Infinitely Repeated PD Games: Comparing Individuals with Teams

David J. Cooper and John H. Kagel

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Motivation

- Part of a broader research program comparing two person teams and individuals in strategic interactions.
- Why compare the two ?
  - Most economic decisions are made by teams/groups of individuals so if there are important differences in behavior we need to know what they are.
  - Looking at within team dialogues gives direct insight into DMs thoughts and motivation for actions taken - a “poor man’s” FMRI.
    - But arguably better than an FMRI

Main Issues Covered in this Study

- Comparing cooperation rates between teams and individuals in IRPD games.
- Use of within team chats to identify strategies employed.
- Comparing strategy frequency estimated method (SFEM; Dal Bo and Frechette, 2011) based on choices to identify strategies employed versus those identified directly from team chats.
- Comparing FRPD with IRPD games with the same expected number of stage games.

Prior Research

- Numerous studies of both FRPD and IRPD games – see Dal Bó and Fréchette (2018) for a survey of IRPD. Embry et al. (2017) brief survey FRPD games.
- Most involve individuals. Exceptions Kagel and McGee (2016) compare two person teams with individuals for FR games (decisions agreed on jointly). Cason and Moi (2018) compare three person teams and individuals in IR games (decisions based on majority rule).
- Psychology research comparing differences between individuals and teams in PD games (see Wildschut et al., 2003 and Wildschut and Insko, 2007 for surveys). Employ very different procedures –
  - Main finding - *Discontinuity effect* – teams less cooperative than individuals.
- Most prior studies use direct response method – just play game out. Use SFEM to estimate the distribution of strategies over a set of supergames.
- A few have agents choose between an extensive set of strategies which then play out (Cason and Moi, 2018; Dal Bo and Frechette, 2018b). Can change strategy between super-games.
- Some more recent research IRPD games with noise (Fudenberg et al, 2012; Ayogi et al. (2019)

Experimental Design

- Stage game payoffs (in experimental currency units – ECUs)

	A	B
A	105, 105	5, 175
B	175, 5	75, 75

- Each IRPD supergame has a 90% continuation probability, for an expected duration of 10 stage-games.
- Compare results to earlier FRPD experiment comparing teams with individuals with 10 stage games to each supergame (Kagel and McGee, 2016).

Theory

- The payoff table in conjunction with the high continuation value implies mutual cooperation is part of a Risk Dominant sub-game perfect equilibrium (SPE,) making cooperation more likely (Dal Bo and Frechette, 2018 (DF)).
- The game has a Basin of Attraction for Always Defect below ½ (a basin of attraction compared to an opponent playing Grim and AD), which makes cooperation even more likely (DF, 2018). (BAD = .42).

Experimental Design

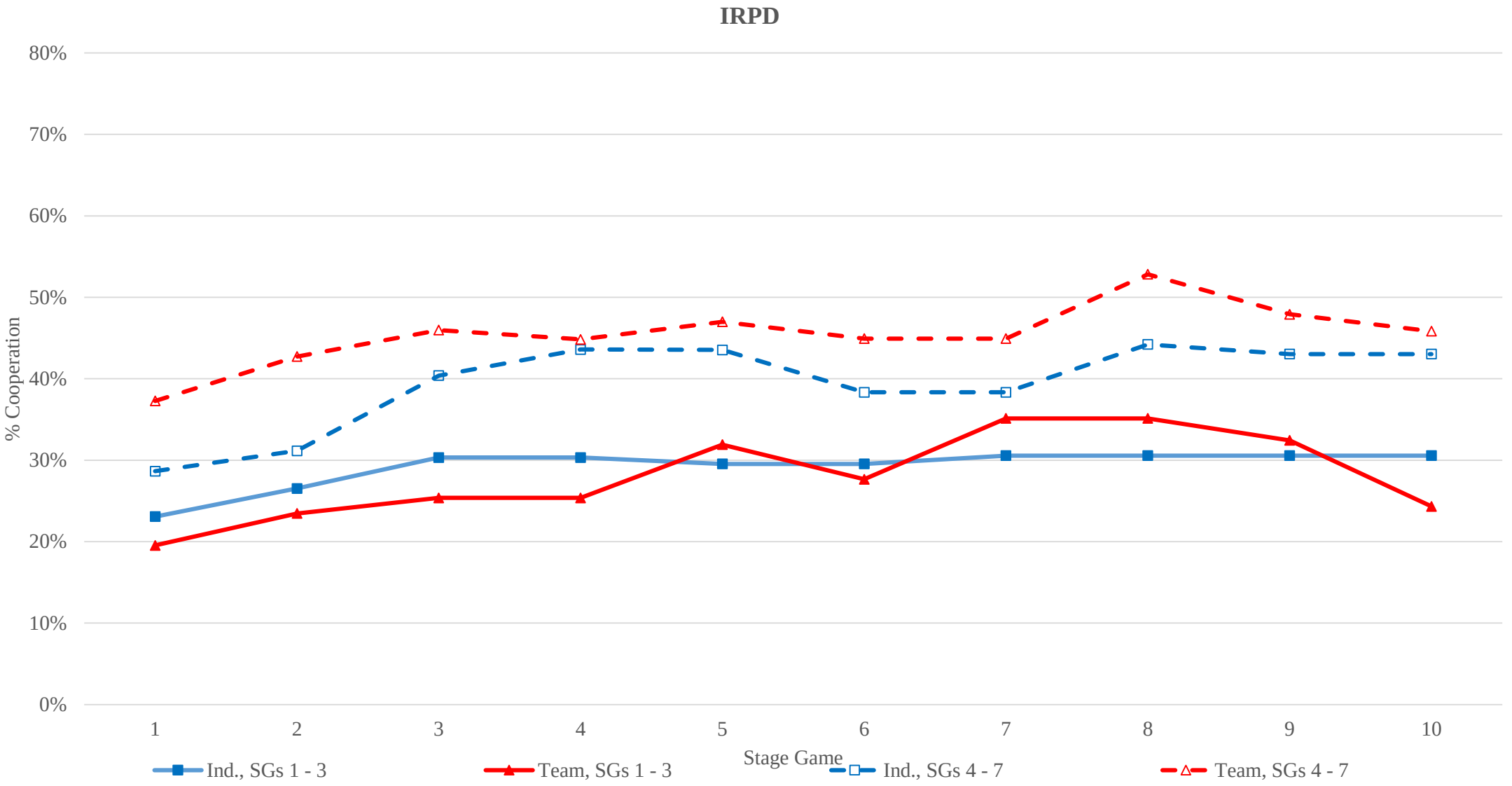
- Subjects play either as individuals or in fixed two-person teams.
  - Random rematching between players (individuals or teams) between supergames.
  - Teams can chat for two minutes prior to each stage game. These chats are the source of content that we analyze.
  - Seeds are matched between individual and team sessions.
  - Team sessions ran slower than individual sessions, so analysis is based on common supergames by seed.
  - 250 ECUs = $1. Payoffs averaged $45 a session.
  - Each team member received team payoff.

	Finite	Infinite
Individual	52 Subjects 5 Sessions	104 Subjects 6 Sessions
Team	52 Subjects 5 Sessions	58 Teams 6 Sessions

Will also compare to FRPD games in KM, 2016. Comparison is interesting in it's own right + adds a sufficient number of sessions to use cluster standard errors at the session level.

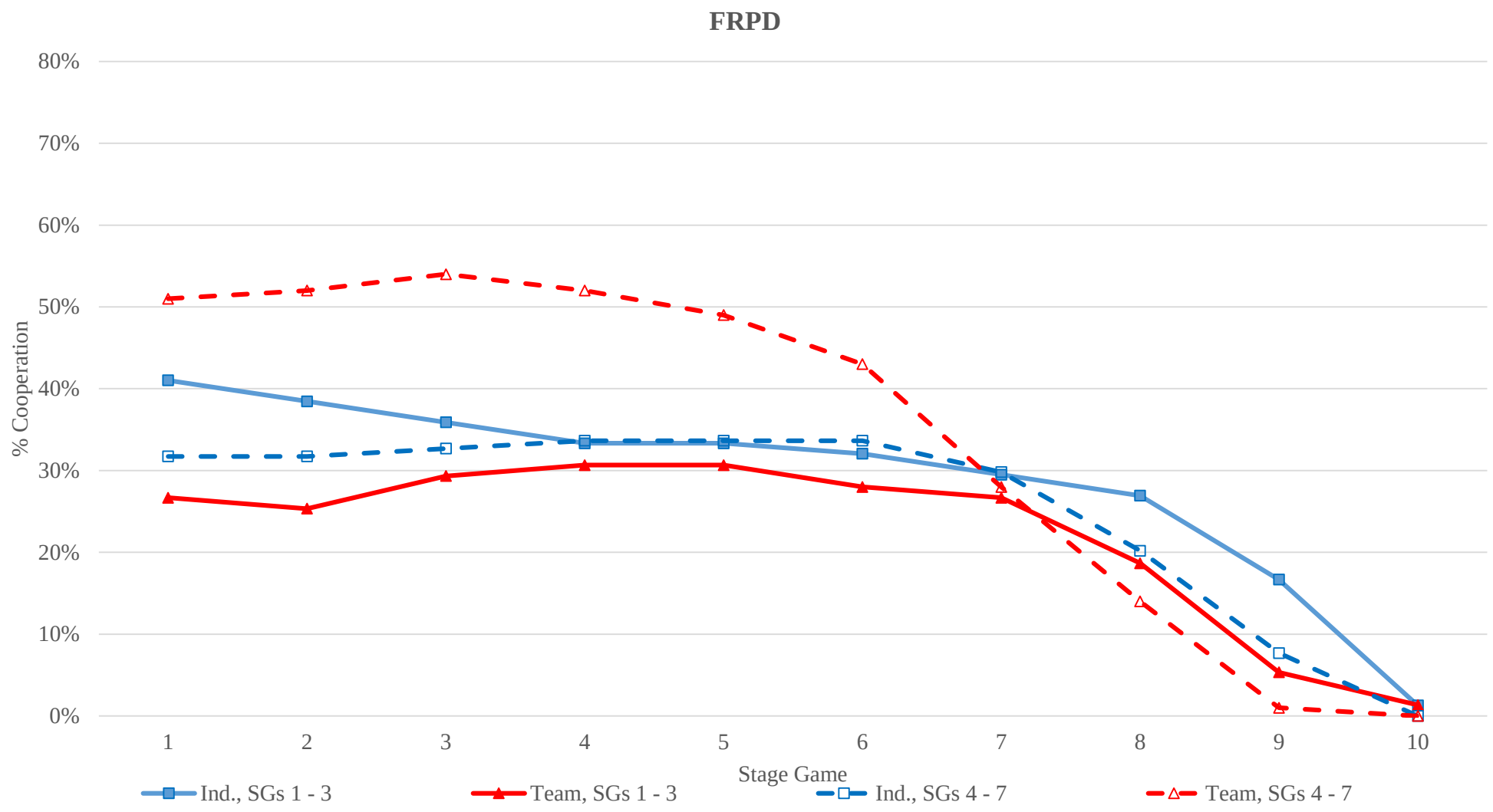
Cooperation over Time: Teams compared to Individuals

Mutual Cooperation rates across Stage Games



Cooperation rates: Non-parametric Estimates
(IRPD Games)

- Mutual cooperation in stage game 1 (St1) is *higher* for individuals than teams in supergame 1 (SG1) (19.2% vs. 10.3%).
- Teams overtake individuals. By final common supergame, mutual cooperation in St1 is *lower* for individuals than teams (36.5% vs. 55.2%).
- Comparing SG1 and the last common supergame, mutual cooperation in St1 increases significantly for teams ($z = 2.20$; $p = 0.028$) but not individuals ($z = 1.05$; $p = 0.292$).
  - The increase is significantly larger for teams than individuals as well ($z = 1.78$; $p = 0.075$).


FRPD
80%
70%
60%
50%
40%
30%
20%
10%
0%
% Cooperation
1
2
3
4
5
6
7
8
9
10
Stage Game
Ind., SGs 1 - 3
Team, SGs 1 - 3
Ind., SGs 4 - 7
Team, SGs 4 - 7

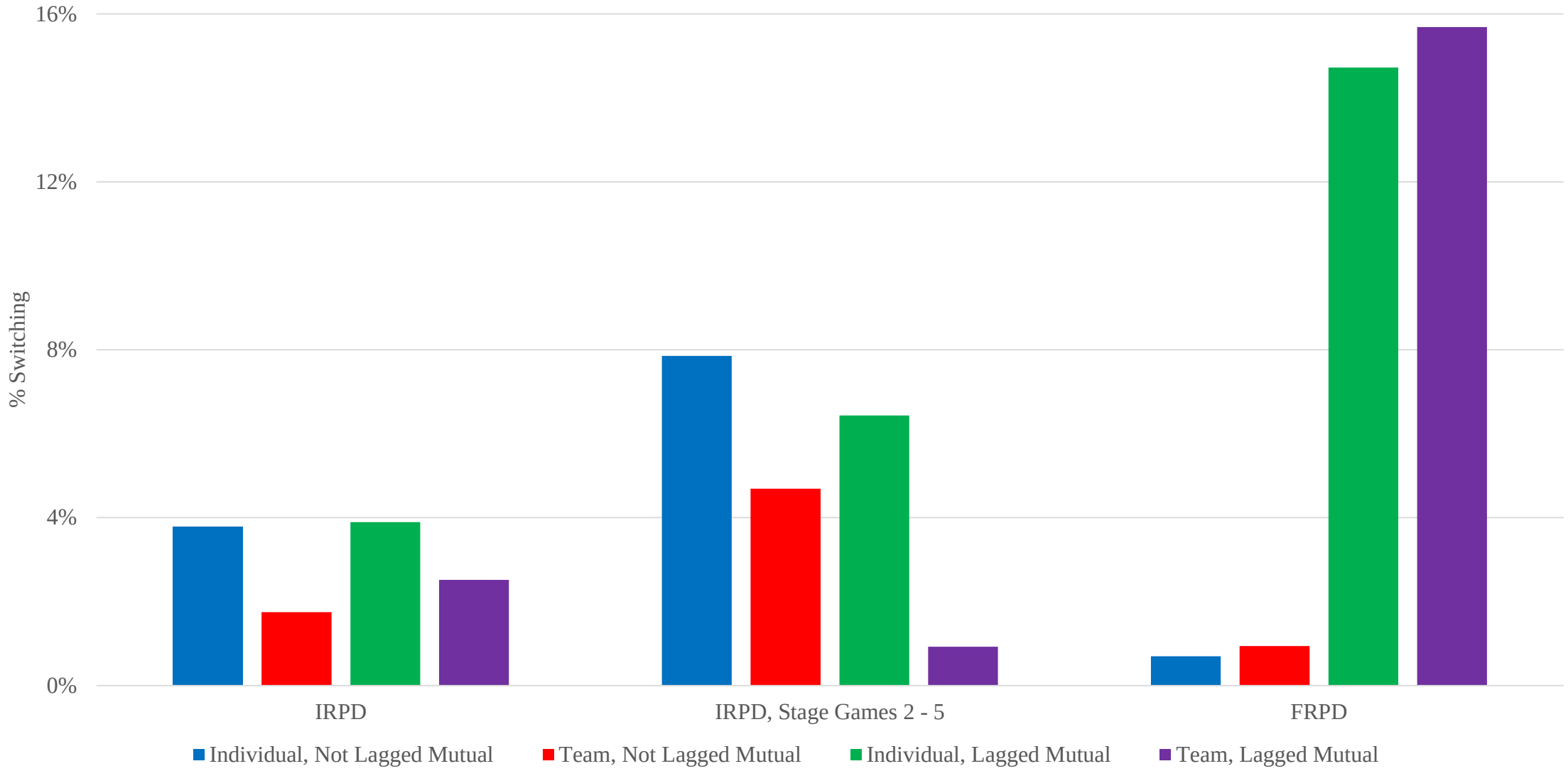
Cooperation rates: Non-parametric Estimates
(FRPD Games)

- Comparing the IRPD and FRPD, there is a similar pattern with respect early stage game cooperation rates:
- Mutual cooperation in St1 is higher for individuals than teams in SG1 (46.2% vs. 12.0%).
- By the final common supergame, SG7, difference has flipped with individuals with individuals less cooperative (38.5% vs. 52% in St1).
- Change in mutual cooperation is not significant for individuals ($z = 0.00$; $p = 1.000$), but is for teams ($z = 1.76$; $p = 0.078$).
  - The difference in differences between teams and individuals statistically significant ($z = 1.79$; $p = 0.074$).

Parametric Estimates Dependent Variable: Mutual Coop St1	(1)	(2)
Team, IRPD	0.105*	-0.107
	(0.060)	(0.077)
Team, FRPD	0.031	-0.221**
	(0.092)	(0.089)
Lagged # Stage Games	0.003*	0.003
	(0.002)	(0.002)
Experienced Defection St1, Previous Supergame	-0.234***	-0.208***
	(0.040)	(0.034)
Supergame * IRPD		0.036**
		(0.016)
Supergame * Team, IRPD		0.039**
		(0.017)
Supergame * Team, FRPD		0.073***
		(0.024)
Team Infinite – Finite	0.074	0.114
	(0.155)	(0.103)
Supergame * Team Infinite – Finite		-0.034
		(0.030)

Stability of Mutual Cooperation Across Stage Games

(what happens after St1)



What happens after St1

- For IRPD games:
- If agents are mutually cooperating after St1, they normally continue to cooperate in the next stage game (96.2% of the time)
- If not cooperating, this tends to persist into the next stage game as well (96.8% of the time).
- Probability of switching, either to or from mutual cooperation, is consistently less with teams than individuals.
- Difference between teams and individuals is even stronger in early stage games (i.e. St2 – St5) when switches are most frequent.
- Difference in stability between teams and individuals appears small, but has relatively large cumulative effect: By the fifth stage game 19.5% of individuals have switched either to or from mutual cooperation in St1, as opposed to 10.3% for teams.
  - Net effect of switches is close to zero for both, so differences in stability have little impact on the differences in **levels** of mutual cooperation.
- FRPD games: very unstable (increasing defection across St games)

Summary: Cooperation Over Time

- Higher initial cooperation rates for individuals is consistent with the “discontinuity effect” from Social Psychology literature.
- Attributed to greater fear and greed on the part of teams compared to individuals. Find evidence for this as well: Coding team chats - 64.5% (20/31) playing AD in first SG do so out of safety considerations (concern for getting sucker payoff).

  “D is always the safe choice” “so we are guaranteed 75 each time”

  “I think we should stick with D to be safe”

- Additional 25.8% (8/31) of chats indicate myopia or greed as teams focused on the higher payoff for defecting, not considering the possibility of cooperatiing:

  “choose D since our payoffs will be 175 or 75, instead of 105 or 5”

  “I say we always do optimum D, as it has the highest payoff on average” “That’s what I was thinking too definitely”

- What the psychology literature fails to identify is the higher cooperation rate for teams with experience as they typically study a single supergame, with no rematching of player opponents.

Identifying Strategies in IRPD Games

- Two ways

  (1) From team chats

  (2) Strategy Frequency Estimation Method (SFEM)

Coding of Team Chats/Strategies

- Experimenters first identify strategies/issues to code.
- Two students code up data – starting first with a sample of data.
- Meet with experimenters to clarify differences in coding.
- Code full data set.
- Coders identified – and provided samples of unanticipated "strategies"
- Teams employing the *same* strategy across super-games typically no longer discuss strategy. In these cases – if behavior is the same – coded as the same strategy.

Strategies

- *Always Defect*: See examples reported earlier.
- *Grim* (including Grim 2 and 3):"My plan is choose C first for a few times, and if the other team keeps choosing D, we will switch to D."
  - *Grim with counting:* planned to start with Grim, but if mutual cooperation established, unilaterally defect, typically in St 6-9.
    - Based on "gambler's fallacy" - SG likely to end around St 10, so defect before their opponent does.
- *TFT*: "So this is the dove's and hawk's game. … C first then play tit for tat?"

  "anyway, I heard the best why to play the hawks and doves game is tit for tat with some room for forgiveness" Usually associated with something they had learned in class.
- *Generalized suspicious TFT: (*i) choosing D to begin with out of fear of getting the sucker payoff, followed by (ii) efforts at mutual cooperation if opponent plays C early on.
  - Simple case "I will choose D this match …if they choose C we can catch on" – leads to mutual cooperation if opponent playing Grim 2 or 3.
  - More complicated case: beginning with St 1 (own choice listed first): DD, DD, CD, CD, DC, CD, CC thereafter. Note that if their opponent's strategy was Always Defect, STFT would not be identified other than through the team chats.
- *Always Cooperate*: **no** evidence for this effect in the chats.
- WSLS: Never considered as well. (Inconsistent with long stretches of DD).

Strategies: Teams Chats compared to SFEM

(aggregate analysis)

Early (SGs 1-3)	Always Defect	Grim	TFT	STFT	Always Cooperate
Chats[a]	56	30	8	7	0
SFEM	42 (3.7)	27 (2.8)	9 (10.7)	18 (4.7)	3 (10.0)
Late (last 3)					
Chats[a]	24	53	12	11	0
SFEM	23 (3.3)	51 (9.0)	11 (16.5)	3 (6.5)	12 (10.8)

Percentage of super-games not coded: Early (7%) and Late (2%)

Strategies from Team Chats vs SFEM

- A reasonably close match between the two. *However*
- Never observed a commitment to always cooperate. What SFEM estimates most likely is identify is both teams play Grim, resulting in joint cooperation for an entire SG.
- The category Grim includes
  - Grim 2 and 3 (18 teams doing so in one or more SGs).
  - Grim with counting – 8% and 9% of teams playing Grim in first 3 and last 3 SGs respectively.
    - Average stage game in which defected – 10.2!
  - Introducing Grim 2 and 3 into SFEM essentially eliminates Always Cooperate

- STFT includes true STFT – DC CD DC, etc. As well a Generalized STFT – start out with Defection but looking to Cooperate.

Changes in Strategy Over Time (SGs1-7)

Strategy	Frequency	Number of Teams[+]
Always Defect	19.6%	11
Cooperate*	36.7%	20 (4)
Defect to Cooperate	44.6%	25 (7)

11 teams played Always Defect for the first 7 SGs. Never changed!

20 consistently adopted one of cooperative strategies – Grim, TFT, STFT, Generalized STFT
(Number is parentheses indicate backsliding 1-2 SGs.)

25 teams switched from AD to one of cooperative strategies. On average 4 SGs prior to switch.
No team switched from one of the cooperative strategies to Always Defect.

Teams locked into mutual defection occasionally make an effort to cooperate. Example: Mutual cooperation St 2-9. In St 10 one defects - DD through St 17. Defector unilaterally switches to C, with CC for the following 9 st-g games.
(Not common, occurring in 8 (longer SGs) – CC re-established in 4 out of 8).

Table 4
Team versus Individual Strategies: SFEM Estimates with Grim2 and 3
(bootstrap standard errors of the mean in parentheses)

Early (SGs 1-3)	Always Defect	Grim	Grim2 and 3.	TFT	STFT	Always Cooperate	WSLS
Individuals	30*** (6.6)	11 (7.1)	6 (4.0)	30*** (8.5)	22** (9.0)	1 (2.3)	1
Teams	44*** (10.4)	2 (6.3)	2 (4.0)	32*** (12.5)	20** (8.1)	0 (0.1)	0
Late (last 3)							
Individuals	15*** (5.5)	10** (5.2)	24*** (8.7)	33*** (7.8)	16*** (5.2)	2 (4.4)	0
Teams	19* (10.0)	19 (18.6)	19** (9.6)	27* (16.2)	15** (5.9)	0 (0.0)	0

Strategies: Teams vs Individuals

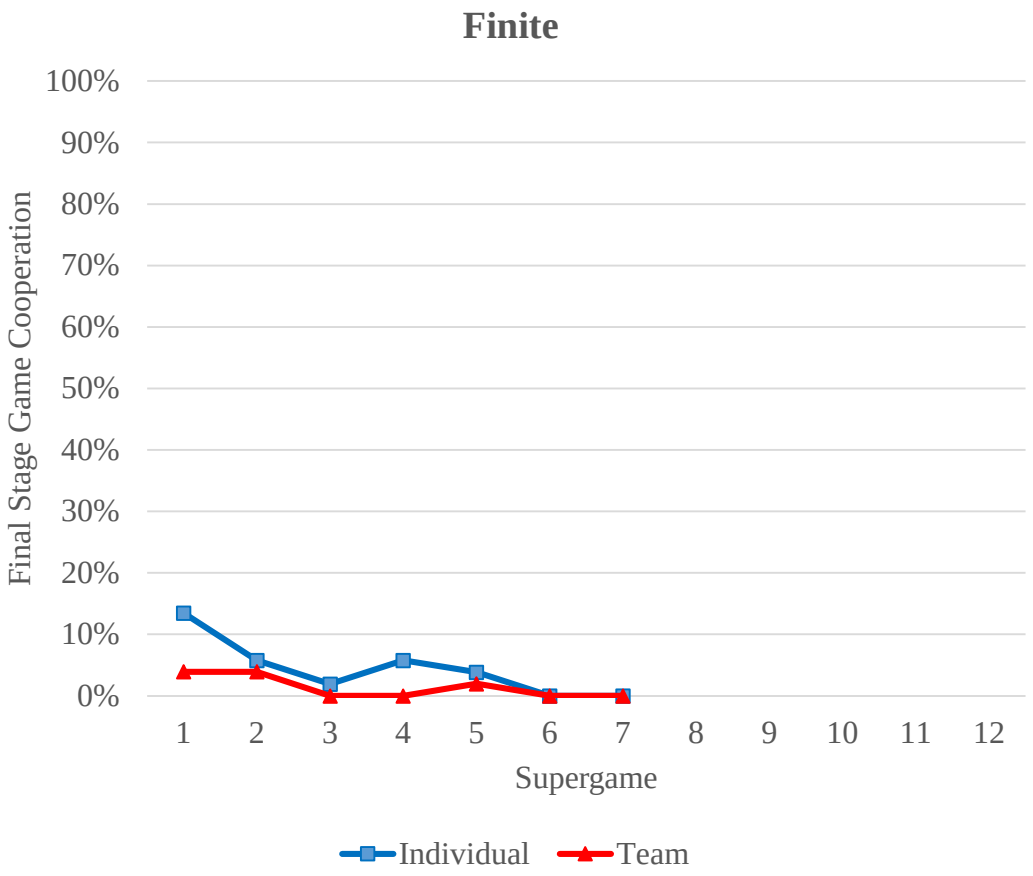
- Always Defect substantially lower for individs to begin with (30% vs 44%), consistent with probit estimates - teams less cooperative to begin with.
- Always Defect halved by super-games 4-7, with the differences between teams-individs eliminated.
- Grim 2 and 3 are estimated with high frequency over the last 3 super-games.
- Adding Grim 2 and 3 has strong impact on estimates of other strategies:
  - Always Cooperate is at 20% (12%) for individuals (teams) in SG 4-7 without Grim 2 & 3 - 2% (0%) when Grim 2 and 3 included.
  - TFT also increases substantially, from 11% (19%) for individuals (teams) in SG 4-7 without Grim 2 and 3 to 27% (33) in later SGs

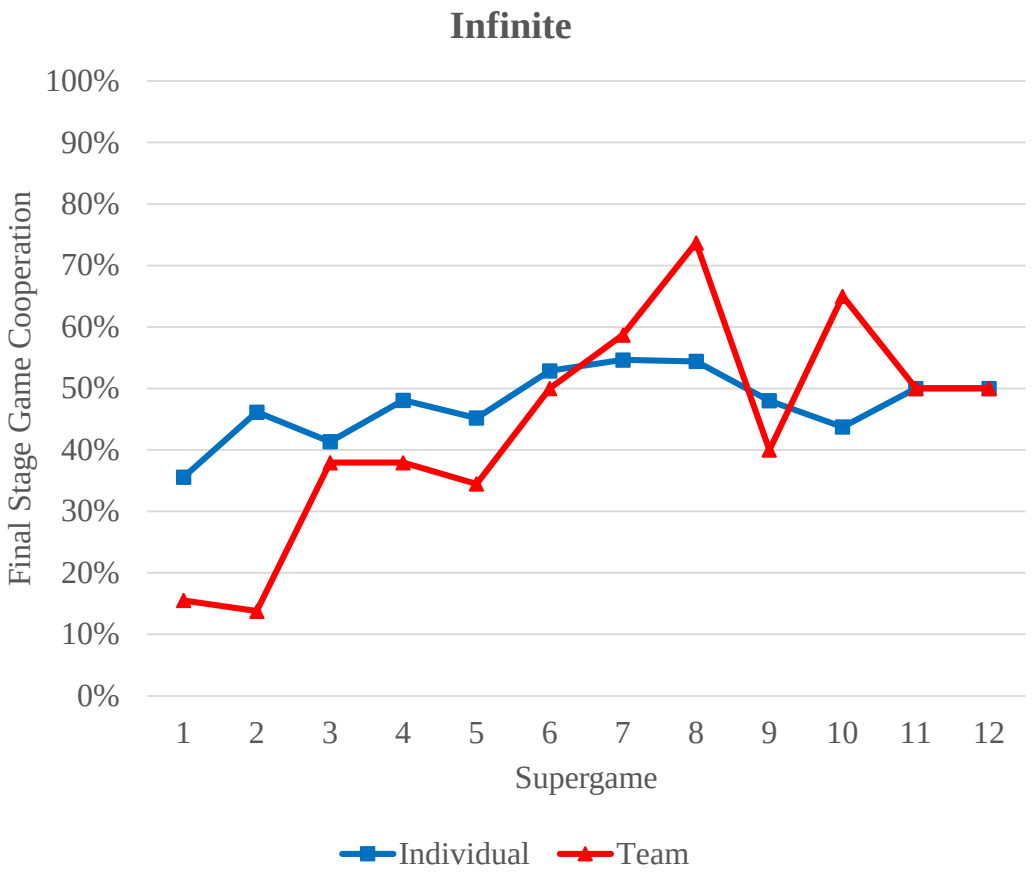
Strategies for Teams Familiar with PD Games
(10 teams identified)

- Example: “we should choose D …haha yeah its called the prisoner’s dilemma from nash equilibrium … You ever learn about that in econ?
- 3 of 5 starting with Always Defect continued throughout the session - 2 switched to Grim.
- Those choosing AD had, apparently, not covered repeated play games in their classes, or missed that day’s class ☺
- Frequency of these agents using one of cooperative strategies to begin with only slightly higher than for teams as a whole.

Comparing Cooperation Rates: IRPD vs FRPD

Comparing IRPD with FRPD: Final Stage Games





FR vs IR: Final Stage Cooperation Rates

- As would be expected final stage game cooperation rates are converging to zero for FR games. They converge faster for teams, consistent with the assertion that teams are more rational than individuals.
- For IR games final stage cooperation rates are increasing over time consistent with the increasing stage 1 cooperation rates along with the fact that behavior is “sticky” across stage games.

Table 5

Stage 1 Cooperation Rates: FR vs IR

	Individuals			Teams		
	Finite	Infinite	Diff	Finite	Infinite	Diff
Super-Game 1	61.5%	47.1%	14.4%*	65.4%	59.6%	5.8%
Last Common Super-Game	65.4%	59.6%	5.8%	68.6%	65.5%	3.1%

- Stage 1 cooperation rates higher for FR vs IR games – contrary to Dal Bo (2005).
- Dal Bo's continuation values much lower than in KM - .1 and .3 versus .9.
- Has two effects: (1) unraveling will take longer here; (2) Larger number of FR stage games greater incentive for "fully rational" to imitate the "crazies" early on.

Summary and Conclusions

- Teams less cooperative to begin with - consistent with the “discontinuity effect” reported in the psychology literature.
  - These lower cooperation rates result of seeking safety from sucker payoff and failure to even consider cooperating (myopia).
- Cooperation rates increasing over time for both teams and individuals – but faster and greater for teams.
- Team chats provide alternative to SFEM method.
  - Quite similar at aggregate level providing important verification of value of SFEM.
  - Differences (at micro level): (i) Absent commitment devices, strategies change *within* a SG, and (2) Identify strategies not reported previously; e.g., Grim 2 and 3 (absent “noise”), Grim with counting, no subjects play Always Cooperating.
- Stage game 1 cooperation rates higher in FR vs IR games with long FR games.
- Study not fit easily into arguments that teams more rational than individuals since, given the folk theorem, IRPD games have multiple equilibria.

Our Favorite Quote

106: i think we should choose D everytime
113: Game theory says we should choose C
106: because theortically we could make the most that way
113: ...
113: But this is Trump's america lol
113: and I was thinking D too
106: i think the other team will do the same thats why
106: and if they choose C then right now we'll get 175

Team coded as Generalized STFT as SG-4 decided to try C "I think we should try C" … "but if we switch to C then they will too. They started with C. Meaning they might be willing to go back" Got CC in St 5 and after!