MW24.2 Experimental Economics (SS2021)
Cooperation Games: Prisoner's Dilemma

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Prisoner's Dilemma

⇒ originally introduced by Melvin Dresher and Merril Flood (1950) to test the Nash Equilibrium predictions

	C	D
C	$a,\ a$	$d,\ c^*$
D	$_*c,\ d$	$_*b,\ b^*$

exa)

	C	D
C	2, 2	0, 3^*
D	$_*3$, 0	$_*1$, 1^*

C: "cooperate"

D: "defect"

$c > a > b > d$

$\{D; D\}$ → dominant strategy equilibrium
→ Nash Equilibrium (NE)

Predictions:

- one-shot → defect (NE)
- repeated finite → defect (SPNE)
- repeated infinite → cooperative play *can* be sustained as equilibrium play

  ⇒ Folk Theorem [Friedman, 1971][1]:
  - * sufficiently patient players
  - * grim trigger strategies

Behavioral Data:

⇒ significant share of subjects exhibit cooperative behavior [Dawes and Thaler, 1988][2]

[1] James W. Friedman. A non-cooperative equilibrium for supergames. *The Review of Economic Studies*, 38(1):1–12, 1971

[2] Robyn M. Dawes and Richard H. Thaler. Anomalies: Cooperation. *The Journal of Economic Perspectives*, 2(3):187–197, 1988

Axelrod [1980] Competition(s)

⇒ How should one play a *repeated* Prisoner's Dilemma?

Some sample strategies:

- always defect
- always cooperate
- equiprobable randomization

} unconditional; perhaps, not the smartest

- match what the opponent plays, e.g., on average
- grim trigger (e.g., cooperate until defected)
- "tit-for-tat" (i.e., start by cooperating, then copy what the opponent does)

First Tournament:

- 14 strategies from leading scientists + RANDOM
- each strategy plays against every other (and itself) for 200 rounds × 5 times

Second Tournament:

- 62 strategies + RANDOM
- infinitely repeated play (∼200 rounds × 5 times)

Ecological Tournament:

- second tournament in an "evolutionary" setting
- all strategies equally represented with the more successful replacing the less successful over 1000 generations [Fig. 1, p. 400]

⇒ TIT-FOR-TAT is the best throughout (Anatol Rapoport) [Table 2. p. 384]

  * nice
  * provocable/retaliating
  * forgiving

  } properties of all successful strategies

(!) *not* a "solution" to Prisoner's Dilemma, though

  * would only come in 4^{th} if played the top 50% strategies only
  * cannot detect RANDOM
  * won't exploit when given the opportunity
  * there is no best rule independent of the environment (i.e., the distribution of opponent strategies)

How Do Human Subjects Play Prisoner's Dilemma?

⇒ Two major perspectives:

Reputation Building [Kreps et al., 1982][3]

- (some) players have the *belief* that their opponent is *not* rational but rather is playing some conditionally cooperative strategy (e.g., tit-for-tat)
- cooperation then is more beneficial as that probability $\rightarrow 1$

⇒ *selfish* players will cooperate in early rounds!

⇒ defection is still dominant in the last round as well as in one-shot games!

Altruism Theories

- (some) players are not strictly selfish but benefit from cooperation in a manner *not* reflected in the payoff matrix

a) pure altruism:
$u_i = \pi_i + \delta \cdot \pi_j$ s.t. $\delta > 0$,
where u_i is own utility, and π_i and π_j are own and opponent's payoffs, respectively

b) duty/"warm glow":
$u_i = \pi_i + \delta$ s.t. $\delta > 0$ if one chooses to cooperate, and 0 otherwise

c) reciprocal altruism:
$u_i = \pi_i + \delta$ s.t. $\delta > 0$ if both players choose to cooperate, and 0 otherwise

⇒ a) and b) can support cooperation even in one-shot games by making cooperation either a *best response* or *dominant* strategy

exa)

	C	D
C	$a+\delta,\ a+\delta$	$d+\delta,\ c$
D	$c,\ d+\delta$	$b,\ b$

* both players can exhibit "warm glow" altruistic behavior potentially

* based on the actual value of δ, cooperation can be:

— *dominated* strategy ⇔ $\delta < min(b-d, c-a)$

— *best response* strategy ⇔ $min(b-d, c-a) < \delta < max(b-d, c-a)$

— *dominant* strategy ⇔ $\delta > max(b-d, c-a)$

[3] David M Kreps, Paul Milgrom, John Roberts, and Robert Wilson. Rational cooperation in the finitely repeated prisoners' dilemma. *Journal of Economic Theory*, 27(2):245 – 252, 1982

Cooper et al. [1996]: Reputation Versus Altruism

⇒ reputation building versus "warm glow" altruism

- one-shot treatment (OST): 20 rounds; perfect stranger matching; 40 subjects
- repeated treatment (RT): 2 × 10 periods; partner matching; 30 subjects
- between-subject design

(!) last 10 rounds from OST; 10 rounds of practice (one-shot) in RT

[Table 1 and Fig. 1, p. 199]

⇒ cooperation rates are positive and generally declining over time in both treatments

⇒ cooperation rates in RT are higher than in OST

⇒ neither theory can describe all of the data

[Fig. 2, p. 201]

⇒ most of cooperative play in OST comes from the subjects who do not cooperate all the time → best response altruism

⇒ 12.5∼15% are altruists (i.e., cooperate more than 50% of the time); 62.5∼85% are selfish

[Fig. 3, p. 205]

⇒ actual cooperation rates in RT follow a concave pattern while reputation building predicts a convex one and altruism predicts a constant level after the initial drop from period one

⇒ only 25% of subjects behave in accordance with reputation building on the individual level (e.g., defection in the last period, no cooperation following defection)

Suggested Literature

- Charles A Holt. *Markets, games, & strategic behavior*. Boston Pearson Addison Wesley, 2007 [Chapters 3.1–3.2]

- Robert Axelrod. More effective choice in the prisoner's dilemma. *The Journal of Conflict Resolution*, 24(3):379–403, 1980

- Russell Cooper, Douglas V. DeJong, Robert Forsythe, and Thomas W. Ross. Cooperation without reputation: Experimental evidence from prisoner's dilemma games. *Games and Economic Behavior*, 12(2):187 – 218, 1996

* James Andreoni and John H. Miller. Rational cooperation in the finitely repeated prisoner's dilemma: Experimental evidence. *The Economic Journal*, 103(418):570–585, 1993