Game Theory, Psychology & Neuroscience

UBC COGS300  002
Mar 3 2015
Peter Danielson
1. IPD Tournament
2. Beauty Contest
3. Ultimatum Game
4. Comparisons
   1. Humans/Computers
   2. Human/Chimps
5. Research Ethics
IPD Tournament COGS 300 March 2015

Graph showing bars for different strategies such as Tit-for-Tat, Tit-for-Tat with x, Tit-for-Tat Grim, Second Shot, Tit for Tat, Tit for Tat with x, Tit for Tat Grim, Tit for Two Tats, Tit for Two Tats with x, Tit for Two Tats Grim, Grim, Grim Trigger, Second Chance, and Second Chance with x.
Accidental Kingmakers

• All would be nice
  – And boring
• 4 Errors => variety
  – (evol 1)
  – Kingmakers
• Evolution 1: replicator dynamics
• Late
  – Redo (evol 2)?
  – No need w/o random or other disturbance

<table>
<thead>
<tr>
<th>strat</th>
<th>tft</th>
<th>grim</th>
<th>x</th>
<th>y</th>
<th>total</th>
</tr>
</thead>
<tbody>
<tr>
<td>tft</td>
<td>5322</td>
<td>5322</td>
<td>1779</td>
<td>8760</td>
<td>21183</td>
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<tr>
<td>grim</td>
<td>5322</td>
<td>5322</td>
<td>1779</td>
<td>8815</td>
<td>21238</td>
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<tr>
<td>x</td>
<td>1804</td>
<td>1804</td>
<td>1784</td>
<td>8840</td>
<td>14232</td>
</tr>
<tr>
<td>y</td>
<td>90</td>
<td>45</td>
<td>20</td>
<td>3550</td>
<td>3705</td>
</tr>
</tbody>
</table>

\[
\text{Tit-For-Tat-x,z} \\
2 \\
C,1,0 \\
D,1,1 \\
\text{Tit-For-Tat-y} \\
2 \\
C,1,0 \\
D,1,0
\]
2. Beauty Contest Game

• Choose a decimal in interval [0,100]; winner (of extra point) is closest to 2/3 of average of all submissions.
• Pseudonym/S#; choice # on paper
FIGURE 1. RELATIVE FREQUENCIES OF CHOICES IN THREE NEWSPAPER EXPERIMENTS
Beauty Contest Experiments

• Surprise: “Fact4: Those subjects who conducted their own experiments in order to decide which number to choose were, on average, closer to the winning answer than theorists and the general public.” Bosch-Domènech, A. et al. (2002)
Camerer: Brain Activity Confirms Difference
3. The Ultimatum Game

Normal form:

<table>
<thead>
<tr>
<th></th>
<th>Proposer Fair</th>
<th>Proposer Unfair</th>
</tr>
</thead>
<tbody>
<tr>
<td>Responder Accept</td>
<td>5,5</td>
<td>1,9</td>
</tr>
<tr>
<td>Responder Reject</td>
<td>0,0</td>
<td>0,0</td>
</tr>
</tbody>
</table>

• “One-shot”: No iteration; no reputation effect.
• Contrast:
  – in iterated game, threats can be rational (Aumann)
Game Theory + Neuroscience = Neuroeconomics

• “The emergence of an interdisciplinary field, neuroeconomics ... offers a promising avenue to examine decision-making at different levels of analysis... taking into account cognitive and neural constraints as investigated by psychology and neuroscience, while using the mathematical decision models and tasks that have emerged from economics.” (Sanfey 2007)
Big Question

Are we humans rational as specified by decision & game theory? (Sanfey et al, 2003)

• Experiments with simple, single play Ultimatum Game
• “Standard economic solution”
  – Nash equilibrium analysis
  – Vs. other accounts
Q1:
What is the standard economic solution to the ultimatum game?

A. The proposer offers the smallest sum of money possible to the responder and for the responder to accept this offer.

B. The proposer offers the most reasonable sum of money for a given situation in order to maximize the probabilities of acceptance by the responder.

C. The proposer offers the largest sum of money possible to the responder and for the responder to accept this offer.

D. none of the above.
The Ultimatum Game

- **Normal form:**

<table>
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<th></th>
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<tbody>
<tr>
<td>Responder Accept</td>
<td>5, 5</td>
<td>1, 9</td>
</tr>
<tr>
<td>Responder Reject</td>
<td>0, 0</td>
<td>0, 0</td>
</tr>
</tbody>
</table>

- **Extensive form:**

  - P1: Giver (Proposer)
    - Offer 5
      - P2: Receiver (Responder)
        - Accept: 5, 5
        - Reject: 0, 0
    - Offer 1
      - P2: Receiver (Responder)
        - Accept: 9, 1
        - Reject: 0, 0
Second Mover has more complex strategies available: Quiz 3

What is/are the Nash equilibria in this game?
A) \{Offer 5, Accept/Reject\}
B) \{Offer 1, Accept/Accept\}
C) \{Offer 5, Accept/Reject\} and \{Offer 1, Accept/Accept\}
D) None

<table>
<thead>
<tr>
<th>Second Mover:</th>
<th>First Mover:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Offer 5</td>
</tr>
<tr>
<td>Accept/Accept</td>
<td>5,5</td>
</tr>
<tr>
<td>Accept/Reject</td>
<td>5,5</td>
</tr>
<tr>
<td>Reject/Accept</td>
<td>0,0</td>
</tr>
<tr>
<td>Reject/Reject</td>
<td>0,0,0</td>
</tr>
</tbody>
</table>
**Sub-game Perfection**

- "Perfect equilibrium means, roughly, that the threat of punishment is credible; that if you have to go to a punishment, then after you punish, you are still in equilibrium – you do not have an incentive to deviate" (Aumann p. 355).

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**Ultimatum Game Extensive Form**

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Player 2</th>
<th>Player 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fair</td>
<td>Accept</td>
<td>$5, $5</td>
</tr>
<tr>
<td>Fair</td>
<td>Reject</td>
<td>$0, $0</td>
</tr>
<tr>
<td>Unfair</td>
<td>Accept</td>
<td>$9, $1</td>
</tr>
<tr>
<td>Unfair</td>
<td>Reject</td>
<td>$0, $0</td>
</tr>
</tbody>
</table>
A Philosophical Argument: The ‘Rationality’ of Promises (solves the Prisoner’s Dilemma)

- Switch to (extended) Prisoner’s Dilemma
- Argument for ‘keeping’ promises: “Plan rationality” (Gauthier)
  - Rational to promise C -> C?
  - consistent to keep promise
    - If rat(‘C -> C’) & C, rat(C)
- But not sub-game perfect equilibrium

Extended PD
Extensive Form
A Parallel Argument for the ‘Rationality’ of Threats (in the Ultimatum Game)

• Is Unfair -> Reject a
  – Promise or a Threat?

• Argument for ‘keeping’ threats: “Plan rationality” (Gauthier)
  – Rational to threaten Unfair -> Reject
  – consistent to keep threat
    • If rat(‘U -> R’) & U, rat(R)

• But no reputation effect w/o iterated game

Ultimatum Game
Extensive Form
Criticism: The Doomsday Machine

“Suppose you take it to be rational to build a doomsday machine for its deterrent effect, and you build one and announce it. The other side launches a first strike. If the doomsday machine works, you have no choice, but it malfunctions. You now have a choice at whether to launch all missiles. You decide not to. Are you inconsistent? I do not see an inconsistency. The judgment not to launch all missiles was made in a different state than the judgment that it was optimal to construct the doomsday machine. The decision against massive retaliation was made with the knowledge that a first strike had indeed been launched. The decision to build the doomsday machine was made without that knowledge and in the belief that building the machine would prevent the first strike. There is nothing very surprising here, and certainly no inconsistency.” (Skyrms, p 39)
GT Prediction vs. Empirical Evidence

- Player 1 should offer as little as possible
- Player 2 should accept any offer
- Since “any monetary amount is preferable to none” (axiom)
- Modal offers typically around 50%
- Low offers (around 20% of total) have a 50% chance of being rejected
Experimental Design

• Only Player_2 real participants
  – “human”, computer & random as Player_1
  – all scripts
  = \{5,5 \times 5; 8,2 \times 2; 9,1 \times 2; 7,3 \times 1\}

• High incentive: How much to typical partic?

• Single iteration with each partner; decisions not revealed

• In MRI scanner, playing via computer interface
Neuroscience Perspective

• “Unfair offers in the UG induce conflict in the responder between cognitive ("accept") and emotional ("reject") motives, motives that we might expect to see represented in [different] brain areas”

• Hypothesis: “unfair offers would engage neural structures involved in both emotional and cognitive processing, and the magnitude of activation in these structures might explain variance in decision to accept/reject offers.”
Results

1. Stronger emotional reaction to unfair offers
4. Humans & Chimps

A) Task
- Trial start, self-start stimuli presented.
- Matcher
- Mismatcher

B) Game Payoffs
- Matcher Left | Right
  - Symmetric Matching Pennies
    - Mismatcher Left: 0, 1
    - Mismatcher Right: 0, 1
  - Asymmetric Matching Pennies
    - Mismatcher Left: 3, 0
    - Mismatcher Right: 0, 1
- Matcher Left | Right
  - Inspection Game
    - Matcher Left: 4, 0
    - Matcher Right: 0, 2

C) Setup
- Food reward dispensed to winner. Opponent's choice shown as blinking stimulus for 2000ms.
## Matching Pennies

<table>
<thead>
<tr>
<th>Mis-matcher</th>
<th>Left</th>
<th>Right</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left</td>
<td>0,1</td>
<td>1,0</td>
</tr>
<tr>
<td>Right</td>
<td>1,0</td>
<td>0,1</td>
</tr>
</tbody>
</table>

![Symmetric MP](chart.png)
### Shifting Nash Equilibrium: Inspection Game

**Matcher's left payoff is much increased.**

<table>
<thead>
<tr>
<th>Mis-matcher</th>
<th>?</th>
<th>Left</th>
<th>0.4</th>
<th>2.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>?</td>
<td>Right</td>
<td>2.0</td>
<td>0.1</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Matcher</th>
<th>?</th>
<th>Left</th>
<th>0.4</th>
<th>2.0</th>
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<tbody>
<tr>
<td>?</td>
<td>Right</td>
<td>2.0</td>
<td>0.1</td>
<td></td>
</tr>
</tbody>
</table>

Nash strategy for Matcher is: Left/Right

A. .8/.2  
B. .75/.25  
C. .5/.5  
D. .25/.75  
E. .2/.8
Shifting Nash Equilibrium: Inspection Game

<table>
<thead>
<tr>
<th>Matcher</th>
<th>Left</th>
<th>Right</th>
</tr>
</thead>
<tbody>
<tr>
<td>.5</td>
<td>.5</td>
<td></td>
</tr>
<tr>
<td>Left</td>
<td>Right</td>
<td></td>
</tr>
</tbody>
</table>

Mismatcher

| .2 | Left | 0.4 | 2.0 |
| .8 | Right| 2.0 | 0.1 |
Nash in Humans & Chimps

“These NE predictions are extremely counterintuitive: In this class of games, the payoffs of Matcher subjects change. However, their predicted behavior should not change across the games (they are predicted to choose P(R) = .50 in all three treatments). Instead, the behavior of the Mismatcher subjects should change, even though their payoffs do not change.”

“Inspired by ‘cognitive tradeoff hypothesis’: distinctly human cognitive capacities ... reduced more basic capacities such as detailed perception and pattern matching, useful for tracking opponent choice during competition... Intra-group competition is clearly important in chimpanzee societies for establishing a dominance hierarchy, whereas large-scale cooperation is a human specialty.”
Discussion Question

a) In Colin Camerer's TED talk, he suggests that chimps, being more conscious of and prioritizes social status, adhere more closely to game theory predictions about decision making. Humans, on the other hand, does not adhere closely to this. Do you think humans place significant weight on status in games with meaningful rewards?
   
i) If they do, what confounding factors might cause them to not follow game theory predictions?

b) The assigned paper by Sanfey et al. suggests that fairness has a larger weight than status for humans. How does this affect our adherence to game theory predictions? Can the predictions be changed to account for this (an incentive for being fair, etc)?
Rate Discussion Question 1

A. Excellent
B. Very Good
C. Good
D. Acceptable
E. Poor
4b. Human/Computer Asymmetry

In the study it was found that people are less likely to reject unfair offers made by computers.

- This widely cited result is based on one game design.
- Confirmed by other methods (but same game design)
  - Skin conductance direct measure of emotion (Van’t Wout, Sanfey et al. 2006)
  - Intervention: “Interestingly, although rTMS of the right DLPFC reduced the rejection rate, rTMS did not change subjects’ fairness judgments.” (Koch et al, 2006).
    - The authors of this study highlight the role of DLPFC in executive control and suggest this region is essential for overriding selfish impulses in order to reject unfair offers. When this region is disrupted, participants are more likely to act selfishly and are less able to resist the economic temptation of accepting any non-zero offer.
Practical Application: Blame the Algorithm?

Our reputations are increasingly at the mercy of algorithms, too. No one knows this better than Bettina Wulff, the former German first lady who has sued Google for autocompleting searches for her name with words like “escort” and “prostitute.” Ms. Wulff insists that Google’s algorithms spread false rumors about her; Google says that the suggested terms are just an “algorithmically generated result of objective factors, including the popularity of the entered search terms.”

5. Research Ethics: Deceiving Participants

• “This methodology deviates somewhat from the standards of experimental economics, a field that generally proscribes the use of deception... We chose to use a limited amount of deception in the current study” (n. 14)

• What was the deception?
  – What are the risks of deception in this type of experiment?
Deception in Experiments:

• A difference between Economics & Psychology:
  – Deceiving participants is generally taboo among experimental economists ... a handful vs. 59% (1979)
  – “offers .. fictitious ... justified

• Too much meaning
  – The researcher should...be careful to avoid deceiving participants. Most economists are very concerned about developing and maintaining a reputation among the student population for honesty in order to ensure that subject actions are motivated by the induced monetary rewards rather than by psychological reactions to suspected manipulation. Subjects may suspect deception if it is present. Moreover, even if subjects fail to detect deception within a session, it may jeopardize future experiments if the subjects ever find out that they were deceived and report this information to their friends.
What Game Are Researchers Playing?

<table>
<thead>
<tr>
<th>No Deception</th>
<th>Deception</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.2</td>
<td>0.5</td>
</tr>
</tbody>
</table>

And do Sanfey et al all understand it?

“...Although we are sensitive to the issue of deception, we believe that the methodological constraints of fMRI justified our practice and that the findings do not appear to be tainted by subjects’ possible perceptions of the deception used.

15. A common concern regarding the use of deception involves possible contamination of the participant pool. As mentioned previously, rejection rates in the current study replicate those typically reported from uncontrolled Ultimatum Game studies; therefore, we do not believe we suffered unduly from this...”
References