Rational Inattention in Games: Experimental Evidence

David Almog [1] and Daniel Martin [1,2]

[1]Kellogg School of Management, Northwestern University
[2]University of California, Santa Barbara

Workshop of Experimental and Behavioral Economics of the Americas
December 5th 2023

Motivation

- **Our question:** Do individuals adjust their attention in response to the strategic decision of others?
- And do they adjust their attention optimally?
  - In other words, are they rationally inattentive in games?
- Why care? Consumers face both attentional constraints and strategic firms in a number of important markets
  - Online retail
  - Trading
  - Health care: pharmaceuticals, health coverage
- Answering these questions with market data is extremely hard

This is why we go to the lab!

What We Do

- We use a laboratory experiment to implement a "buyer-seller" game:
  1. Seller is informed about the product's value
  2. Seller sets a price and offer the buyer a take-it-or-leave-it offer
  3. Buyer is told the price
  4. The buyer does not know the value of the product but
     $\longrightarrow$ Can acquire information by performing a cognitive task
  5. Buyer accepts or rejects the offer
- We study whether buyers exhibit an attentional response as we vary the seller's outside option
  - By varying the seller's outside option, we change their leverage
    - In the world: other available buyers, matching frictions, etc.
  - Changing the seller's leverage should change their pricing strategy

What We Do

- Growing literature on inattention to uncertain states in experimental games (e.g., de Clippel and Rozen, 2021; Spurlino 2022)
- **Novelty in design:** Only change opponent payoffs
  - Allows us to isolate the impact of changes in seller strategies on buyer attention with minimal and natural intervention
  - Issue: Might be too subtle for buyers to pick up
- **Our result:** We do find evidence that buyers adjust their attention to available information in response to changes in seller strategies

"Buyer-Seller" Game

Parameters:

- Two value levels: $V = \mathbf{100}$ or $V = 50$
- Two price levels: $P = \mathbf{50}$ or $P = 25$

Each round:

1. Value drawn (both equally likely)
2. Price determined based on seller's strategy
   - High value ($V = \mathbf{100}$): Automatically a high price ($P = \mathbf{50}$)
   - Low value ($V = 50$): Seller **sets** likelihood of high price ($P = \mathbf{50}$)

   $\longrightarrow$ So this is the rate they "mimic" prices of high value
3. Buyer is informed about the price and has the option to sum 20 numbers to learn the value before they **accept** or **reject**

"Buyer-Seller" Game

Payoffs:

- When the buyer accepts, the buyer gets $V - P$, seller gets P
- When the buyer rejects, both get their outside options

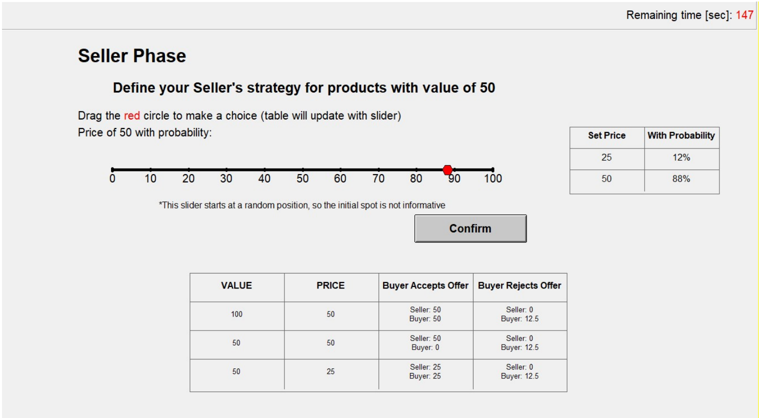
Implications:

- When the price is high ($P = \mathbf{50}$) and value is low ($V = 50$), the buyer should **reject** and take their outside option of 12.5
- Thus, the seller only wants to set a positive probabilty of a high price ($P = \mathbf{50}$) when value is low ($V = 50$) if the buyer is sufficently uncertain about value
- The seller's loss from being caught mimicking high value prices is determined by their outside option, which is either 0 or 20

Experimental Design: Seller Stage

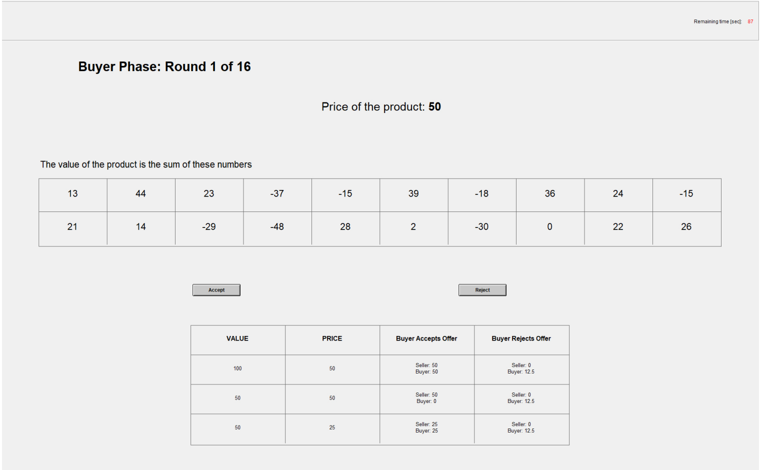
The game was implemented in two stages:

1. **Seller stage:** Disclose contingent (mixed) pricing strategy



Experimental Design: Buyer Stage

2. **Buyer stage:** 16 rounds playing the buyer role



Implementation and Extra Tasks

- 12 in-person sessions with a total of 238 students
- Conducted at WISO Research Laboratory of University of Hamburg
- Average time: 75 minutes, average pay: €23.9
- Comprehension questions:
  - Reading the payoff matrix
  - Basic understanding of a mixed strategy
- Practice session, then set seller pricing strategy
- 16 rounds as buyer with random rematching
- Extra tasks:
  - Elicited beliefs on opponents' average seller strategy
  - Memory test
  - Math test
- Payment from a random round for each role

Treatment Effect

- Low value sellers with higher outside option **increase mimicking**
  - 43.6 % to 55.2 % (p-value 0.0054)
- Buyers believe there is **more mimicking** with higher outside option
  - 50.8 % to 61.8 % (p-value 0.0013)

Beliefs by Treatment Beliefs by Strategy

- Buyers make **fewer mistakes**[1] conditional on state when $P = \mathbf{50}$
  - Accepting when $\theta = \theta_L$: 18.2 % to 13.6 % (p-value 0.19)
  - Rejecting when $\theta = \theta_H$: 23.4 % to 17.8 % (p-value 0.0331)

[1] Using second half of rounds, but holds for entire game

Treatment Effect: Buyer Mistakes

	(1) mistake	(2) mistake	(3) mistake	(4) mistake
Seller's High Outside Option	-0.0528**	-0.0420**	-0.0474**	-0.0474*
	(0.0212)	(0.0213)	(0.0214)	(0.0285)
mathexact=1		-0.141***	-0.134***	-0.134***
		(0.0291)	(0.0293)	(0.0373)
mathexact=2		-0.144***	-0.149***	-0.149***
		(0.0378)	(0.0378)	(0.0340)
mathexact=3		-0.0987	-0.102	-0.102
		(0.0804)	(0.0804)	(0.0724)
mathexact=4		-0.0952	-0.0994	-0.0994
		(0.0732)	(0.0731)	(0.0721)
mathexact=5		-0.119	-0.125	-0.125
		(0.0782)	(0.0782)	(0.101)
Friend			-0.0759*	-0.0759*
			(0.0398)	(0.0399)
clustvar				subject_id
N	1415	1415	1415	1415

Standard errors in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

Sample Statistics | RT and Mistakes | RT by Price | RT by Half | RT by Treatment

Treatment Effect: Attention?

- Does this mean subjects are changing their attention?
- First step: assess the *No Improving Action Switches (NIAS)* condition of Caplin and Martin (2015)
    - This condition tells us if we can model individuals *as if* they are adjusting their attention in response to changes in opponent strategies
- The NIAS condition requires there should be no utility gain from wholesale action switches in either treatment
- NIAS **fails** for the choices we observe, so the answer to our question appears to be "no" – what is going on?

Disutility from Accepting Bad Offers

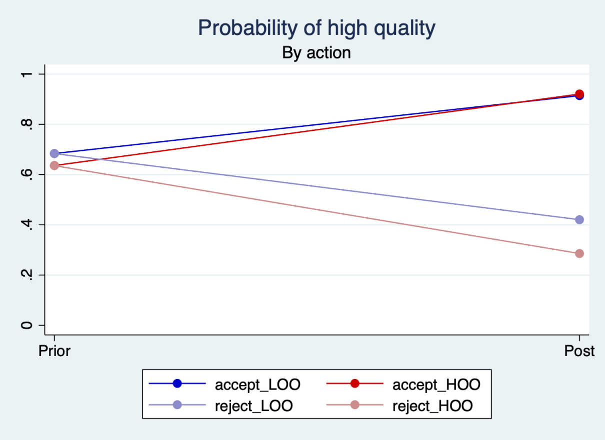
- Evidence from ultimatum games: individuals reject unfair offers
- Rejection of unfair offers holds for the Demand Ultimatum Game with uncertainty in the pie size
  $\longrightarrow$ Mitzkewitz and Nagel (1993); Rapoport, Sundali, and Seale (1996)
- Let define ϕ as the disutility of accepting an unfair offer in terms of probability points
- Using NIAS to partially identify ϕ:

$$-21.25 \geq \phi \geq -289.91937$$

Attentional Change?

- With these estimates of the disutility of accepting unfair offers, NIAS now passes
- This means that we can model individuals as if they are adjusting their attention in response to changes in opponent strategies
- But could the results be explained by no change in attention, just by a change in prior?

Average posteriors at each action are Blackwell-ordered



Results are not driven by a prior shift

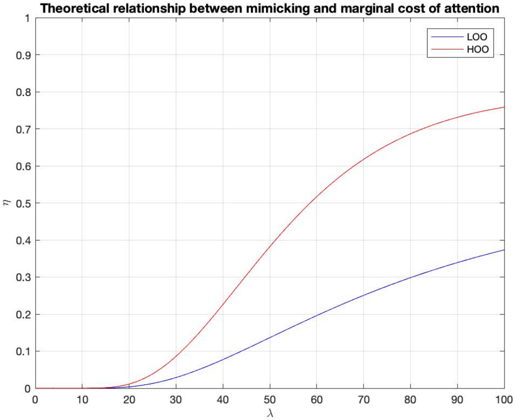
We have an attentional response!

Optimal Attention Adjustment?

- Test whether buyers are adjusting their attention optimally:
  - Rational inattention with Shannon Costs is a natural benchmark
- We follow Martin (2017) theoretical characterization of rational inattention in a "buyer-seller" game

Testing RI w/ SC: Mimicking Rate

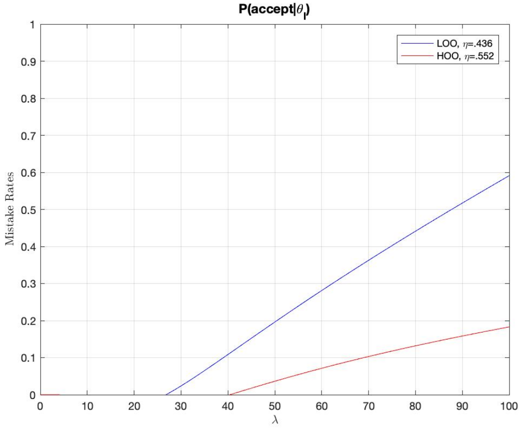
Prediction 1: Mimicking rate increases with higher outside option



43.6 % to 55.2 % ✓

Testing RI w/ SC: Mistakes when Mimicking Increases

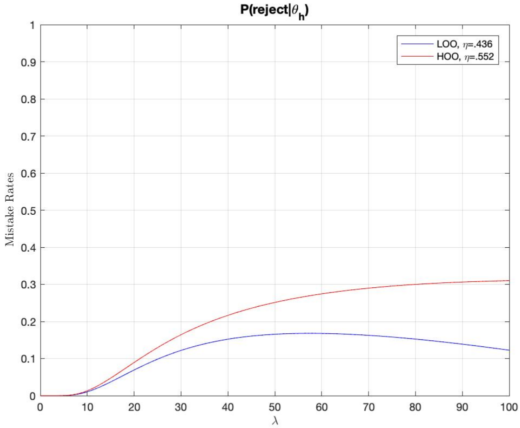
Prediction 2: Fewer mistakes from accepting low value products



18.2 % to 13.6 % ✓

Testing RI w/ SC: Mistakes when Mimicking Increases

Prediction 3: More mistakes from rejecting high value products



23.4 % to 17.8 % $\times$

Departures from Rational inattention with Shannon Costs

- For RI with Shannon Costs:
  1. More mimicking leads to more rejecting (sensible!)
  2. But optimal posteriors do not change with the sellers outside option, so buyers should be equally well informed when accepting and rejecting for both outside option levels
- As a result, RI predicts that we will see more rejecting even with high value (more mistakes with high value)
- But buyers in our experiment appear to be better informed when both accepting and rejecting
  - "Revealed" posteriors (average likelihood at each action) are Blackwell-ordered across treatments (Caplin and Martin 2021)

Attention as Costly Experiments

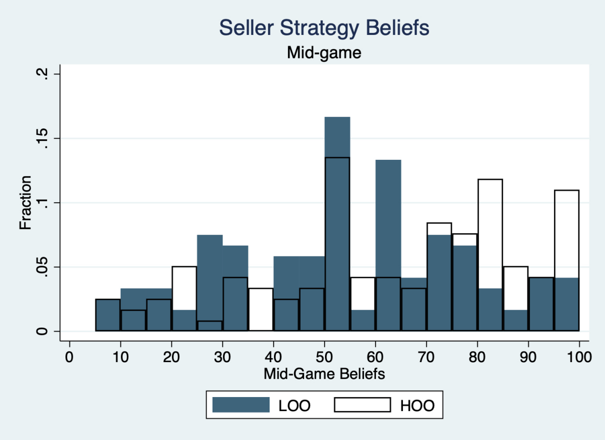
- Optimal posteriors can vary with the prior in models of costly experiments (e.g., Denti, Marinacci, and Rustichini 2022; Pomatto, Strack, and Tamuz 2023)
- Unlike the Shannon model, the costs in this class of models are not on the posteriors themselves
- This is advantageous to use in strategy settings in which one player can impact the prior over states (“endogenous”priors).

Conclusion

- Buyers foresee the mimicking upsurge and react by increasing their attention
- Buyers make fewer mistakes regardless of the value
- The attentional response shown by the buyers is NOT consistent with a model of RI with Shannon costs
- However, other models of costly attention ARE consistent
  - Attention as costly experiments
  - All or nothing models of costly attention
  - Dual-process DDM (Caplin and Martin 2017)

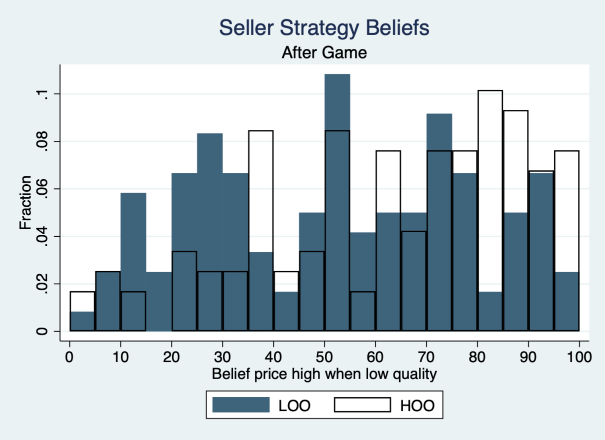
Thank You!

Mid-Game Beliefs



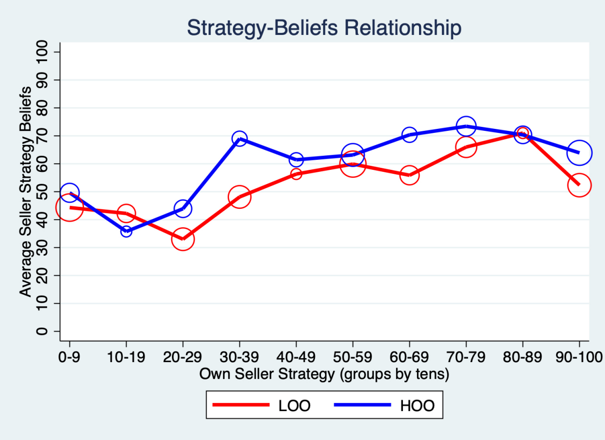
Back

After Game Beliefs



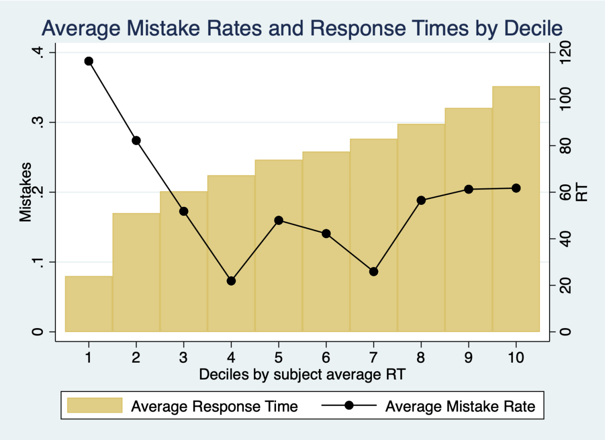
Back

Beliefs by Own Strategy



Back

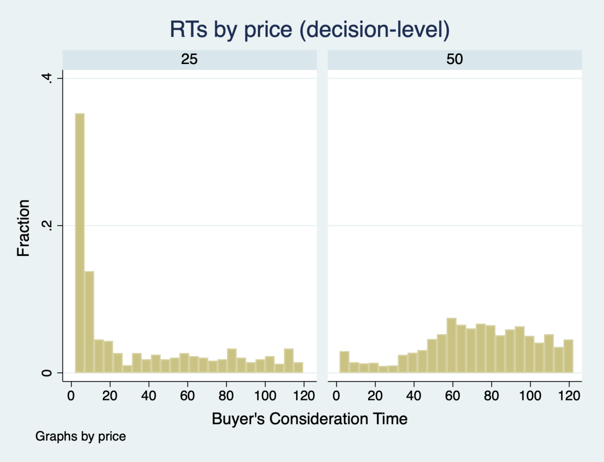
Response Times & Mistakes



RT informative about extensive margin of attention

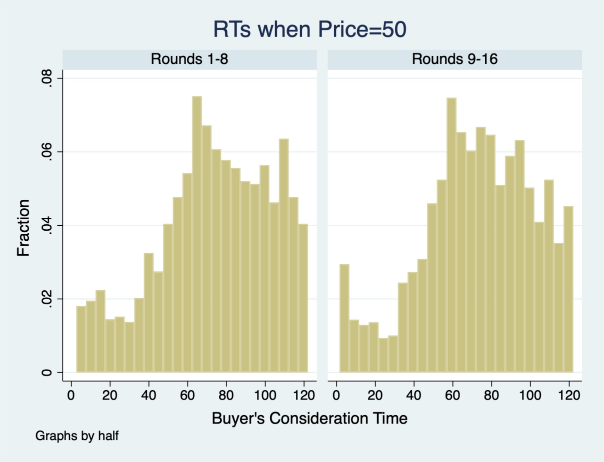
Back

Response Times by Price



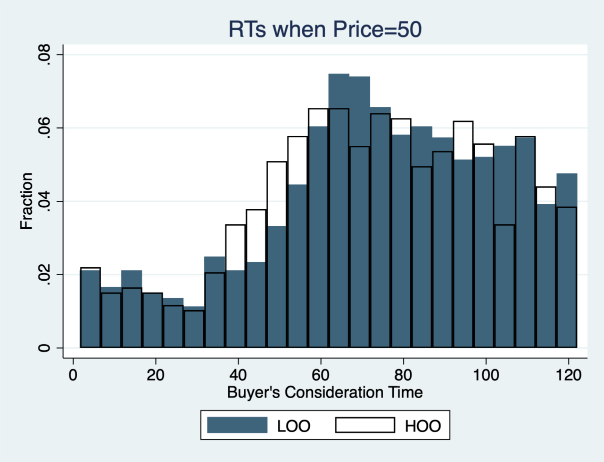
Back

Response Times by Half



Back

Response Times by Treatment



Back

Sample Descriptive Stats and Balance

	LOO		HOO		Comparison	
	Mean (sd.)	Obs.	Mean (sd.)	Obs.	Diff	$\lvert t - stat \rvert$
Male (dummy)	.401 (.49)	112	.5 (.50)	112	-.09	1.4
Age (years)	26.4 (5.9)	120	25.9 (5.8)	118	.55	0.7
English level (1-5)	4.04 (.84)	117	4.05 (.91)	118	-.01	0.07
Friend in session (dummy)	.116 (.35)	120	.042 (.20)	118	.074	2.1^{**}
10+/12 correct on payoff comp. Qs (dummy)	.891 (.31)	120	.881 (.32)	118	.010	0.24
12/12 correct on payoff comp. Qs (dummy)	.733 (.44)	120	.733 (.44)	118	0	0.06
Mixed Strategy comp. Q (dummy)	.741 (.40)	120	.762 (.42)	118	-.02	0.37
Memory task all correct (dummy)	.633 (.48)	120	.703 (.45)	118	-.07	1.4
Math test correct (0-5)	.416 (.90)	120	.677 (1.17)	118	-.26	1.92^{*}
Math test correct or close (0-5)	.9 (1.12)	120	1.34 (1.40)	118	-.44	2.7^{***}
1+ Math test correct (dummy)	.258 (.43)	120	.338 (.47)	118	-.080	1.35
1+ Math test correct or close (dummy)	.533 (.50)	120	.618 (.48)	118	-.08	1.3

Notes.Observation is per subject. Value is missing if demographic information not provided by the subject.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Back