Rationally Inattentive and Strategically (un)Sophisticated: Theory and Experiment

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Motivation

- Two CEOs are deciding whether or not to agree to a merger
- This merger is ex-ante optimal, but ex-post sub-optimal for one
- Prior to deciding, they can try to acquire information about whether the merger will be good or bad
- Do they acquire information strategically?

Motivation

Two key sources of cognitive friction in games

1. Rational Inattention: Friction of Information
    - Agents acquire information to maximize benefits of information less costs
    - In games, one player's benefits of information are a direct function of the opponent's information acquisition

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1. Rational Inattention: Friction of Information
   - Agents acquire information to maximize benefits of information less costs
   - In games, one player's benefits of information are a direct function of the opponent's information acquisition
2. Strategic Sophistication: Friction of Reasoning
   - Calls into question how capable agents are of contingent reasoning
   - How well can players anticipate and best respond to the behavior of others

Research Questions

Do players acquire information *strategically*?

1. Are they strategically sophisticated?
    - To what extent do players correctly predict the information acquisition of other players in a strategic setting?
2. Are they rationally inattentive?
    - To what extent do players best respond to these beliefs in their own information acquisition?

Preview

Do players acquire information strategically? *No*

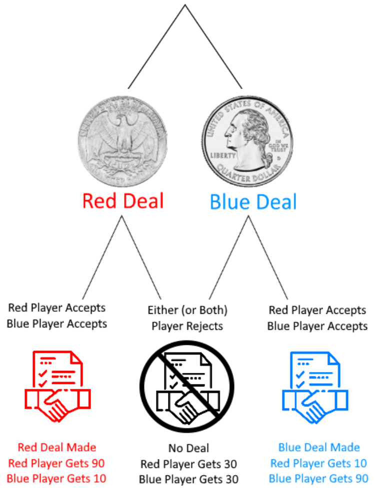
- Subjects almost entirely ignore opponent information acquisition
- However, when *given* correct beliefs about opponent behavior, they respond accordingly
- Predicting opponent information is difficult! So subjects treat games like single agent decision problems

Related Literature

- Rational Inattention
  - *Theory*: Caplin and Martin 2015, Martin 2015, Ravid 2022, Genzkow and Kamenica 2014, Bloedel and Segal 2018, Matyskova 2018, Yang 2015, Szkup and Trevino 2015, Domotor 2021
  - *Experiments*: Almog and Martin 2022, Dean and Neligh 2019
- Strategic Sophistication
  - Nagel 1995, Arad and Rubinstein 2012, Costa-Gomes et al 2001
  - Alaoui and Penta 2016, Agranov et al 2012

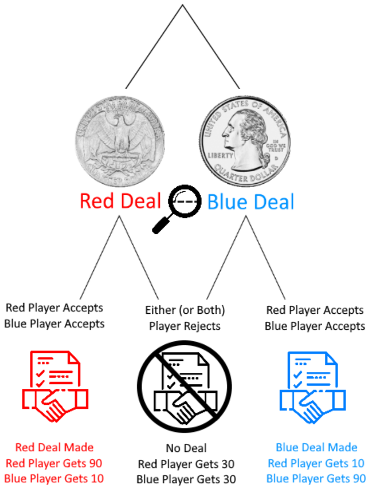
The Game

- Game is intentionally simple for lab experiment
- Two players: Red and Blue
- Two states: $\theta \in \{R, B\}$
- Assumptions: Deal ex-ante optimal for both, but ex-post sub-optimal for one



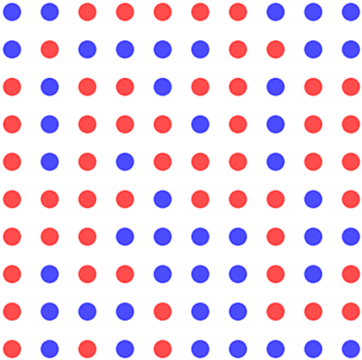
The Game

- Players only know 50-50 prior
- Can *both* acquire costly information about θ before choosing Accept or Reject



Information Acquisition

- Use Red/Blue dot task from Dean and Neligh (2018)
- More red dots = Red Deal, more blue dots = Blue Deal



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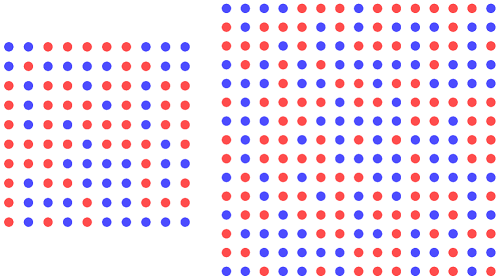

Figure: 100-Dot Task (Left), 225-Dot Task (Right)

How should subjects acquire information?

- Cost of acquiring information modelled in standard RI sense, with linear attention cost parameter $\lambda^i > 0$ Details on RI
- Higher λ^i = Higher costs of information
- Costs are possibly asymmetric, and are common knowledge

How should subjects acquire information?

- First must determine *rewards* of information
- In games, rewards of info are not exogenous but a function of opponent behavior
- Opponent's behavior is a function of their information

How should subjects acquire information?

- Beliefs of B's SDSC determines the utility of correct decision (accepting when $\theta = R$) and mistake (accepting when $\theta = B$)
- $u^R(a, R) = \tilde{P}^B[a|R] * 90 + (1 - \tilde{P}^B[a|R]) * 30$
- $u^R(a, B) = \tilde{P}^B[a|B] * 10 + (1 - \tilde{P}^B[a|B]) * 30$
- $u^R(r, \theta) = 30$

Rational Inattention: Best Response SDSC

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- Blue pays no attention $\rightarrow$ Accepts all deals $\rightarrow$ Red pays attention, SDSC depends on λ^R
- Blue pays only some attention $\rightarrow$ Red has incentive to pay attention, Red's SDSC will depend on degree of Blue's mistakes and λ^R

Nash Equilibrium

- Equilibrium is a tuple of SDSC $\{P^i[a|R], P^i[a|B]\}_{i\in\{R,B\}}$ such that each player's SDSC is a best response to the other's (conjectures are correct)
- Very high costs for both $\rightarrow$ unconditional accept eq'm
- Very low costs for either $\rightarrow$ unconditional reject eq'm
- Smooth map between the two, as λ^R or λ^B increase, $P[a|\theta]$ increases
- Costly attention as commitment

Strategic Sophistication

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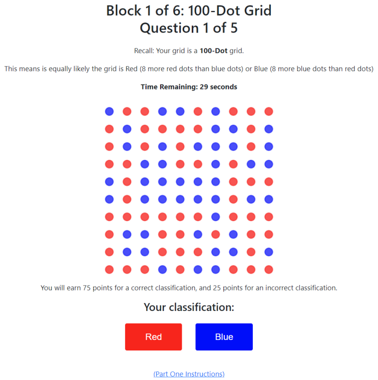
- Level 1 will best respond to Level 0 (SDSC invariant to the other person's attentional ability)
- Level 2 will best respond to Level 1 (their SDSC will depend on how attentive their opponent is–how well their opponent separates their SDSC)

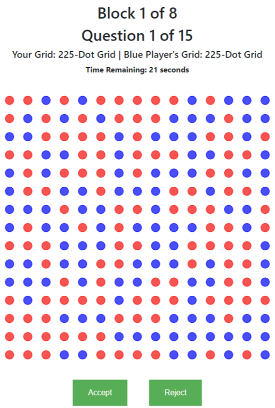
Experimental Design: Part 1 (Decisions)

- Payments in probability points for one random round, equal to probability of winning $10 bonus
- Decision making rounds: 30 rounds (6 blocks of 5)
  - 75 points for determining the state, 25 points for picking incorrect classification
  - 15 rounds for each difficulty level



Experimental Design: Part 2 (Games)

- Players assigned to one of two roles (Red and Blue), fixed throughout experiment
- 120 rounds (8 blocks of 15)
    - All combinations of own task and other task, 30 times each
    - No feedback after each round/block
- Belief elicitation at end of blocks 5-8

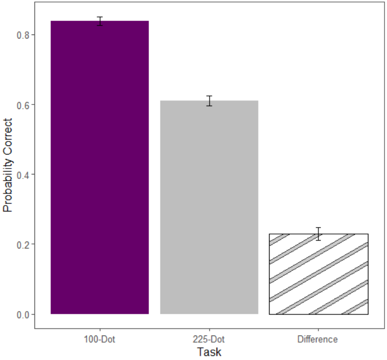


Results: Summary

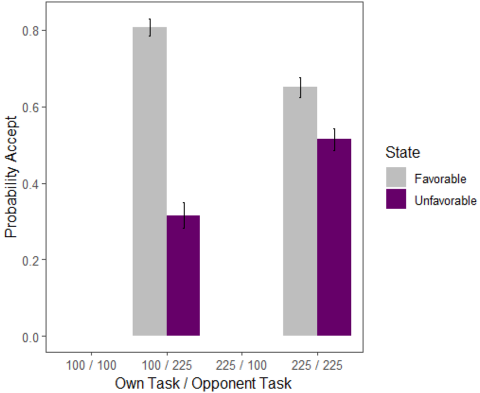
- Ran on Prolific (18-30, U.S. residents, at least a high school degree) via oTree
- 100 subjects over the past summer
- Experiment usually took around 40 minutes

Was the hard task hard?

- 225-Dot task was *much* harder than the 100-Dot task
- 61% vs 84% correct classification rate, paired t-test significant at $p < 0.0001$



Did game behavior reflect this?



	Dependent variable:	
	Accept (Fav)	Accept (Unfav)
Constant	0.654***	0.505***
	(0.028)	(0.032)
Own100	0.158***	−0.199***
	(0.034)	(0.044)
Opp100		
Own100*Opp100		
Round	−0.00005	0.0002
	(0.0002)	(0.0002)
Note:		*p<0.1; **p<0.05; ***p<0.01

- Hard task still hard: More favorable rejects and unfavorable accepts

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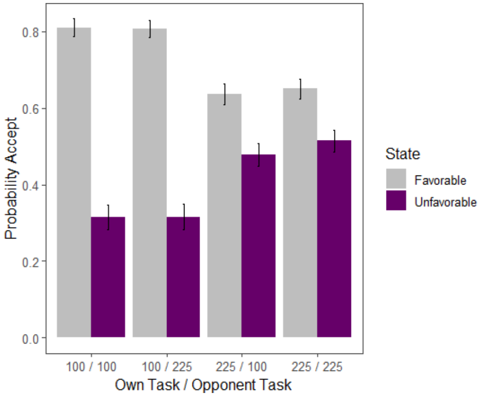

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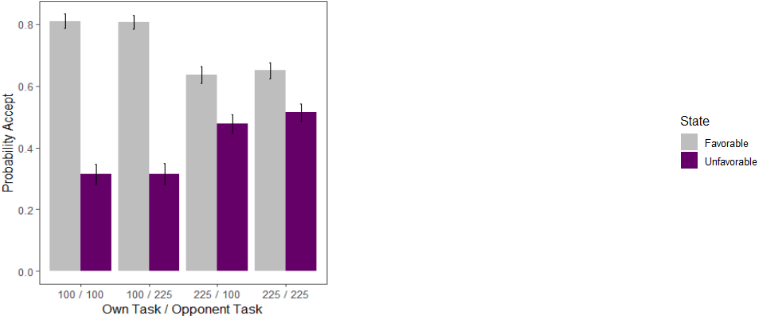
Own100	0.158***	−0.199***
	(0.034)	(0.044)
Opp100	−0.014	−0.036*
	(0.020)	(0.021)
Own100*Opp100	0.016	0.036
	(0.025)	(0.027)
Round	−0.00005	0.0002
	(0.0002)	(0.0002)

Note: *p<0.1; **p<0.05; ***p<0.01

- But absolutely no reaction to opponent!
- Almost *all* subjects act like "Level-1" players

How did subjects *think* their opponents did?



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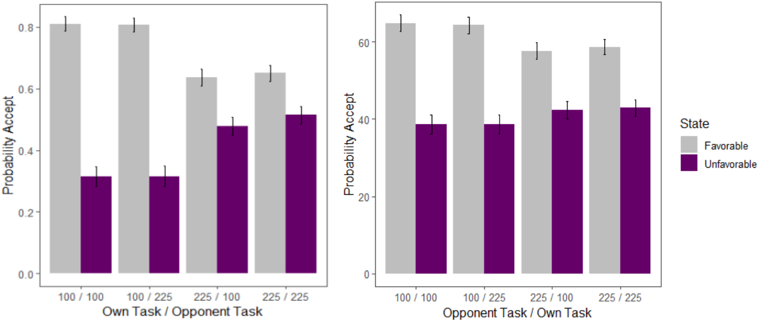

- Regression of belief on attentional setup shows opponent having 225-Dot task gives 5.6% lower favorable accept belief ($p < .01$) and 4.2% higher unfavorable accept belief ($p < .05$)
- Plurality of subjects report $P[a|B]$ very close to $P[a|R]$

Experiment Two: Computer Opponents

- Regression analysis suggests that behavior *is* responding to beliefs, beliefs are just wrong Regressions
- So what happens when subjects are *given* correct beliefs?

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- Computers characterized by their SDSC—how often they accept deals of either color

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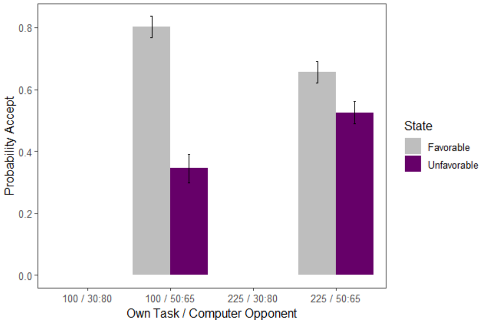
- Regression analysis suggests that behavior *is* responding to beliefs, beliefs are just wrong Regressions
- So what happens when subjects are *given* correct beliefs?
- Instead of human opponents, now play Computer opponents
- Computers characterized by their SDSC—how often they accept deals of either color
- Values of SDSC chosen to exactly mirror that of average behavior in Experiment 1
  - Computer 50:65 accepts 50% of unfavorable deals and 65% of favorable deals (225-Dot equivalent)
  - Computer 30:80 accepts 30% of unfavorable deals and 80% of favorable deals (100-Dot equivalent)

Design: Experiment Two

- Remainder of experiment identical—including belief elicitation
- 40 subjects on Prolific in September 2022
- Subjects from Experiment 1 excluded from participation

Experiment Two: Game Behavior



	Dependent variable:	
	Accept (Fav)	Accept (Unfav)
Constant	0.641***	0.527***
	(0.036)	(0.038)
Own100	0.147***	−0.182***
	(0.048)	(0.058)
30:80		
Own100*30:80		
Round	0.0003	−0.00002
	(0.0003)	(0.0003)

Note: *p<0.1; **p<0.05; ***p<0.01

- Hard task still hard: More favorable rejects and unfavorable accepts

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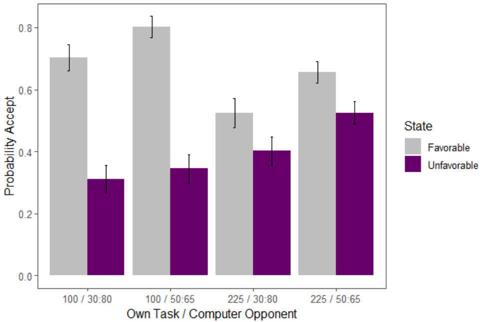

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	(0.048)	(0.058)
30:80	−0.133***	−0.124***
	(0.045)	(0.040)
Own100*30:80	0.033	0.089*
	(0.060)	(0.052)
Round	0.0003	−0.00002
	(0.0003)	(0.0003)
Note:	*p<0.1; **p<0.05; ***p<0.01	

- Now a large significant effect of opponent ability!

Conclusion

- Actions are responsive to beliefs in ways that align with RI
- People have difficulty modelling other's information acquistion, leads them to ignore it altogether

Conclusion

- Actions are responsive to beliefs in ways that align with RI
- People have difficulty modelling other's information acquistion, leads them to ignore it altogether
- Must be careful in assuming knowledge of strategic behavior in strategic RI settings
- Integration of RI with endogenous depth of reasoning / cognitive uncertainty pave a path forward

Comments welcome at spurlino@nyu.edu

On the job market!

www.ericspurlino.com

Thank you!

Rational Inattention in One Slide

- Suppose you're an R player in my model, what would you do if you acquired full information?
  - You would Accept whenever deal is Red, Reject otherwise
  - So $P[a|R] = 1$ and $P[a|B] = 0$
  - RI says the marginal costs of information here should be infinite, very marginally costly to learn more
- Suppose you're an R player in my model, what would you do if you acquired no information?
  - You couldn't condition your acceptance probability on the state, because you have no idea what the state is
  - So $P[a|R] = P[a|B]$
  - RI says this is free
- RI then allows us to study the continuum between these two points (e.g. $P[a|R] = 2/3$, $P[a|B] = 1/3$)

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Did subjects respond to their beliefs?

	Dependent variable:			
	Accept (Favorable)		Accept (Unfavorable)	
	(1)	(2)	(3)	(4)
Constant	0.267^{***}	0.235^{***}	0.026	-0.010
	(0.066)	(0.077)	(0.059)	(0.062)
Own100	0.323^{***}	0.300^{**}	-0.195^{**}	-0.230^{***}
	(0.099)	(0.119)	(0.080)	(0.089)
$\Delta P^{-i}[a\|\theta]$	-0.001^{*}	-0.001	-0.002^{***}	-0.002^{***}
	(0.001)	(0.001)	(0.001)	(0.001)
$P^{-i}[a]$	0.008^{***}	0.008^{***}	0.010^{***}	0.010^{***}
	(0.001)	(0.001)	(0.001)	(0.001)
Own100*BD	0.002^{***}	0.003^{***}	-0.001	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Own100*BA	-0.004^{***}	-0.003^{**}	0.001	0.001
	(0.002)	(0.002)	(0.001)	(0.001)
Round	-0.00004	-0.0001	0.0001	0.00004
	(0.0002)	(0.0003)	(0.0002)	(0.0002)
Note:			*p$<$0.1; **p$<$0.05; ***p$<$0.01	

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