors.

Exception is “Irrelevance of Counterfactual Choices” axioms.
- Robustly remains an outlier when restrict attention to participants with \( \leq 5 \) inconsistencies (who may be trying harder to resolve).
## Mean Inconsistency Rates, ≤5 Inconsistencies

<table>
<thead>
<tr>
<th>Axiom</th>
<th>U1</th>
<th>R1</th>
<th>U2</th>
<th>R2</th>
<th>P-value U1-R1</th>
<th>P-value U1-U2</th>
<th>P-value U2-R2</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrelevance of Background Counterfactuals</td>
<td>11%</td>
<td>4%</td>
<td>6%</td>
<td>1%</td>
<td>&lt;0.0005</td>
<td>0.0089</td>
<td>0.0001</td>
<td>184</td>
</tr>
<tr>
<td>Simple Actions = State-Contingent Actions</td>
<td>11%</td>
<td>7%</td>
<td>4%</td>
<td>4%</td>
<td>0.0513</td>
<td>0.0002</td>
<td>1.000</td>
<td>184</td>
</tr>
<tr>
<td>Irrelevance of Counterfactual Choices</td>
<td>21%</td>
<td>24%</td>
<td>14%</td>
<td>17%</td>
<td>0.2919</td>
<td>0.0120</td>
<td>0.3083</td>
<td>184</td>
</tr>
<tr>
<td>Fusion + Shift from Nodewise to Pairwise</td>
<td>23%</td>
<td>13%</td>
<td>14%</td>
<td>6%</td>
<td>&lt;0.0005</td>
<td>&lt;0.0005</td>
<td>&lt;0.0005</td>
<td>184</td>
</tr>
<tr>
<td>Complete Strategies = Implied Lotteries</td>
<td>21%</td>
<td>8%</td>
<td>11%</td>
<td>4%</td>
<td>&lt;0.0005</td>
<td>&lt;0.0005</td>
<td>&lt;0.0005</td>
<td>184</td>
</tr>
<tr>
<td>Reduction of Compound Lotteries</td>
<td>25%</td>
<td>8%</td>
<td>15%</td>
<td>4%</td>
<td>&lt;0.0005</td>
<td>&lt;0.0005</td>
<td>&lt;0.0005</td>
<td>184</td>
</tr>
<tr>
<td>Overall</td>
<td>21%</td>
<td>9%</td>
<td>12%</td>
<td>5%</td>
<td>&lt;0.0005</td>
<td>&lt;0.0005</td>
<td>&lt;0.0005</td>
<td>184</td>
</tr>
</tbody>
</table>

**Note:** P-values are from two-sided t-test.
By end of wave 2, almost no intransitivies remain.
- Consistent with recent literature finding little evidence for intransitivity. (e.g., Regenwetter, Dana, and Davis-Stober, 2011; cf., Tversky, 1969)

Most inconsistencies driven by relatively few participants.
- 35% have 0, 55% have ≤1, and 68% have ≤2; only 14% have >5.

With one exception, inconsistency rate is ≤11% for all axioms.
- *Not* high inconsistency rate for Reduction of Compound Lotteries.
  - Consistent with axiom violations as reasoning/math errors.

Exception is “Irrelevance of Counterfactual Choices” axioms.
- Robustly remains an outlier when restrict attention to participants with ≤5 inconsistencies (who may be trying harder to resolve).
- Suggests that regret, or counterfactual reference point, drives some violations of EU—but the violations are *not* systematic.
Axiom: Irrelevance of Counterfactual Choices

In one question you chose DE over DF, but in another question you chose DF over DE.
Do you think the two situations are different enough that it makes sense to have different choices, or should they be the same?

- It makes sense to have the same choice in both questions.
- It makes sense to have different choices.
Outline

1. Introduction
2. Experiment Sample and Set-Up
3. Results
4. Conclusion
Reconsideration virtually eliminates intransitivities and substantially reduces inconsistencies with EU axioms in our data.
- Remaining inconsistencies concentrated among relatively few participants.
- Primarily related to regret or counterfactual reference points.
Results suggest other inconsistencies with EU are mainly mistakes, rather than normative preferences.
Substantial convergence across frames of risk aversion estimated from reconsidered choices.
Further work needed to test if reconsideration can lead to complete convergence in choices across frames.
(Simplified!) version of method might be applicable for financial advice.
Reconsideration method might be useful for helping to identify normative preferences in other types of choices.
Frame: Single Action in Isolation

Note: 2 such questions (C vs. D and E vs. F).
Frame: Single Action with Backdrop

at age 35

A

B

|| 50%

|| 50%

at age 50

C or D?

C

D

54%

Conservative

$50,000/yr

$47,000/yr

$44,000/yr

Conservative

$70,000/yr

Conservative

$70,000/yr

$75,000/yr

$70,500/yr

$112,500/yr

from age 65 on

Note: 2 such questions (C vs. D and E vs. F).