Reacting to Incentives

Duarte Gonçalves

University College London

Experimental Economics

Motivation

How do agents react to incentives in games?

Different incentives, different game. Can people recognise small changes and anticipate others behaviour?

NE predictions often very sharp. What is robust and what needs relaxing?

Modelling Bounded Rationality.

Literature incorporates frictions via choice mistakes (QRE) and limited or costly reasoning (level-*k*, EDR, SSE).

Different models imply different reactions to absolute and. relative incentives.

The Identification Challenge.

In standard settings, changing incentives conflates:

(1) Direct Effect: I change my behaviour due to different incentives.

(2) Indirect Effect: I expect *you* to change your behaviour due to your own incentive changes or even just by anticipating my behaviour change.

This lecture: Survey the evidence on relative/absolute incentives.

Discuss methodological innovations.

Highlight robust patterns in the data, as well as gaps in the literature.

Overview

1. Incorportating Choice Mistakes and Costly Reasoning
2. Relative Incentives and Choices
3. Relative Incentives and Beliefs
4. Absolute Incentives and Choices
5. Absolute Incentives, Choices, and Beliefs
6. Revisiting Questions

Overview

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Models of Costly Mistakes/Reasoning

Challenge: incorporate reaction to incentives.

Models:

- Noisy/Costly best response: random utility (Strzalecki 2025), additive perturbed utility (Fudenberg, Ijima, and Strzalecki 2015 Ecta)
  $\mapsto$ quantal response equilibrium (McKelvey and Palfrey 1995 GEB; Mattsson and Weibull 2002 GEB).
- Random beliefs: random belief equilibrium (Friedman and Mezzetti 2005 GEB), noisy belief equilibrium (Friedman 2022 AEJMicro).
- Sampling-based models: payoff sampling S(n) (Osborne and Rubinstein 1998 AER), (action) sampling equilibrium (Osborne and Rubinstein 2003 GEB).
- Cost-benefit of reasoning: endogenous depth of reasoning (Alaoui and Penta 2016 REStud).
- Optimal reasoning: optimal stopping $\mapsto$ sequential sampling equilibrium (Gonçalves 2024).

Models of Costly Mistakes/Reasoning

Structural QRE (McKelvey and Palfrey 1995 GEB).

$\sigma = q(\sigma)$ s.t. $q_i(\sigma_{-i})(s_i) = Q_i(u_i(\cdot, \sigma_{-i}))(s_i) = \mathbb{P}(s_i \in \arg\max u_i(s_i, \sigma_{-i}) + \varepsilon_{i,s_i})$.

Typically, assume ε_{i,s_i} iid zero mean. Logit QRE if $\varepsilon_{i,s_i} \sim$ extreme value distrib.

Interpretation: ε_i as reduced-form for errors due to unmodelled information processing costs.

Issues with Structural QRE.

If drop (1) independence or (2) identical marginals of error terms across strategies of same player, then any fully mixed σ can be rationalised as QRE (Haile et al. 2008 AER).

Cross game restrictions if assume:

Invariance of error term distribution wrt payoff function u_i.

Exchangeability, invariance of the joint distribution to permutations of the labels.

Models of Costly Mistakes/Reasoning

Regular QRE (Goeree, Holt, and Palfrey 2005 EE). Require Q to satisfy:

Interiority, $Q_i(v_i)(s_i) > 0$ for all $v_i \in \mathbb{R}^{|S_i|}$.

Continuity, Q_i continuous and differentiable.

Responsiveness, $\frac{\partial}{\partial v_{i,s_i}} Q_i(v_i)(s_i) > 0$. (Implied by invariance.)

Monotonicity, $v_{i,s_i} > v_{i,s_i'} \implies Q_i(v_i)(s_i) > Q_i(v_i)(s_i')$. (Implied by exchangeability.)

Note: No prediction regarding absolute payoffs.

Control Costs Approach.

Additive Perturbed Utility: $Q_i(v_i) = \arg\max_{p_i} p_i \cdot v_i - \sum_{s_i} c(p_i(s_i))$,

$c \in \mathcal{C}^1$ and $c'(0^+) = -\infty$. Q_i **is RQRE** satisfying

$$v_{i,s_i} - v_{i,s_i'} = c'(Q_i(v_i)(s_i)) - c'(Q_i(v_i)(s_i')).$$

Logit QRE: If c is relative entropy, then get logit: $\exp(v_{i,s_i} - v_{i,s_i'}) = Q_i(v_i)(s_i)/Q_i(v_i)(s_i')$.

MLR Monotonicity: Order s_i in increasing fashion according to v_{i,s_i}. Then, $\alpha > 1$

$$\frac{Q_i(v_i)(n+1)}{Q_i(v_i)(n)} = \exp(v_{i,n+1} - v_{i,n}) \leq \exp(\alpha(v_{i,n+1} - v_{i,n})) = \frac{Q_{i,n+1}(\alpha v_i)}{Q_{i,n}(\alpha v_i)},$$

i.e., $Q_i(\alpha v_i)$ increases in MLR order wrt α.

Models of Costly Mistakes/Reasoning

Random Beliefs: random belief equilibrium (Friedman and Mezzetti 2005 GEB), noisy belief equilibrium (Friedman 2022 AEJMicro).

- Player i's beliefs drawn $\hat{\sigma}^i_{-i} \sim \mu_i(\cdot \mid \sigma_{-i})$.
- Players best-respond to beliefs.
- Beliefs unbiased: assume beliefs centred about σ_{-i} (e.g., in mean or median).
- Beliefs responsive: 2x2 $+\sigma_j \implies$ beliefs about σ_j increase in FOSD.
- Note: strat. played in eqm are rationalisable.

Models of Costly Mistakes/Reasoning

Payoff Sampling S(n) (Osborne and Rubinstein 1998 AER).

(i) Player i samples payoffs $\tilde{u}_i(s_i)$ for each strategy s_i according to $\boldsymbol{\sigma}_{-i}$, n times.

(ii) Choose strategy with higher average, inducing distribution of strategies.

(iii) Eqm = fixed point.

Note: allows for play of strictly dominated strategies (but not obviously strictly dominated).

Emphasise $S(1)$, but silly: e.g., in asymmetric matching pennies (assume indifference $\tilde{\boldsymbol{\sigma}}_M, \tilde{\boldsymbol{\sigma}}_C > 1/2$)

$\boldsymbol{\sigma}_M(A) = \mathbb{P}(M \text{ samples } A) = \boldsymbol{\sigma}_C(A)$; $\boldsymbol{\sigma}_C(A) = \mathbb{P}(C \text{ samples } B) = 1 - \boldsymbol{\sigma}_M(A)$;

Unique S(1) $\boldsymbol{\sigma}_M(A) = 1 - \boldsymbol{\sigma}_M(A) = 1/2$, no matter payoffs.

Even S(2) unreactive to payoffs:

$\boldsymbol{\sigma}_M(A) = \mathbb{P}(M \text{ samples } A \text{ twice}) = \boldsymbol{\sigma}_C(A)^2$; $\boldsymbol{\sigma}_C(A) = \mathbb{P}(C \text{ samples } B$ twice$) = (1 - \boldsymbol{\sigma}_M(A))^2$;

Unique S(2) eqm, $\boldsymbol{\sigma}_M(A) + \boldsymbol{\sigma}_M(A)^{1/4} = 1$.

Models of Costly Mistakes/Reasoning

Sampling Equilibrium (Osborne and Rubinstein 2003 GEB).

(i) Player i samples opponents' strategies according to σ_{-i}, n times.

(ii) Exogenous, fixed, and arbitrary mapping from sample to strategies (e.g., best respond to empirical frequency), inducing distribution of strategies.

(iii) Eqm = fixed point.

Special case 1: random beliefs = empirical sample distribution; unbiased on avg, responsive beliefs.

Special case 2: random beliefs = posterior from uniform prior + sample distribution; no longer unbiased on avg, still sat. belief responsiveness.

Models of Costly Mistakes/Reasoning

Endogenous Depth of Reasoning (Alaoui and Penta 2016 REStud).

- Exogenous anchor a^0, $a_i^{k+1} = BR_i(a_{-i}^k)$.
- Value of reasoning $v_i(k) \geq 0$, exogenously specified; e.g., $v_i(k) := \max_{a_{-i}} u_i(BR_i(a_{-i}), a_{-i}) - u_i(a_i^{k-1}, a_{-i})$.
- Cost of reasoning $c_i(k) \geq 0$.
- Cognitive bound = max steps reasoning.
  Myopic stopping: $\hat{k}_i := K(c_i, v_i) = \min\{k \in \mathbb{N} : v_i(k) \leq c_i(k)\}$.
- Behavioural bound k_i = min {own cognitive bound ($\hat{k}_i$), believed opponent cognitive bound (k_j^i) + 1}.
- Also allow for higher order uncertainty, i.e. beliefs about opponents' beliefs about their own cognitive bound.
- Lower costs $\implies$ higher order rationalisability of actions played $a_i^{k_i}$, more steps.

Models of Costly Mistakes/Reasoning

Sequential Sampling Equilibrium (Gonçalves 2024).

- Player i has uniform prior about σ_{-i} (can generalise).
- Player i samples signal about σ_{-i}, e.g., $y_i \sim \sigma_{-i}$, at cost $c_i > 0$.
- Optimally decides when to stop sampling and best responds to posterior belief.
- Eqm = fixed point.
- Get joint distribution of strategies, beliefs, and stopping time.

Models of Costly Mistakes/Reasoning

Some Predictions:

SE, S(n), EDR, SSE: all satisfy responsiveness weakly (as does NE).

EDR and SSE: Lower costs $\implies$ More steps of reasoning.

SE, SSE, EDR (and S(n) I think): More steps of reasoning $\implies$ higher order rationalisability of strat. played.

SSE: random beliefs sat. belief responsiveness; + steps when closer to indifferent.

Overview

1. Incorportating Choice Mistakes and Costly Reasoning

2. Relative Incentives and Choices
   - Matching Pennies Games
     - Ochs (1995 GEB)
     - McKelvey, Palfrey, and Weber (2000 JEBO)
   - Joker Games
     - Melo, Pogorelskiy, and Shum (2018 IER)
   - Traveler's Dilemma
     - Capra, Goeree, Gomez, and Holt (1999 AER)
   - 11-20 Game
     - Alaoui and Penta (2016 REStud)
     - Alaoui, Janezic, and Penta (2020 JET)
   - Reacting to Relative Incentives: Takeaways
   - Simple Choice Problems
     - Gonçalves, Kneeland, and Ziegler (2025)

3. Relative Incentives and Beliefs

4. Absolute Incentives and Choices

5. Absolute Incentives, Choices, and Beliefs

Relative Incentives and Choices: Matching Pennies Games

Relative Incentives in Matching Pennies Games: Ochs (1995 GEB)

Player Two

Game One

Player One	A	B
A	(1,0)	(0,1)
B	(0,1)	(1,0)

Game Two

Player One	A	B
A	(9,0)	(0,1)
B	(0,1)	(1,0)

Game Three

Player One	A	B
A	(4,0)	(0,1)
B	(0,1)	(1,0)

FIGURE 1

Procedures:

48 students U Pittsburgh; 3 sessions, 16 participants each session.

Session 1: 64 rounds of G1.

Session 2: 16 rounds G1, 56 rounds G2.

Session 3: 16 rounds G1, 64 rounds G3.

Random matching each round, fixed roles.

Points = prob. points toward bonus USD 10 vs 20 USD.

Duration about 90 min.

Relative Incentives in Matching Pennies Games: Ochs (1995 GEB)

Your History with This Game
Game # 1
# of rounds Played 2
Cells per round 10

		Other A	Other B	
You	A	7/20	3/20	10/20
	B	2/20	8/20	10/20
		9/20	11/20	

Procedures:

Each round, 10 instances same game. For each, participants chose in how many chose action A vs B, with computerised randomisation.

All 10 games in each round were payoff relevant.

Display own past play frequencies.

Idea was to induce ‘steady state’ gameplay.

Relative Incentives in Matching Pennies: Ochs (1995 GEB)

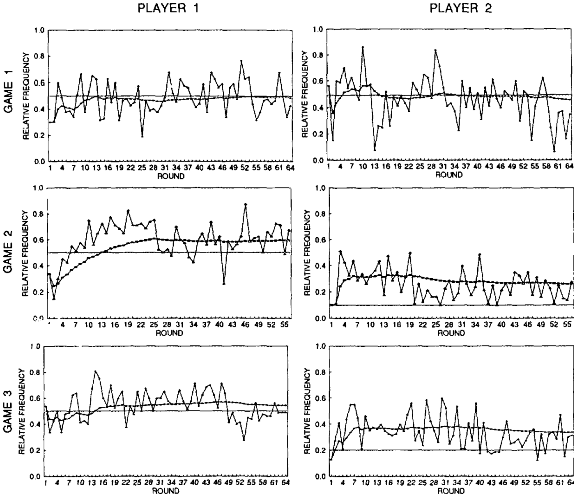

FIG. 2. (▲) Relative frequency of A choices, (■) long-run average frequency of A choice, and (—) Nash equilibrium.

Own payoff effect: P1 plays *A* more in G2 > G3 > G1.

Opp. payoff effect: P2 plays *B* more in G2 > G3 > G1, but insufficiently so relative to NE.

Relative Incentives in Matching Pennies Games: McKelvey, Palfrey, and Weber (2000 JEBO)

Table 1
Payoff tables for Games A–D

	Game A		Game B		Game C		Game D	
	L	R	L	R	L	R	L	R
U	9,0	0,1	9,0	0,4	36,0	0,4	4,0	0,1
D	0,1	1,0	0,4	1,0	0,4	4,0	0,1	1,0

Table 2
First and second treatments by experimental session

Session	First game	Second game
1	A	B
2	B	A
3	B	C
4	C	B
5	A	C
6	C	A
7	A	D
8	D	A

Procedures:

12 Caltech students per session; two games, 50 rounds/game, sequential order. Control for order effects.

Random matching each round, fixed roles.

Points = money, pay all.

Display own past play frequencies.

Matching Pennies: McKelvey, Palfrey, and Weber (2000 JEBO)

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Payoff tables for Games A–D

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	L	R	L	R	L	R	L	R
U	9,0	0,1	9,0	0,4	36,0	0,4	4,0	0,1
D	0,1	1,0	0,4	1,0	0,4	4,0	0,1	1,0

Table 4
Summary of results and estimates for all games

Game	$\hat{p}$	p	$\hat{q}$	q	λ	λ_{LO}	λ_{HI}	QRE	NASH	RAND
A	0.690	0.643	0.115	0.241	5.38	4.73	6.25	−2286.1	−2388.7	−2495.3
B	0.711	0.630	0.220	0.244	0.75	0.64	0.89	−1478.0	−1602.0	−1663.5
C	0.635	0.594	0.107	0.257	1.97	1.58	2.63	−1603.8	−1634.9	−1663.5
D	0.590	0.550	0.210	0.328	7.33	4.41	18.13	−817.3	−822.9	−831.8

Relative Incentives:

-Payoff U (A $\rightarrow$ D):

Own payoff affect: row plays U less by 10pp***.

Opp. payoff affect: col plays L more by 9pp***.

Also in the paper: data fitting exercise, allowing for heterogeneity.

Relative Incentives and Choices: Joker Games

Relative Incentives in Joker Games: Melo, Pogorelskiy, and Shum (2018 IER)

Procedures:

96 students UC Irvine. 40 rounds, 3 sessions, games played in order (12, 23, 3412).

Random rematching each round.

Elicit beliefs once (unincentivised, no data reported).

Pay all (!), points = money.

Relative Incentives Beyond 2x2: Melo, Pogorelskiy, and Shum (2018 IER)

TABLE 1
FOUR 3 × 3 GAMES INSPIRED BY THE JOKER GAME OF O'NEILL (1987)

Game 1 (Symmetric Joker)			1 **[1/3]** (0.325)	2 **[1/3]** (0.308)	J **[1/3]** (0.367)
	1	**[1/3]** (0.273)	10, 30	30, 10	10, 30
	2	**[1/3]** (0.349)	30, 10	10, 30	10, 30
	J	**[1/3]** (0.378)	10, 30	10, 30	30, 10
Game 2 (Low Joker)			1 **[9/22]** (0.359)	2 **[9/22]** (0.439)	J **[4/22]** (0.202)
	1	**[1/3]** (0.253)	10, 30	30, 10	10, 30
	2	**[1/3]** (0.304)	30, 10	10, 30	10, 30
	J	**[1/3]** (0.442)	10, 30	10, 30	55, 10
Game 3 (High Joker)			1 **[4/15]** (0.258)	2 **[4/15]** (0.323)	J **[7/15]** (0.419)
	1	**[1/3]** (0.340)	25, 30	30, 10	10, 30
	2	**[1/3]** (0.464)	30, 10	25, 30	10, 30
	J	**[1/3]** (0.196)	10, 30	10, 30	30, 10
Game 4 (Low 2)			1 **[2/5]** (0.487)	2 **[1/5]** (0.147)	J **[2/5]** (0.366)
	1	**[1/3]** (0.473)	20, 30	30, 10	10, 30
	2	**[1/3]** (0.220)	30, 10	10, 30	10, 30
	J	**[1/3]** (0.307)	10, 30	10, 30	30, 10

NOTES: For each game, the unique Nash equilibrium choice probabilities are given in bold font within brackets, whereas the probabilities in regular font within parentheses are aggregate choice probabilities from our experimental data, described in Subsection 6.1.

Games 1 $\rightarrow$ 2. Row: -1, -2, +J. Col: +BR (-J).

Games 1 $\rightarrow$ 3. Row: +1, + 2, -J. Col: +BR (+J).

Games 1 $\rightarrow$ 4. Row: +1, -2, -J. Col: +BR (+1, -2, +J).

Relative Incentives and Choices: Traveler’s Dilemma

Traveler's Dilemma: Capra, Goeree, Gomez, and Holt (1999 AER)

Two travelers purchase identical antiques while on a tropical vacation. Their luggage is lost on the return trip, and the airline asks them to make independent claims for compensation. In anticipation of excessive claims, the airline representative announces:

> *We know that the bags have identical contents, and we will entertain any claim between 80 and 200, but you will each be reimbursed at an amount that equals the minimum of the two claims submitted. If the two claims differ, we will also pay a reward of R to the person making the smaller claim and we will deduct a penalty of R from the reimbursement to the person making the larger claim.*

Undercutting logic, unique rationalisable strat. is to make min claim.

Procedures:

Groups of 9-12 students U Virginia; no mention of total.

Context-free, stylised description.

Feedback: choice of opponent.

Part A/B: Vary R; 10 rounds Part A + 10 or 5 rounds Part B.

R: low (5, 10), medium (20, 25), high (50, 80). 6 sessions.

Random rematching each round.

Traveler's Dilemma: Capra, Goeree, Gomez, and Holt (1999 AER)

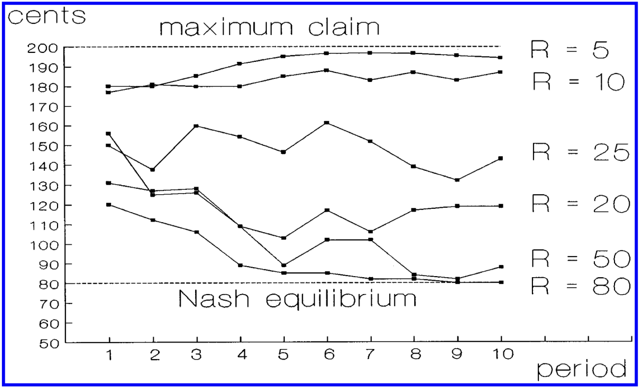


FIGURE 1. DATA FOR PART A FOR VARIOUS VALUES OF THE REWARD/PENALTY PARAMETER

Lower *R*, lower incentive to undercut, farther away from NE.

Low *R* persistently far away from NE.

Traveler's Dilemma: Capra, Goeree, Gomez, and Holt (1999 AER)

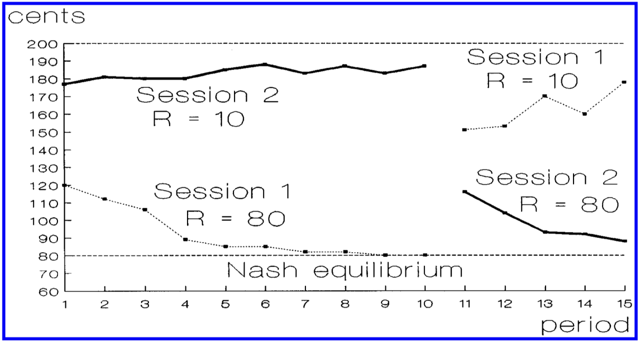


FIGURE 2. AVERAGE CLAIMS FOR PARTS A AND B OF SESSION 1 (DARK LINE) AND SESSION 2 (DASHED LINE)

Switch of *R* high to low reversed convergence to NE.

Traveler's Dilemma: Capra, Goeree, Gomez, and Holt (1999 AER)

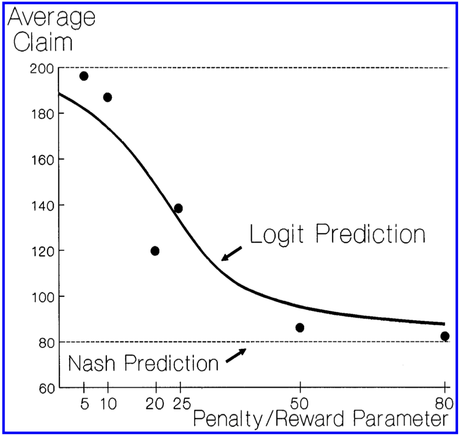


FIGURE 4. PREDICTED AND ACTUAL AVERAGE CLAIMS FOR THE FINAL THREE PERIODS

Note: Dots represent average claims for each of the treatments.

Logit QRE fits avg claims rather well.

Relative Incentives and Choices: 11-20 Game

Modified 11-20: Alaoui and Penta (2016 REStud)

The subjects are matched in pairs. Each subject enters an (integer) number between 11 and 20, and always receives that amount in tokens. If he chooses exactly one less than his opponent, then he receives an extra x tokens. If they both choose the same number, then they both receive an extra 10 tokens.

$x = \mathbf{20}, \mathbf{80}$. Undercutting logic. Unique NE is 11. All numbers rationalisable, i.e., not dominance-solvable for these values of x ($\exists\, \boldsymbol{\sigma}_{-i}$ that makes 20 a BR).

Procedures:

120 undergrad students Universitat Pompeu Fabra (UPF).

Each participant plays each treatment twice, nonconsecutively. 4 orders of treat's.

Split participants according to degree or test score (CRT and the like).

Random rematching each round, no feedback.

TABLE 1

Treatment summary: label I refers to "math and sciences" or to "high" subjects, and label II refers to "humanities" or to "low" subjects

Treatment	Own label	Opponent's label	Own payoffs	Opponent's payoffs	Replacement of opponent's opponent
Homogeneous [A]	*I (II)*	*I (II)*	Low	Low	No
Heterogeneous [B]	*I (II)*	*II (I)*	Low	Low	No
Replacement [C]	*I (II)*	*II (I)*	Low	Low	Yes
Homogeneous-high [A+]	*I (II)*	*I (II)*	High	High	No
Heterogeneous-high [B+]	*I (II)*	*II (I)*	High	High	No
Replacement-high [C+]	*I (II)*	*II (I)*	High	High	Yes

Notes: There are 120 subjects for each treatment (sixty subjects for each classification).

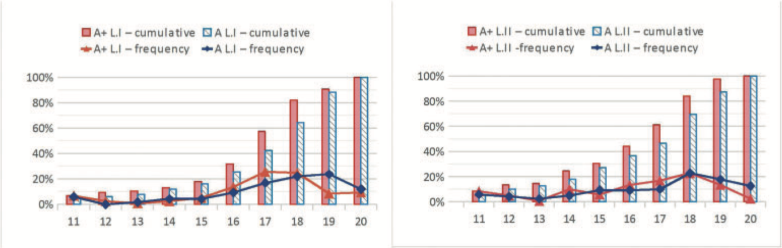
Aside: Replacement Method

Replacement Method:

- Game played between players $j = 1, ..., n$ under fixed conditions.
- Then take player i and replace them with another player i', with potentially different payoffs/information/characteristics; i' plays against $j \neq i$ from original game.
- Allows you to hold fixed distribution of play of opponents and higher-order beliefs.

Idea originates in ‘observer’ methods in experimental, but deployed carefully by Alaoui and Penta (2016 REStud).

Modified 11-20: Alaoui and Penta (2016 REStud)



(a) : A and A+

FIGURE 4

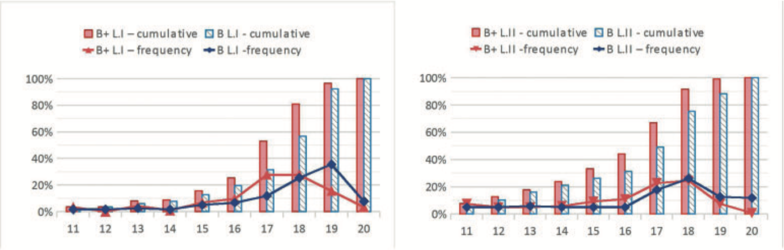
Changing payoffs, label *I* (left) and label *II* (right)

Notes: Recall that label *I* denotes the high score and math and sciences combined, and label *II* the low scores and humanities combined. Also, for X=A,B,C, [X+] denotes treatment [X] with high payoffs. Summary: For both labels, increasing incentives shifts the level of play towards more sophisticated behaviour (*i.e.* lower numbers). This holds within each treatment: homogenous ([A] to [A+]), heterogenous ([B] to [B+]), and replacement ([C] to [C+]).

X $\rightarrow$ X+ effect of incentives.

Higher incentive to undercut $\implies$ FOSD shift toward lower numbers.

Modified 11-20: Alaoui and Penta (2016 REStud)



(b) : B and B+

FIGURE 4

Changing payoffs, label *I* (left) and label *II* (right)

Notes: Recall that label *I* denotes the high score and math and sciences combined, and label *II* the low scores and humanities combined. Also, for X=A,B,C, [X+] denotes treatment [X] with high payoffs. Summary: For both labels, increasing incentives shifts the level of play towards more sophisticated behaviour (*i.e.* lower numbers). This holds within each treatment: homogenous ([A] to [A+]), heterogenous ([B] to [B+]), and replacement ([C] to [C+]).

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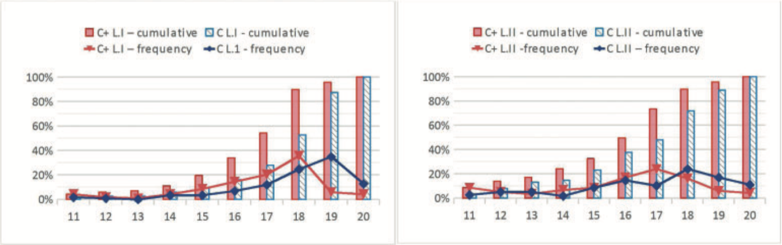

(c) : C and C+

FIGURE 4

Changing payoffs, label *I* (left) and label *II* (right)

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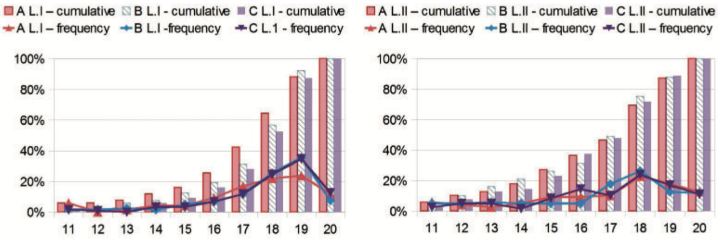


FIGURE 5

Treatments [A], [B], and [C] for label *I* (left) and *II* (right)

Notes: Changing beliefs (comparison of treatments [A] and [B]) affects behaviour in a way consistent with our model. Moreover, as predicted by our theory, higher-order beliefs effects (comparison of treatments [B] and [C]) are observed only for the more sophisticated subjects (label *I*).

A $\rightarrow$ B: Opponent of perceived lower/higher sophistication.

B $\rightarrow$ C: Opponent of perceived lower/higher sophistication but also playing with opponent of lower/higher sophistication.

Indicative of FOSD, but not too cleanly.

Modified 11-20: Alaoui, Janezic, and Penta (2020 JET)

Table 1
Summary of the baseline treatments.

Baseline treatments	Opponent's label compared to own	Own payoffs	Opponent's payoffs	Replacement of opponent's opponent
Homogeneous [Hom]	same	Low	Low	No
Heterogeneous [Het]	different	Low	Low	No
Higher-Order Beliefs [HOB]	different	Low	Low	Yes
Homogeneous-high [Hom+]	same	High	High	No
Heterogeneous-high [Het+]	different	High	High	No
Higher-Order Beliefs-high [HOB+]	different	High	High	Yes

Table 2
Summary of the post-tutorial treatments.

The tutorial treatments	Opponent's label compared to own	Own payoffs	Opponent's payoffs	Own tutorial	Opponent's tutorial
Tutorial [Tut]	–	Low	Low	Yes	Yes
Asymm. Tutorial-Homog. [AT-Hom]	same	Low	Low	Yes	No
Asymm. Tutorial-Heterog. [AT-Het]	different	Low	Low	Yes	No

Table 3
Summary of the asymmetric payoff treatments.

Asymmetric payoffs treatments	Opponent's label compared to own	Own payoffs	Opponent's payoffs	Replacement of opponent's opponent
Asymm. Payoffs-Homogeneous [AP-Hom]	same	High	Low	Only payoffs
Asymm. Payoffs-Heterogeneous [AP-Het]	different	High	Low	Both label and payoffs

Original dataset included treatments also providing tutorial.

Modified 11-20: Alaoui, Janezic, and Penta (2020 JET)

Table 4
Summary of the treatments in Experiment 2.

Baseline treatments	Own payoffs	Opponent's payoffs	Own tutorial	Opponent's tutorial	Replacement of opponent's opponent
Unlabeled [Un]	Low	Low	No	No	No
Unlabeled-high [Un+]	High	High	No	No	No
Tutorial-Unlabeled [Tut-Un]	Low	Low	Yes	Yes	No
Asymm.Tut.-Unlab. [AT-Un]	Low	Low	Yes	No	Tutorial only
Asymm.Payoffs-Unlab. [AP-Un]	High	Low	No	No	Payoffs only

Table 5
Summary of the treatments in Experiment 3.

Baseline treatments	Own payoffs	Opponent's payoffs	Own Tutorial	Opponent's tutorial	Replacement of opponent's opponent
Unlabeled [E3-Un]	Low	Low	No	No	No
Unlabeled-high [E3-Un+]	High	High	No	No	No
Tutorial-Unlabeled [E3-Tut-Un]	Low	Low	Yes	Yes	No
Asymm.Tut.-Unlab. [E3-AT-Un]	Low	Low	Yes	No	Tutorial only
Asymm.Payoffs-Unlab. [E3-AP-Un]	High	Low	No	No	Payoffs only

Added replacement treatment for same and different payoffs to undercutting (x) as well as unlabelled-participants treatments.

Modified 11-20: Alaoui, Janezic, and Penta (2020 JET)

Table 6
Summary of all treatments over all experiments.

Payments	Same label (Homogeneous)		Different labels (Heterogeneous)		No label (Unlabeled)			
	No tutorial	Own tutorial	No tutorial	Own tutorial	No tutorial	Own tutorial	Both tutorial	Semi-tutorial
Both low	[Hom]	$[\text{AT-Hom}]^{tr}$	[Het] $[\text{HOB}]^{lr}$	$[\text{AT-Het}]^{tr,lr}$	[Un]	$[\text{AT-Un}]^{tr}$ $[\text{E3-AT-Un}]^{tr}$	[Tut] [Tut-Un] [E3-Tut-Un]	[E3-Un] $[\text{E3-AT-Un}]^{tr}$ [E3-Tut-Un]
Both high	[Hom+]		[Het+] $[\text{HOB+}]^{lr}$		[Un+]			[E3-Un+]
Own high, opponent's low	$[\text{AP-Hom}]^{pr}$		$[\text{AP-Het}]^{pr,lr}$		$[\text{AP-Un}]^{pr}$			$[\text{E3-AP-Un}]^{pr}$

Superscripts next to the treatments indicate replacement of opponent's opponent's payoff ($[.]^{pr}$), label ($[.]^{lr}$) or tutorial ($[.]^{tr}$).

Monster of acronyms.

Higher incentive to undercut tends to shift toward lower numbers, but FOSD shift not clear.

Reacting to Relative Incentives

Own Payoff Effect: Increase payoffs to action $\implies$ play action more often?

Opp. Payoff Effect: Increase payoffs to opponent's action $\implies$ play BR against it more often?

Findings focus on cases when own/opp. payoff effect don't go against Nash equilibrium, e.g.,
NE predicts predicts no change, yet we see some.

Word of caution:

(Responsiveness) Own Payoff Effect: Increase payoffs to action $\implies$ play action more often?

Not generically true for NE.
$\implies$ won't be generically true for any model that nests NE as limit.

Couldn't find experiments with games in which NE prediction goes strictly against own/opp. payoff effect.

Relative Incentives and Choices: Simple Choice Problems

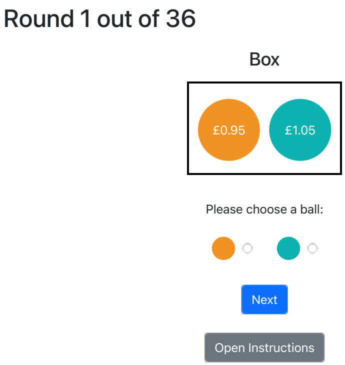
Relative Incentives in Simple Choice Problems

Own Payoff Effect: Increase payoffs to action $\implies$ play action more often?

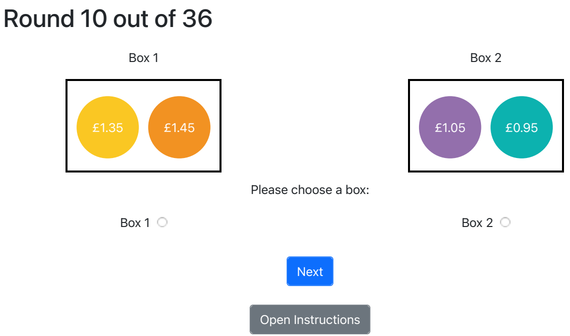
Based on underlying primitive individual choice model.

- Is this true even in very simple choices or a feature of complex settings?

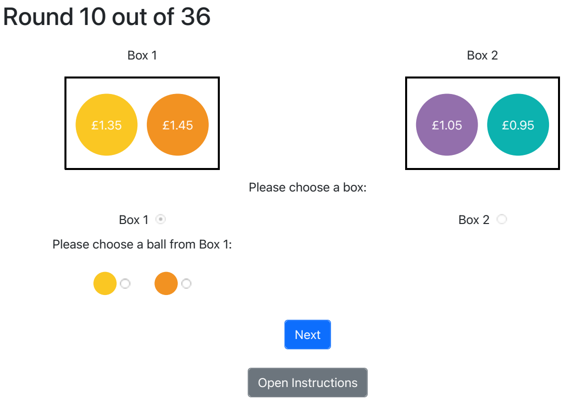
Simple Choice Problems: Goncalves, Kneeland, and Ziegler (2025)



Simple Choice Problems: Goncalves, Kneeland, and Ziegler (2025)



Simple Choice Problems: Goncalves, Kneeland, and Ziegler (2025)



Simple Choice Problems: Goncalves, Kneeland, and Ziegler (2025)

Careful construction of boxes

Box = (Min, Max) = (Min, Min + Spread)

Min = £0.45, £0.95, £1.35

Spread = £0.10, £0.60, £1.20

All combinations: 9 boxes; All pairwise combinations: 45 pairs

Two parts

Part 1: 9 rounds, one for each box, random order

Part 2: 27 rounds, random subset of pairs of boxes

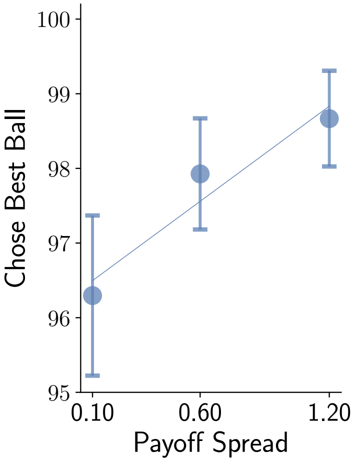
1 round randomly selected for payment

Choices:

WYSIWYG payment + £2.55 completion

225 participants on Prolific. Avg pay £4.35; Median duration 7min.

More Indifferent $\implies$ More Mistakes: Gonçalves, Kneeland, and Ziegler (2025)



+ Spread

$\implies$ Less indifferent

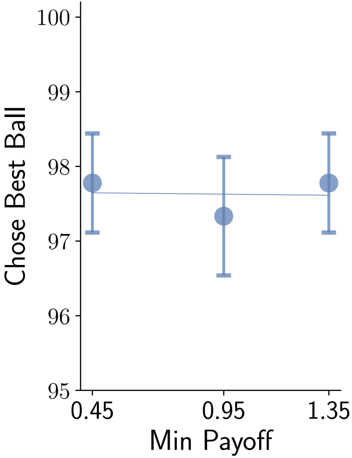
$\implies$ Fewer mistakes

(Figs: 95% CI with clustered se's at participant level)

Level Shifts Don't Matter: Gonçalves, Kneeland, and Ziegler (2025)

No effect of min

- i.e., adding a constant has no effect.



Choosing Worst Box: Gonçalves, Kneeland, and Ziegler (2025)

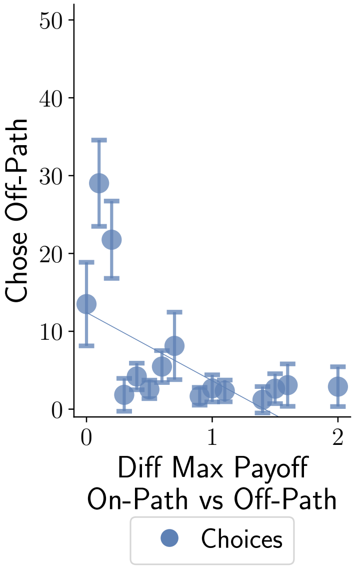
Larger difference in max payoff

$\Longrightarrow$ Off-Path worse

$\Longrightarrow$ Less indifferent

$\Longrightarrow$ Fewer mistakes/off-path choices

(On avg off-path <6%)



Choosing Worst Box: Gonçalves, Kneeland, and Ziegler (2025)

Smaller difference in min payoff

$\implies$ Off-Path relatively safer

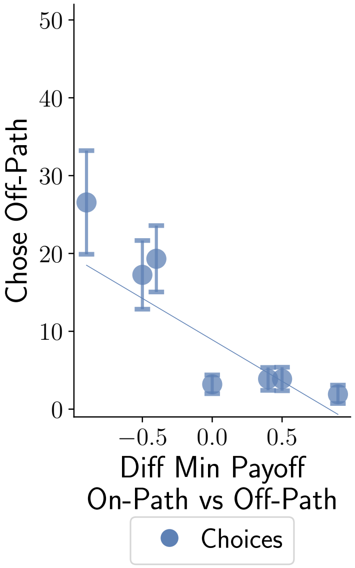
$\implies$ Fewer mistakes/off-path choices

Difference in min negative

$\implies$ Off-Path min > On-Path min

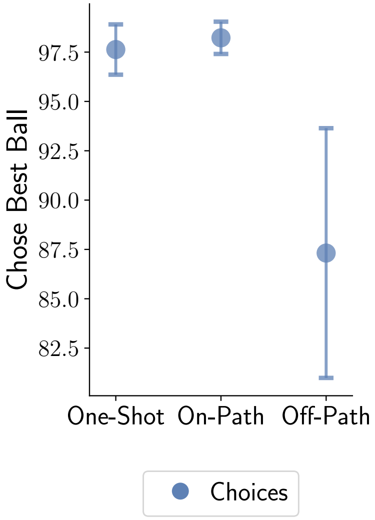
(by definition, Off-Path max < On-Path max)

'Trade-off' gain vs risk? (temptation/self-control problem?)



Mistakes Predict Further Mistakes: Gonçalves, Kneeland, and Ziegler (2025)

Underlying heterogeneity in mistake propensity.



Simple Choice Problems

Own Payoff Effect: Increase payoffs to action $\implies$ play action more often?

Based on underlying primitive individual choice model.

Is this true even in very simple choices? Yes, though with small effects.

Overview

Relative Incentives and Beliefs: Simple Choice Problems

Simple Choice Problems: Gonçalves, Kneeland, and Ziegler (2025)

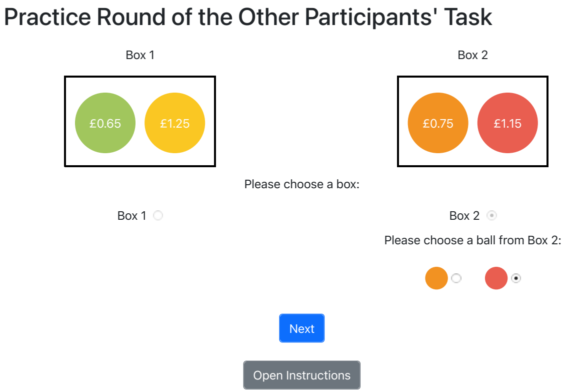
Back to simple choice problems...

Experimental framework to study off-path beliefs

- Elicit beliefs about choices at terminal info set
- Compare to beliefs about choices same info set when on-path vs off-path

1. Elicited choices first (experiment 1)
2. Elicit beliefs (experiment 2)
   - Explain other's task (practice)
   - Elicit beliefs

Simple Choice Problems: Gonçalves, Kneeland, and Ziegler (2025)



Simple Choice Problems: Gonçalves, Kneeland, and Ziegler (2025)

Practice Round of the Other Participants' Task

Box 1 | Box 2

In the practice round, you chose Box 2 and the ● ball.

If this were a paid round and the other participant had made this choice, they would be paid a bonus of £1.15.

Click 'Next' to see your instructions for this study.

Next

Simple Choice Problems: Gonçalves, Kneeland, and Ziegler (2025)

Round 6 out of 36

Box

£1.05 £0.95

What do you think is the probability that the other participant chose:

55 % 45 %

Next

Other Participants' Instructions | Your Instructions

Simple Choice Problems: Gonçalves, Kneeland, and Ziegler (2025)

Round 10 out of 36

Box 1

£2.15 £0.95

You predicted the following probabilities of the other participant choosing Box 1:

5.0 %

Suppose you've been matched with one of the other participants who chose Box 1.

What do you think is the probability that the other participant chose:

80 % 20 %

Box 2

£1.55 £0.95

You predicted the following probabilities of the other participant choosing Box 2:

95.0 %

Suppose you've been matched with one of the other participants who chose Box 2.

What do you think is the probability that the other participant chose:

50 % 50 %

Next

Other Participants' Instructions

Your Instructions

Simple Choice Problems: Gonçalves, Kneeland, and Ziegler (2025)

Careful construction of boxes

Box = (Min, Max) = (Min, Min + Spread)

Min = £0.45, £0.95, £1.35

Spread = £0.10, £0.60, £1.20

All combinations: 9 boxes; All pairwise combinations: 45 pairs

Two parts

Part 1: 9 rounds, one for each box, random order

Part 2: 27 rounds, random subset of pairs of boxes

1 round randomly selected for payment

Beliefs:

BSR £3 vs 0 + £3 completion

225 participants on Prolific. Avg pay £5.70; Median duration 17min

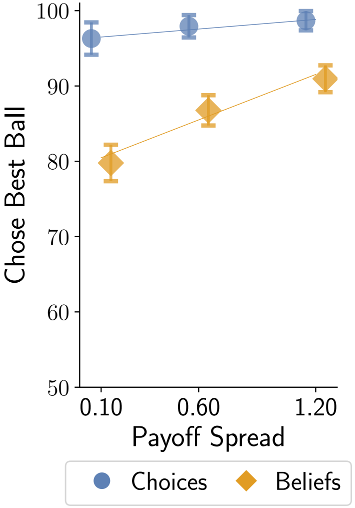
More Indifferent $\implies$ More Mistakes: Gonçalves, Kneeland, and Ziegler (2025)

+ Spread

$\implies$ Less indifferent

$\implies$ (Believe) Fewer mistakes.

Overpredict noise and sensitivity to relative incentives.

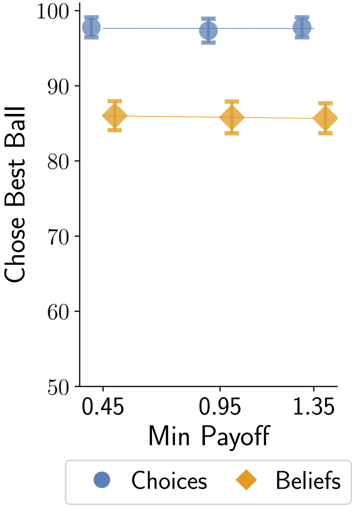


(Figs: 95% CI with clustered se's at participant level)

Level Shifts Don't Matter: Gonçalves, Kneeland, and Ziegler (2025)

No effect of min

- i.e., adding a constant has no effect.



Choosing Off-Path: Gonçalves, Kneeland, and Ziegler (2025)

Larger difference in max payoff

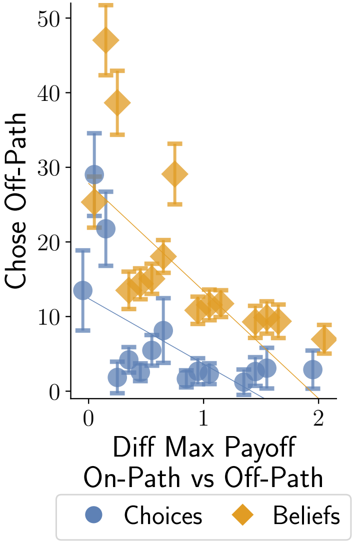
$\implies$ Off-Path worse

$\implies$ Less indifferent

$\implies$ (Believe) Fewer mistakes/off-path choices

Overpredict noise and sensitivity to relative incentives.

(On avg off-path <6%)



Choosing Off-Path: Gonçalves, Kneeland, and Ziegler (2025)

Smaller difference in min payoff

$\implies$ Off-Path relatively safer

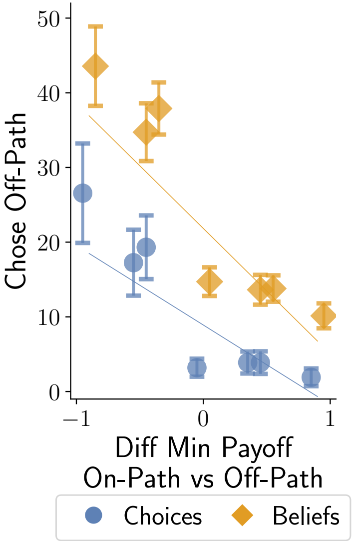
$\implies$ (Believe) Fewer mistakes/off-path choices

Difference in min negative

$\implies$ Off-Path min > On-Path min

(by definition, Off-Path max < On-Path max)

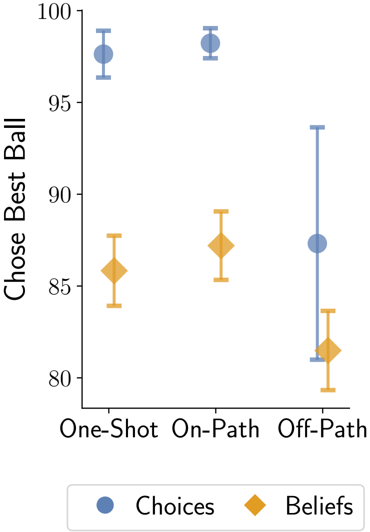
(Believe in others') sophistication regarding their own self-control?



Mistakes Predict Further Mistakes: Gonçalves, Kneeland, and Ziegler (2025)

Underlying heterogeneity in mistake propensity.

Significantly underinfer from mistake.



Relative Incentives and Beliefs: Matching Pennies Games

Matching Pennies Games: Friedman and Ward (2025)

		Player 2	
		L	**R**
Player 1	**U**	X, 0	0, 20
	D	0, 20	20, 0

Treatment	Player 1-subjects	Player 2-subjects	Total
[A,BA]	54	56	110
[A,A]	27	27	54
Total	81	83	164

Table 2: *Subjects in each treatment*

Procedures:

164 undergrad students at Columbia U.

Part 1: 20 rounds, only elicit actions.

Part 2: 40 rounds, only elicit actions or both beliefs and actions, sequentially; matched with random part 1 participant.

Within-participant treatments: $X = 1, 2, 5, 10, 40, 80$.
Twice in part 1 and 5x in part 2.
Also include other 2x2 dominance solvable games.

Roles fixed throughout, no feedback. Randomised order of games.

Points = prob. bonus. Beliefs use BDM. Pay 5 random rounds.

Will use a mix of different working papers as reporting has changed.

Matching Pennies Games: Friedman and Ward (2025)

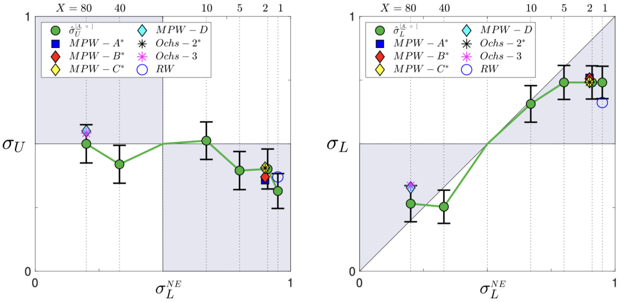


Figure 2: *Actions data.* This figure plots the first-stage empirical frequencies from [$\underline{A}$, $\circ$] with 90% confidence bands (clustered by subject), superimposed with the empirical frequencies from other studies.

Own and opp. payoff effects, though with weird X = **40** violations.

Matching Pennies Games: Friedman and Ward (2025)

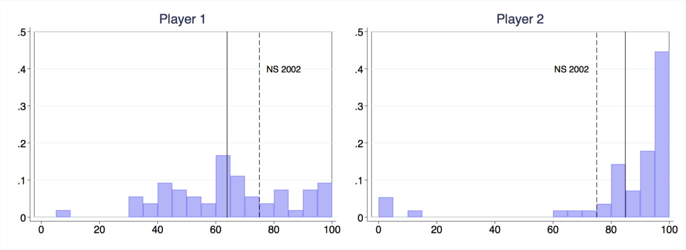


Figure 5: *Subjects' rates of best response.* This figure gives histograms of subjects' rates of best response across all X-games. The solid lines are averages, and the dashed lines are set at 75%, the average best response rate from Nyarko and Schotter [2002].

Moderate BR rate for P1 (asymmetric payoffs): 64%; high for P2 (sym payoffs): 85%.

Considerable heterogeneity in BR rate for P1; not so much for P2.

Suggestive evidence that belief elicitation mitigates P1's own payoff effect.

Matching Pennies Games: Friedman and Ward (2025)

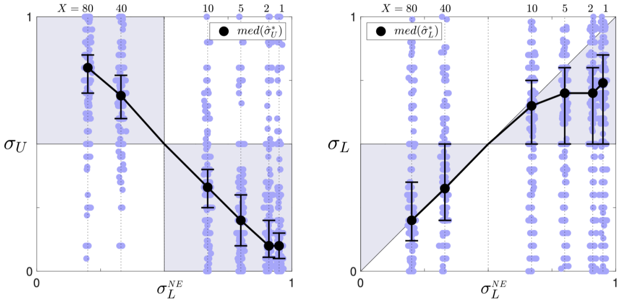


Figure 3: *Beliefs data.* This figure plots individual belief statements along with the median and quartiles of beliefs. The left panel gives player 2's beliefs over σ_U, and the right panel gives player 1's beliefs over σ_L.

Beliefs shift in FOSD sense with relative incentives in direction of own/opp. payoff effect.

Matching Pennies Games: Friedman and Ward (2025)

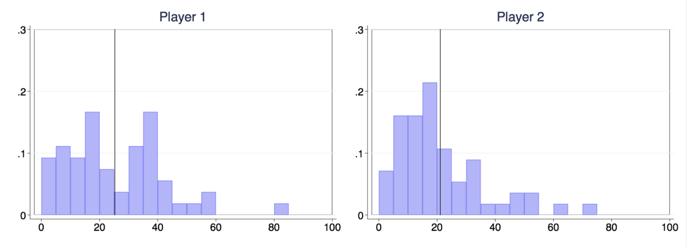


Figure 7: *Subjects' spreads of beliefs.* This figure gives histograms of subjects' spreads of beliefs, averaged across all X-games.

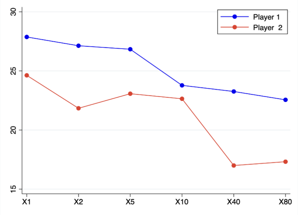


Figure 8: *Average spread of beliefs by game and player role.* We plot the average spread in subjects' beliefs for each game and player role.

Individual-level randomness in beliefs.

Matching Pennies Games: Friedman and Ward (2025)

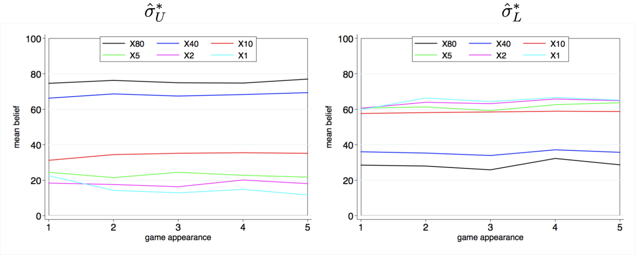


Figure 7: *Stability of average beliefs throughout the experiment.* For each game and player role, this figure plots average stated beliefs for each of five appearances of the game throughout the experiment.

Individual-level randomness in beliefs. Not due to learning.

Matching Pennies Games: Friedman and Ward (2025)

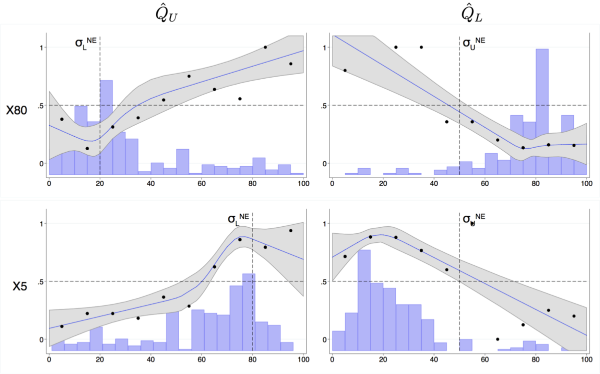
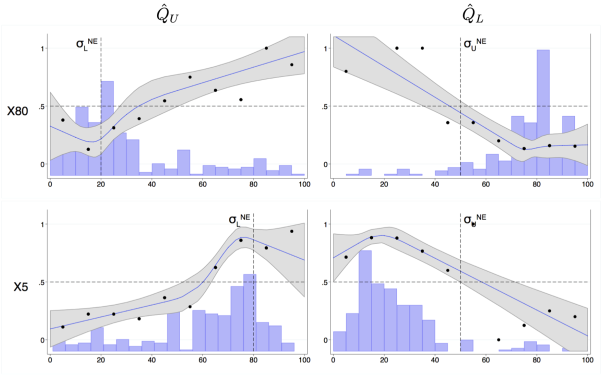


Figure 8: *Action frequencies predicted by beliefs.* For each player and games $X80$ and $X5$, we plot the predicted values (with 90% error bands) from restricted cubic spline regressions of actions on beliefs (4 knots at belief quintiles, standard errors clustered by subject). Belief histograms appear in gray and the average action within each of ten equally spaced bins appear as black dots. The vertical dashed line is the indifferent belief $\sigma_j' = \sigma_j^{NE}$, and the horizontal line is set to one-half.

Responsivenesss: more extreme beliefs $\iff$ more extreme subjective expected payoff differences $\implies$ more extreme play.

Tends to be satisfied.

Matching Pennies Games: Friedman and Ward (2025)



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Subjective monotonicity: Should play subjectively better strategy more often than not.

Typically holds for P2 (sym) and fails for P1 (asym).

Matching Pennies Games: Friedman and Ward (2025)

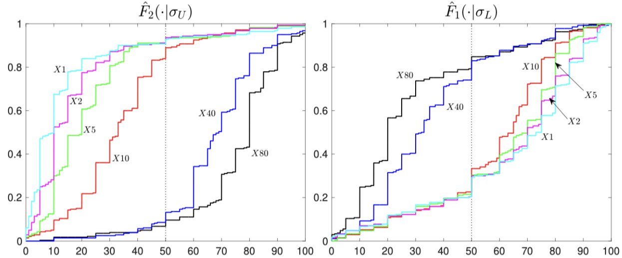


Figure 10: *CDFs of belief-distributions.* We plot the empirical CDFs of belief-distributions. The left panel is for player 2's beliefs over σ_U, and the right panel is for player 1's beliefs over σ_L.

Belief Responsiveness: Beliefs shift in FOSD sense with relative incentives in direction of own/opp. payoff effect.

Matching Pennies Games: Friedman and Ward (2025)

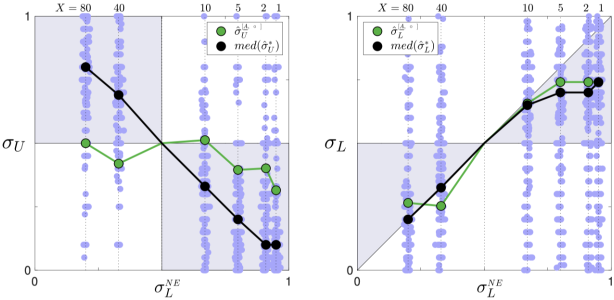


Figure 11: *Bias in beliefs.* The left panel gives player 1's action frequency $\hat{\sigma}_U$ from $[\underline{A}, \circ]$ and the median of player 2's beliefs over σ_U. The right panel gives player 2's action frequency $\hat{\sigma}_L$ from $[\underline{A}, \circ]$ and the median of player 1's beliefs over σ_L. Blue circles are individual belief statements.

Belief Bias: quite significant from P2, but not so much for P1.

Matching Pennies Games: Friedman and Ward (2025)

Some other issues to bear in mind:

Fixed player roles led to different behaviour:

- P1 ascribe higher sophistication to P2 than P2 to P1 (beliefs in dominance solvable games).
- P1 consistently spends longer in reporting beliefs.

Overview

1. Incorportating Choice Mistakes and Costly Reasoning

2. Relative Incentives and Choices

3. Relative Incentives and Beliefs

4. Absolute Incentives and Choices
   - 2x2 Games
     - McKelvey, Palfrey, and Weber (2000 JEBO)
     - Parravano and Poulsen (2015 GEB)
   - Ultimatum Bargaining
     - Slonim and Roth (1998 Ecta)
     - Andersen, Ertaç, Gneezy, Hoffman, and List (2011 AER)
   - Centipede Games
     - McKelvey and Palfrey (1992 Ecta)
     - Rapoport, Stein, Parco, and Nicholas (2003 GEB)

5. Absolute Incentives, Choices, and Beliefs

6. Revisiting Questions

Absolute Incentives

Many models silent about scaling effects.

Historically, conjecture that behaviour tends to NE with higher stakes, more sophisticated.

Need: better choices and more accurate beliefs.

Absolute Incentives and Choices: 2x2 Games

Absolute Incentives in Matching Pennies: McKelvey, Palfrey, and Weber (2000 JEBO)

Table 1
Payoff tables for Games A–D

	Game A		Game B		Game C		Game D	
	L	R	L	R	L	R	L	R
U	9,0	0,1	9,0	0,4	36,0	0,4	4,0	0,1
D	0,1	1,0	0,4	1,0	0,4	4,0	0,1	1,0

Table 4
Summary of results and estimates for all games

Game	$\hat{p}$	p	$\hat{q}$	q	λ	λ_{LO}	λ_{HI}	QRE	NASH	RAND
A	0.690	0.643	0.115	0.241	5.38	4.73	6.25	−2286.1	−2388.7	−2495.3
B	0.711	0.630	0.220	0.244	0.75	0.64	0.89	−1478.0	−1602.0	−1663.5
C	0.635	0.594	0.107	0.257	1.97	1.58	2.63	−1603.8	−1634.9	−1663.5
D	0.590	0.550	0.210	0.328	7.33	4.41	18.13	−817.3	−822.9	−831.8

Absolute Incentives:

A, B, C: NE (1/2, 1/10).

Scale up col (A $\rightarrow$ B): row closer to NE by 1.5pp, col farther from NE by 0.3pp.

Scale up both (A $\rightarrow$ C): row closer to NE by 5pp***, col farther from NE by 2pp.

Scale up row (B $\rightarrow$ C): row closer to NE by 3.5pp*, col farther from NE by 1.5pp.

Absolute Incentives in Coordination Games: Parravano and Poulsen (2015 GEB)

Table 2
Experimental treatments.

Treatment	P1	P2		Mixed strategy Nash equilibria		
		A	B	p	q	Coord. rates
Symmetric Low (SL)	A	£0.5, £0.5	£0, £0	0.5000	0.5000	50.0%
	B	£0, £0	£0.5, £0.5			
Symmetric Medium (SM)	A	£5, £5	£0, £0	0.5000	0.5000	50.0%
	B	£0, £0	£5, £5			
Symmetric High (SH)	A	£15, £15	£0, £0	0.5000	0.5000	50.0%
	B	£0, £0	£15, £15			
Asymmetric Low (AL)	A	£0.5, £0.6	£0, £0	0.4545	0.5455	49.6%
	B	£0, £0	£0.6, £0.5			
Asymmetric Medium (AM)	A	£5, £6	£0, £0	0.4545	0.5455	49.6%
	B	£0, £0	£6, £5			
Asymmetric High (AH)	A	£15, £18	£0, £0	0.4545	0.5455	49.6%
	B	£0, £0	£18, £15			

Note: p = probability that P1 plays A, q = probability that P2 plays A.

Procedures:

1 treatment per participant, one round only.

288 students Uni East Anglia, 48 per treatment.

participants received a brown envelope containing two pieces of paper. Each piece of paper was labeled with a letter (A or B) and the monetary reward that each participant would get if he or she and the co-participant chose the same piece of paper.

What do you think happened?

Absolute Incentives in Coordination Games: Parravano and Poulsen (2015 GEB)

Table 3
Results.

	Symmetric Low (SL)	Symmetric Medium (SM)	Symmetric High (SH)	Asymmetric Low (AL)	Asymmetric Medium (AM)	Asymmetric High (AH)
Payoffs for coordinating on "A"	£0.5, £ 0.5	£5, £5	£15, £15	£0.5, £ 0.6	£5, £6	£15, £18
Payoffs for coordinating on "B"	£0.5, £ 0.5	£5, £5	£15, £15	£0.6, £ 0.5	£6, £5	£18, £15
N	48 P1s and P2s	48 P1s and P2s	48 P1s and P2s	24 P1s 24 P2s	24 P1s 24 P2s	24 P1s 24 P2s
N choosing "A"	41(85.4%) P1s and P2s	40(83.3%) P1s and P2s	47(97.9%) P1s and P2s	13(54.2%) P1s 11(45.8%) P2s	12(50%) P1s 10(41.7%) P2s	11(45.8%) P1s 13(54.2%) P2s
Expected coordination rates	74.6%	71.6%	95.8%	49.7%	50.0%	49.7%
Mixed strategy Nash equilibria coordination rates	50.0%	50.0%	50.0%	49.6%	49.6%	49.6%

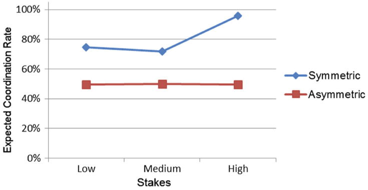


Fig. 1. Expected coordination rates.

Higher stakes have no effect on coordination rates in asymmetric games, but significantly increase coordination on focal point.

Absolute Incentives and Choices: Ultimatum Bargaining

Ultimatum Bargaining

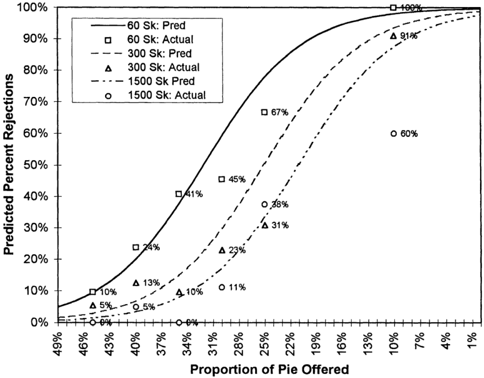
Lots of evidence on ultimatum bargaining.

- Straub and Murnighan (1995 JEBO) little difference USD 5 to 100
- Hoffman, McCabe, and Smith (1996 IJGT) no significant difference offers or rejection between USD 10 and 100.
- Cameron (1995) no difference in proposer or responder behaviour when stakes changed from 5k to 200k Indonesian Rupiahs.

Ultimatum Bargaining: Slonim and Roth (1998 Ecta)

2.5/12.5/62.5h of avg monthly wage in Slovakia; 10 rounds + feedback. No stat. sign. diff. in 1st round.

Higher stakes + experience $\implies$ lower offers and lower rejection of low offers.



Actual Rejection Rates:

		Offer Ranges					
		450 -495	400 -445	350 -395	300 -345	250 -295	0 -245
Pie Sizes	60	9.62%	23.73%	40.74%	45.45%	66.67%	100.00%
	300	5.33%	12.50%	9.68%	22.86%	30.77%	90.91%
	1500	0.00%	4.94%	0.00%	11.11%	37.50%	60.00%

FIGURE 2.—Rejection predictions (from regession model 4).

Ultimatum Bargaining: Andersen, Ertaç, Gneezy, Hoffman, and List (2011 AER)

Villages in India. Vary from low to absurdly high incentives.

One shot play.

Findings:

- Higher stakes $\implies$ Lower shares offered, but higher amounts.
- Rejection rates go down significantly with stakes.
- Unclear how much rejection depends on share vs amount offered.

Ultimatum Bargaining: Andersen, Ertaç, Gneezy, Hoffman, and List (2011 AER)

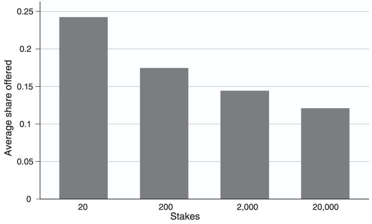


Figure 1. Offer Proportion across Stakes

Notes: Figure shows average proportion of the stakes offered to the responder. Stakes represents our four stakes treatments of 20, 200, 2,000, and 20,000 rupees to be shared in the ultimatum game.

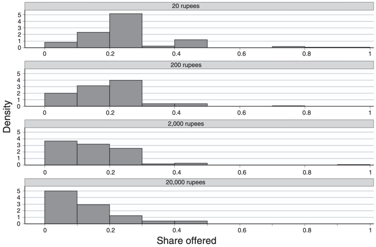


Figure 2. Offer Distribution across Stakes

Notes: Figure shows the distribution of the pie offered to the responder in each stakes condition. Each graph represents one of our four stakes treatments of 20, 200, 2,000, and 20,000 rupees.

Higher stakes $\rightarrow$ offers FOSD shift toward lower shares.

Ultimatum Bargaining: Andersen, Ertaç, Gneezy, Hoffman, and List (2011 AER)

Table 2—Rejection Rates by Wealth and Stakes (*percent*)

	Rs 20	Rs 200	Rs 2,000	Rs 20,000	All
Wealth	34.68	47.30	33.33	8.33	36.34
	[60]	[35]	[21]	[1]	[117]
No Wealth	46.43	36.00	19.57	0	29.41
	[13]	[18]	[9]	[0]	[40]
All	36.32	42.74	27.52	4.17	34.28
	[73]	[53]	[30]	[1]	[157]

Notes: Figures in the table represent average rejection rates by treatment. Numbers in brackets are the number of actual offers rejected. Subjects in the "Wealth" treatment earned earnings in unrelated tasks before bargaining in the ultimatum game. Subjects in the "No Wealth" treatment participated in only the ultimatum game task. Rs 20, 200, 2,000, and 20,000 represent our four stakes treatments and denote the monetary amount to be bargained over in the ultimatum game.

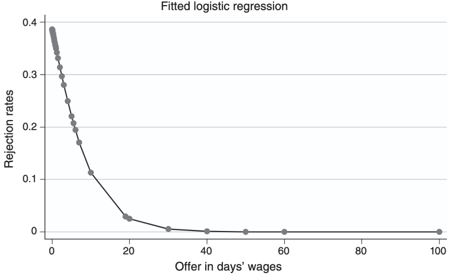


Figure 3. Predicted Rejection Rates (*fitted logistic regression*)

Notes: Figure represents the predicted rejection probabilities, obtained from a logistic regression of rejections on

Ultimatum Bargaining

Lots of evidence on ultimatum bargaining.

Higher stakes $\rightarrow$ fewer rejections, learning to make lower offers.

Significant decrease in offered shares as stakes raised, but not in amounts.

Extremely high stakes among poor populations (moral issues?).

Issues: game itself primes social norms.

Absolute Incentives and Choices: Centipede Games

Centipede Game: McKelvey and Palfrey (1992 Ecta)

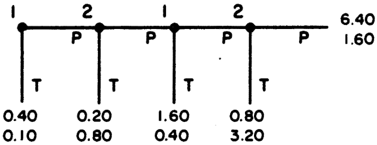


FIGURE 1.—The four move centipede game.

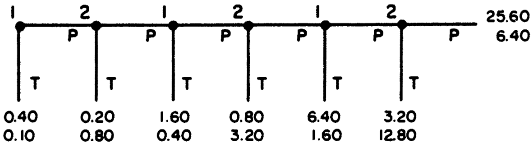


FIGURE 2.—The six move centipede game.

Games:

Passing leads to halving own payoff, multiply other's payoff x8.

Centipede Game: McKelvey and Palfrey (1992 Ecta)

TABLE I

EXPERIMENTAL DESIGN

Session #	Subject pool	# subjects	Games/ subject	Total # games	# moves	High Payoffs
1	PCC	20	10	100	4	No
2	PCC	18	9	81	4	No
3	CIT	20	10	100	4	No
4	CIT	20	10	100	4	Yes
5	CIT	20	10	100	6	No
6	PCC	18	9	81	6	No
7	PCC	20	10	100	6	No

Procedures:

Students Pasadena Community College and Caltech.

Random matching, no repeats.

Pay all. Points = money.

High stakes = x4 increase in payoffs

Centipede Game: McKelvey and Palfrey (1992 Ecta)

TABLE IIA
PROPORTION OF OBSERVATIONS AT EACH TERMINAL NODE

	Session		N	f_1	f_2	f_3	f_4	f_5	f_6	f_7
Four Move	1	(PCC)	100	.06	.26	.44	.20	.04		
	2	(PCC)	81	.10	.38	.40	.11	.01		
	3	(CIT)	100	.06	.43	.28	.14	.09		
	Total	1–3	281	.071	.356	.370	.153	.049		
High Payoff	4	(High-CIT)	100	.150	.370	.320	.110	.050		
Six Move	5	(CIT)	100	.02	.09	.39	.28	.20	.01	.01
	6	(PCC)	81	.00	.02	.04	.46	.35	.11	.02
	7	(PCC)	100	.00	.07	.14	.43	.23	.12	.01
	Total	5–7	281	.007	.064	.199	.384	.253	.078	.014

4x increase in payoffs: distribution of stopping shifts in FOSD sense (stop earlier).

Expected number of periods decreases but small effect: 2.77 $\rightarrow$ 2.54.

Centipede Game: Rapoport, Stein, Parco, and Nicholas (2003 GEB)

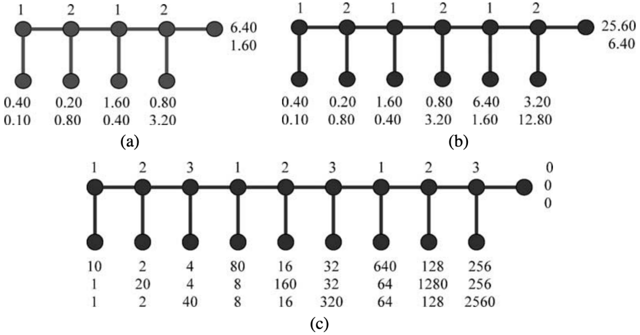


Fig. 1. Three different two- and three-person centipede games in extensive form.

Game: Passing divides by 5 own payoff, multiplies by 20 next player's payoff, multiplies by 2 other player's payoff.

Procedures:

120 undergrad students from U Arizona, strategy and business statistics.

Payoffs in dollars (experiment 1) vs cents (experiment 2).

60 rounds, random role assignment. Pay three at random.

Feedback: see own earnings and outcomes each round.

Centipede Game: Rapoport, Stein, Parco, and Nicholas (2003 GEB)

Table 1
Number and proportion of games ending at each endnode by experiment

Experiment 1		Endnode j									
Session		1	2	3	4	5	6	7	8	9	Total
1	no.	139	95	33	15	8	6	3	1	0	300
	prop.	0.463	0.317	0.110	0.050	0.027	0.020	0.010	0.003	0	1.00
2	no.	118	83	47	26	9	5	7	4	1	300
	prop.	0.393	0.277	0.157	0.087	0.030	0.017	0.023	0.013	0.003	1.00
3	no.	91	84	56	28	16	11	3	1	10	300
	prop.	0.303	0.280	0.187	0.093	0.053	0.037	0.010	0.003	0.033	1.00
4	no.	122	77	55	23	11	5	4	1	2	300
	prop.	0.407	0.257	0.183	0.077	0.037	0.017	0.013	0.003	0.007	1.00
Total	no.	470	339	191	92	44	27	17	7	13	1200
	prop.	0.392	0.283	0.159	0.077	0.037	0.023	0.014	0.006	0.010	1.00

Experiment 2		Endnode j									
Session		1	2	3	4	5	6	7	8	9	Total
1	no.	8	13	28	72	79	68	22	5	4	299
	prop.	0.027	0.043	0.093	0.240	0.263	0.227	0.073	0.017	0.013	0.997
2	no.	7	20	75	73	79	29	11	2	4	300
	prop.	0.023	0.067	0.250	0.243	0.263	0.097	0.037	0.007	0.013	1.00
3	no.	4	7	1	8	53	79	83	37	17	299
	prop.	0.013	0.023	0.037	0.027	0.177	0.263	0.277	0.123	0.057	0.997
4	no.	12	1	4	7	60	98	82	24	11	299
	prop.	0.040	0.003	0.013	0.023	0.200	0.327	0.273	0.080	0.037	0.997
Total	no.	31	41	118	160	271	274	198	68	36	1197
	prop.	0.026	0.034	0.098	0.133	0.226	0.228	0.165	0.057	0.030	0.997

Massive FOSD shift in stopping due to scaling up payoffs.

Centipede Game: Rapoport, Stein, Parco, and Nicholas (2003 GEB)

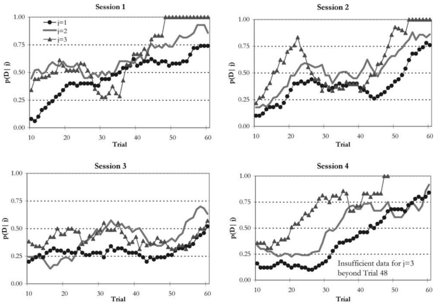


Fig. 2. Arithmetic moving averages of the observed conditional probabilities of moving Down on decision node j ($j = 1, 2, 3$) across players by session in Experiment 1.

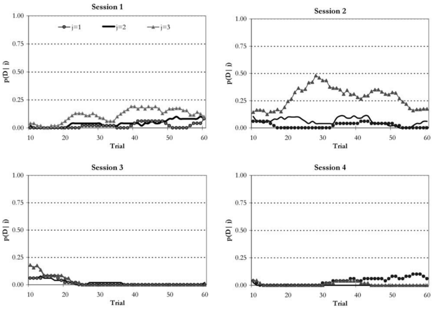


Fig. 8. Arithmetic moving averages of the observed conditional probabilities of moving Down on decision node j ($j = 1, 2, 3$) across players by session in Experiment 2.

Lots of learning/adjustment with high stakes; minimal learning with low stakes.

Overview

Absolute Incentives, Choices, and Beliefs

- Little evidence on effects of absolute incentives on strategic behaviour at large (choices, beliefs, response time, etc).
- Want to disentangle effects on individual behaviour from equilibrium effects.
- Focus on Esteban-Casanelles and Gonçalves (2026).

Absolute Incentives, Choices, and Beliefs

Esteban-Casanelles and Gonçalves (2026):

Experimental Design

Identification Strategy

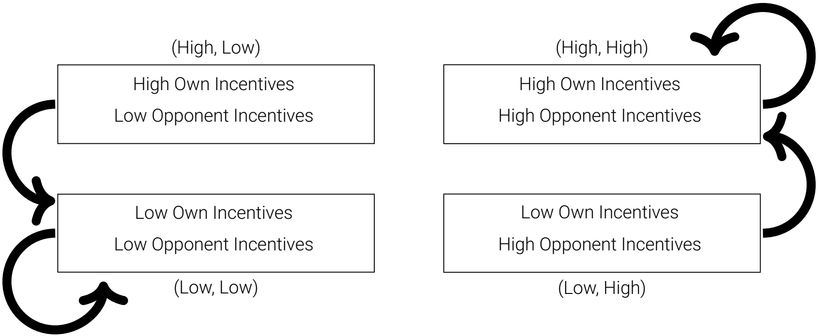
Changing player's incentive level: potentially **conflated effects on observed behaviour**.

- **Direct effect** on the player: beliefs, choices, effort.
- **Indirect effect** due to opponent: form beliefs and react to different event.
- $\Rightarrow$ Disentangle effects by **holding fixed opponent's behaviour**.

Identification relies on two elements:

- **Random allocation** of incentive treatment;
- **Matching protocol**.

Identification Strategy



Randomly assign participants to group determining own and opponent's incentives:

- **(High, High) or (Low, Low)** $\Rightarrow$ matched *within group*.
- **(High, Low) or (Low, High)** $\Rightarrow$ match with opponent in *group with same incentives*.

Player's action doesn't affect opponent's payoff $\sim$ replacement/observer method.

Huck and Weizsäcker (2002 JEBO), Alaoui and Penta (2016 REStud).

Fix higher-order beliefs about incentives (of opponent's opponent, etc).

Games

Actions		Player 2: 1	2	3	4
Player 1	1	40, 40	70, 30	80, 20	10, 10
	2	30, 70	40, 40	70, 30	80, 20
	3	20, 80	30, 70	40, 40	70, 30
	4	10, 10	20, 80	30, 70	40, 40

(a) 2 Steps

Actions		Player 2: 1	2	3	4
Player 1	1	40, 40	70, 30	10, 20	10, 10
	2	30, 70	40, 40	70, 30	10, 20
	3	20, 10	30, 70	40, 40	70, 30
	4	10, 10	20, 10	30, 70	40, 40

(b) 3 Steps

Dominance-solvable games with similar payoffs

- Vary number steps iterated deletion of strictly dominated strategies (IDS).

Strategic Sophistication

- a is more **strategically sophisticated** than a' if a survives more rounds IDS than a', or a iterated strictly dominates a'.
- Actions are **ranked**: a_n is more strategically sophisticated than a_{n+1}.

Level-k actions are pinned-down (regardless of risk-aversion).

Payoffs and payoff structure **minimises coordination**.

- All payoffs vectors are associated to multiple payoff profiles.
- Dominance solution is neither Pareto dominant nor Pareto dominated.

Design and Logistics

Treatments

- $2\times2\times2$ between-subject design
- Own Incentives H or L $\times$ Opponent's Incentives H or L $\times$ IDS 2 or 3.
- Subjects assigned to treatment uniformly at random.
- Randomly shuffle columns and rows.
- Beliefs about the probability that opponent chooses each action, BQSR.
- **One single round**: one-shot game.
- **High bonus: USD 20.00; Low bonus: USD 0.50**; Fixed completion fee of USD 2.00.

Recruitment

- Amazon MTurk (2020): 834 participants; Prolific (2026): 880 participants. >200 per treatment.
- Patterns consistent across both pools.

Design and Logistics

Protocol

- Instructions + comprehension questions.
- Captcha check to control for bots (subjects warned in advance).
- Two practice rounds to get familiar with interface
  (game with dominant action and game with unique NE, in fully mixed strategies).
- Own and Opponent's incentives revealed.
- Game presented and choice and beliefs simultaneously elicited.
- Brief questionnaire on sociodemographics: age, education level and field.

Absolute Incentives, Choices, and Beliefs

Esteban-Casanelles and Gonçalves (2026):

Incentives and Choice Sophistication

Defining Key Concepts

Incentive Levels **Sophistication** **Cognitive Effort**

More sophisticated actions $\equiv$ **higher order *k*-rationalisability**

$a_1 > a_2 > a_3 > a_4$.

Scale up payoffs of the game to increase incentive levels .

Leaves *k*-rationalisability unaffected.

3 IDS game **more complex** than 2 IDS game.

Use **response times** as a proxy for cognitive effort.

Hypotheses: Incentives and Choice Sophistication

$\uparrow$ Incentives $\Rightarrow$ No effect in relative incentives, rationalisability of actions

$\uparrow$ Incentives $\nrightarrow$ Choices   Nash eqm, level-*k*, cognitive hierarchy

$\uparrow$ Incentives $\Rightarrow$ $\downarrow$ Mistakes, $\uparrow$ Cognitive Effort $\Rightarrow$ $\uparrow$ Action Sophistication

$\uparrow$ Incentives $\rightarrow$ $\uparrow$ Sophistication   LQRE, endog depth reasoning, seq sampling eqm

Hypothesis 1

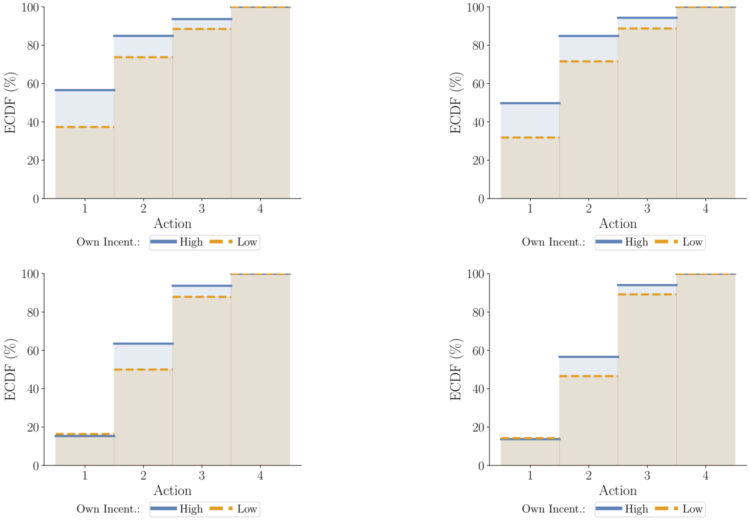
Action sophistication increases in incentive level

Results: Incentives and Choice Sophistication

High Opp. Incent. | Low Opp. Incent.

2 Steps

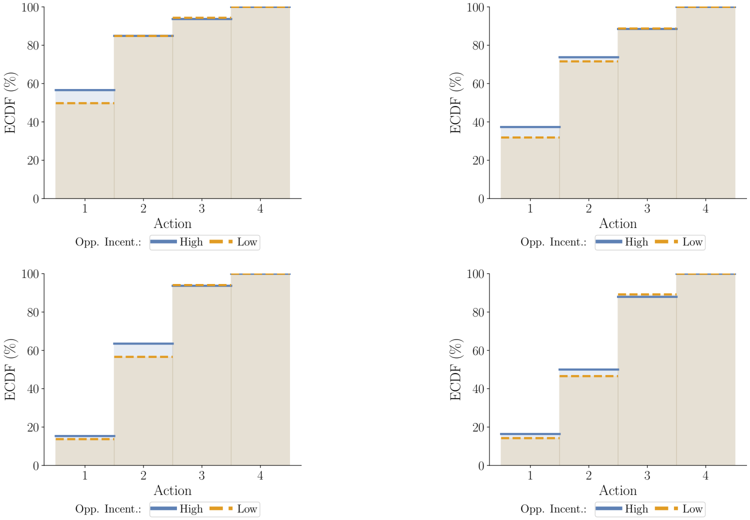
3 Steps



FOSD shift toward higher order rationalisability.

Results: Incentives and Choice Sophistication

High Own Incent. Low Own Incent.



2 Steps

3 Steps

FOSD shift but not significant. More pronounced with high own incentives.

Results: Incentives and Choice Sophistication

$\uparrow$ **Own Incentives** $\Rightarrow$ $\downarrow$ **Freq. Dominated actions**
-12.2pp*** (2IDS)   -5.4pp*** (3IDS).

$\uparrow$ **Own Incentives** $\Rightarrow$ $\uparrow$ **Freq. Dominance play** only in 2IDS
+19.7pp*** (2IDS)   -1.1pp (3IDS).

No significant effect of opponent's incentives.

Mechanisms:

- Control costs: choosing better given beliefs;
- Cognitive costs: forming different/more accurate beliefs.

Absolute Incentives, Choices, and Beliefs

Esteban-Casanelles and Gonçalves (2026):

Incentives and Mistakes

Hypotheses: Incentives and Mistakes

Existing models have **different predictions** on how incentive level affects behaviour.

Payoff-Dependent Mistakes/Control Costs:

Actions with higher expected payoff are chosen more often   LQRE, APU

$\uparrow$ Incentives $\Rightarrow$ $\downarrow$ Mistakes

Mistakes more costly $\rightarrow$ Less likely to choose suboptimal actions

Hypothesis 2

(a) Best-response rates increase in own incentive level, and (b) Actions with higher expected payoff are chosen more often.

Results: Incentives and Mistakes

Assessing Hypothesis 2

Best-response rates using freq. of play (objective) and stated beliefs (subjective)

$\uparrow$ Own Incentives $\implies$ $\uparrow$ Subjective Best Response Rate.

+20.8pp*** (2IDS) +15.8pp*** (3IDS).

Also increase in objective best-response rate (lower effect)

$\Rightarrow$ **Support for H2(a)**.

Participants choose actions with higher subjective payoff more often.

But violations of monotonicity with objective payoff.

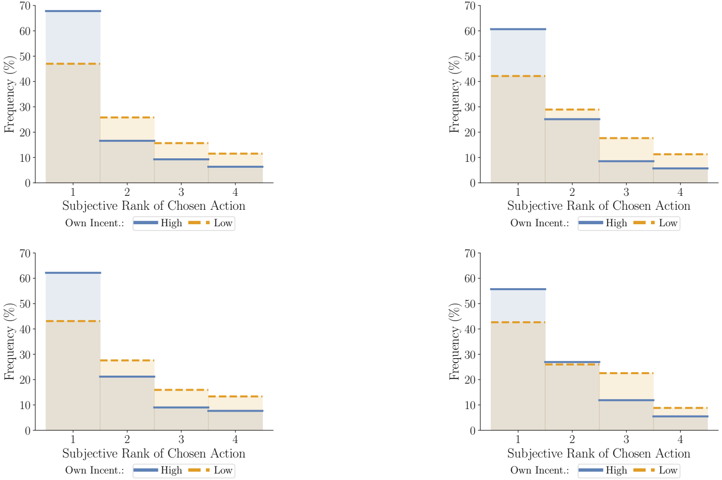
$\Rightarrow$ **Support for H2(b)** using stated beliefs.

Results: Incentives and Mistakes

High Opp. Incent. | Low Opp. Incent.

2 Steps

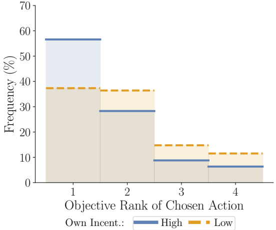
3 Steps

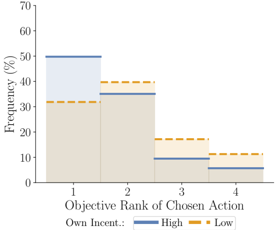


Subjective monotonicity holds. FOSD shift with higher own incentives.

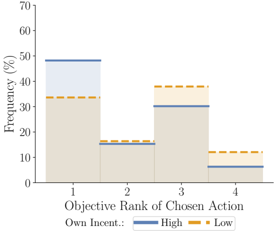
Results: Incentives and Mistakes

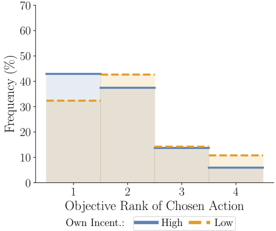
High Opp. Incent. | Low Opp. Incent.





2 Steps





3 Steps

Objective monotonicity does not hold!

Absolute Incentives, Choices, and Beliefs

Esteban-Casanelles and Gonçalves (2026):

Incentives, Beliefs, and Strategic Reasoning

Hypotheses: Incentives and Beliefs

Existing models have **different predictions** on how incentive level affects behaviour

Cognitive Costs

Beliefs about opponent could explain deviations

$\uparrow$ Incentives $\Rightarrow$ $\uparrow$ Sophisticated Choices

$\uparrow$ Opponent Incentives $\Rightarrow$ $\uparrow$ Belief Opponent Sophistication

$\uparrow$ Own Incentives $\Rightarrow$ $\uparrow$ Cognitive Effort $\Rightarrow$ More Accurate Beliefs
Belief in opponent sophistication may depend on opponent incentives

Hypothesis 3

(a) Belief in opponent's sophistication increases in incentive levels, and (b) beliefs are more accurate with higher own incentives

Results: Incentives, Beliefs, and Strategic Reasoning

$\uparrow$ **Own Incentives** $\Rightarrow$ $\downarrow$ **Belief in Dominated actions**

-7.7pp*** (2IDS) -2.5pp** (3IDS).

$\Rightarrow$ $\uparrow$ **Belief in Dominance play** only in 2IDS

+4.7pp*** (2IDS) -1.8pp (3IDS).

$\Rightarrow$ **FOSD shift** towards more sophisticated beliefs; magnitude limited.

Effects more expressive when opponent's incentives are higher and game simpler.

Beliefs less uniform when opponents have higher incentives.

Low incentive opponent: (correctly) predict plays randomly.

$\uparrow$ **Opp. Incentives** $\Rightarrow$ $\downarrow$ **Belief in Dominated actions**

-3.7pp** (2IDS) -1.8pp* (3IDS).

$\Rightarrow$ **Support for H3(a)**.

Results: Incentives, Beliefs, and Strategic Reasoning

	|Belief - Opponent Action Frequency|				|Subj. EU - Obj. EU|	
	Dominance Play		Dominated Play			
	2 Steps	3 Steps	2 Steps	3 Steps	2 Steps	3 Steps
Own Incent.	-1.82*	-0.66	-5.35***	-1.75**	-4.89***	-1.81*
	(0.85)	(0.73)	(0.89)	(0.64)	(0.91)	(0.82)
Opp. Incent.	16.37***	-1.07	5.74***	1.49*	8.75***	6.09***
	(0.85)	(0.74)	(0.87)	(0.64)	(0.90)	(0.82)
Intercept	16.80**	14.97*	12.39**	10.83*	21.86***	19.19***
	(5.15)	(6.02)	(4.50)	(5.15)	(5.82)	(1.84)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.33	0.03	0.13	0.04	0.16	0.09
N	837	877	837	877	837	877

Heterocedasticity-robust standard errors in parentheses.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

$\uparrow$ **Own Incentives** $\Rightarrow \downarrow$ **Bias** wrt opponent action frequency and expected payoffs.

$\uparrow$ **Opponent Incentives** $\Rightarrow \uparrow$ **Bias**: actions become harder to predict.

$\Rightarrow$ **Support for H3(b)**.

Absolute Incentives, Choices, and Beliefs

Esteban-Casanelles and Gonçalves (2026):

Incentives, Response Times, and Strategic Behaviour

Hypotheses: Incentives and Cognitive Effort

It's unlikely we'll have time to talk much about time this year, so here's a teaser...

$\uparrow$ **Incentives** $\Rightarrow \uparrow$ **Cognitive Effort** $\Rightarrow \uparrow$ **Better choices**.

Use response times to proxy for effort.

Hypothesis 4

(a) Response time increases in own incentive level, and (b) expected payoff increases with response time

Incentives and Response Times

$\uparrow$ **Own Incentives** $\Rightarrow \uparrow$ **Response Time** $\approx +40\%$

$\uparrow$ **Own Incentives** $\Rightarrow \uparrow$ **RT** $\Rightarrow \uparrow$ **Best Response rate**

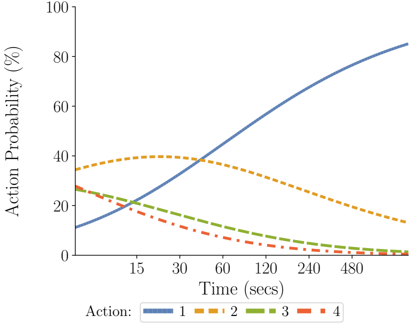
$\Rightarrow \uparrow$ **(objetive) Expected Payoff**

Exploratory Analysis

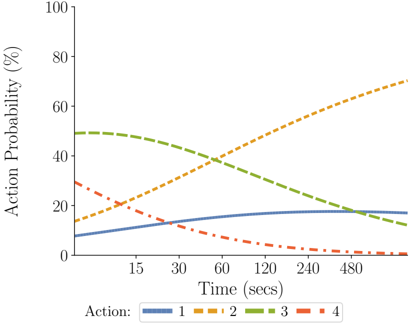
MnLogit estimation impact of RT on choice freq.

NP kernel density estimation of beliefs conditional on RT.

Response Times and Action Sophistication



(a) 2 Steps



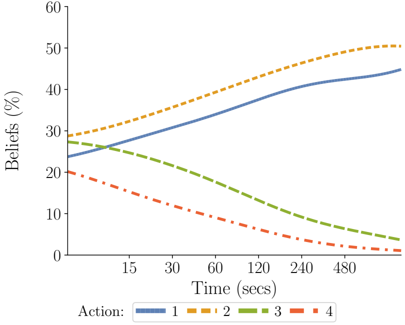
(b) 3 Steps

Action Frequency:

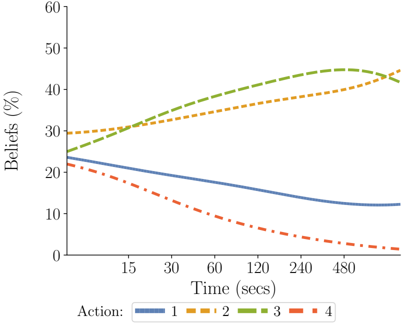
$\uparrow$ **RT** $\Rightarrow$ $\downarrow$ dominated actions, $\downarrow$ L1 action, $\uparrow$ L2 action, limited effect L3 action

Also: recover patterns by fitting SSE to data.

Response Times and Belief Sophistication



(a) 2 Steps



(b) 3 Steps

Action Frequency:

↑ **RT** ⇒ ↓ dominated actions, ↓ L1 action, ↑ L2 action, limited effect L3 action

Beliefs:

↑ **RT** ⇒ ↓ dominated actions, ↑ L1 action, ↑ L2 action, ↓ L3 action

Support for sequential reasoning models.

Absolute Incentives, Choices, and Beliefs

Esteban-Casanelles and Gonçalves (2026):

Takeaways

Takeaways

Identify effects of changing incentive levels in strategic settings.

Own incentives affect mistake propensity and cognitive effort.

Higher own incentives shift beliefs towards greater accuracy.

Higher opponent incentives makes them harder to predict

$\Rightarrow$ Beliefs become more biased.

Higher incentives $\Rightarrow$ **longer response times** $\Rightarrow$ **greater strategic sophistication of choices and beliefs**.

Support for models incorporating both control costs and cognitive costs.

Overview

Revisiting Questions

Are choices explained by beliefs about others?

- Choices and stated beliefs largely but not perfectly consistent.
- Higher incentives increase best-response rates.

Do incentives affect beliefs?

- What about strategic setting itself? I.e., own/other payoffs to actions?
  What kinds of patterns should we expect to be robust?
  Beliefs tend to track opponents.
- Higher incentives also tend to lead to more accurate beliefs.

Do relative incentives affect choices? What kinds of patterns should we expect to be robust? Higher action payoffs $\implies$ higher frequency?

- Yes, relative incentives affect choices a lot!
- Increasing payoffs to a strategy seems to lead people to choose it more often.
- Level shifts seem to matter much less than distorting relative incentives or scaling.

Revisiting Questions

How do people think others react to incentives?

- Evidence suggests people anticipate correctly other's reaction to incentives, despite over-predicting others' randomness.

Is time informative about beliefs and choices?

- Yes, quite a bit! Although there's much more to discuss that we haven't managed to.

Anything else comes to mind?

Next Up:

Coding Experiments! Please install:

- Visual Studio Code.

  Extensions: heroku-cli, Jupyter, Live Share, Excel Viewer, Git History, Live Preview.

  Also recommend: LaTeX Workshop (requires installing some LaTeX distribution, e.g., texlive), Markdown PDF, GitHub Copilot Chat.

- Python (3.14).

  Packages: numpy ($\geq$1.26), scipy, pandas($\geq$2.1), statsmodels ($\geq$0.14), random, matplotlib ($\geq$3.8), otree ($\geq$5.10), sympy, numba, lifelines.

- For hosting: Prolific (online), ELFE (in the lab).

Bring your laptop!