The Enemy of my Enemy: Competitive Framing in Repeated Prisoner's Dilemmas

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Abstract

The tension between selfish behavior and cooperation is a social dilemma often encountered in ordinary life which essence is captured by the Prisoner's Dilemma. This tension can be alleviated or exacerbated if the game is framed in a cooperative or competitive way, respectively. In this study, we investigate how a competitive framing can increase cooperation as long as the hostility is redirected from the partner to an opposing pair of players. We design an experiment in which we frame an indefinitely repeated Prisoner's Dilemma as a competition between pairs of players whose goal is to accumulate more aggregate payoffs. The findings show that a simple framing device, even without additional monetary rewards, is able to increase cooperation among participants in a controlled lab experiment. Moreover, the effect gets stronger as the players gain experience, showing the power and reliability of this framing device.

1 Introduction

The social dilemma between selfish behaviors and cooperation emerges during day to day human interactions. This tension does not only affect human relationships, but it also affects individual behavior in a society, since

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there is a trade-off between what is socially, but not individually optimal. This social dilemma is of great interest and it has been investigated in so many studies that an extensive review of the literature will go beyond the aim of this work[1].

In this paper, instead, we focus our attention to a particular behavior firstly reported in the seminal experiment of Deutsch (1958); how the framing of the instructions induces the subjects to behave in a cooperative or individualistic way in a Prisoner's Dilemma. In his work, the instructions were heavily loaded, strongly implying the behavior that was expected from the participants. Subsequent works show that simply changing the name of the game has significant effect on behavior. Eiser & Bhavnani (1974) finds more cooperation when the situation in the game is described as an international negotiation rather than a business transactions. Others studies (Kay & Ross, 2003; Liberman et al., 2004; Ellingsen et al., 2012) find the same differences between games called *"Community Game"* and *"Stock Market Game"* respectively, without relying on additional framing or context. While, the results found in Engel & Rand (2014) offers a different interpretation of the effect previously reported. In the paper, the authors find that there is no significant difference between games with a neutral or competitive framing, but there is a significant lower cooperation when the game is labeled in a competitive way.

The aim of the present paper is to expand the literature on framing effects in a Prisoner's Dilemma by designing and implementing a new experiment. Our goal is to understand if a competitive framing can be used to increase cooperation. To do so, it is necessary to deflect the rivalry from the partner to someone else, therefore we implement a tournament in which pairs of players compete with the goal of scoring more points, expressed as the sum of the payoffs of both members of the pair.

Indeed, the competitive framing that we propose, as we call it, tournament, is different from previous works because the competition is deflected from the partner to an opposing pair of players. Moreover, in our design, the subjects will play a series of indefinitely repeated Prisoner's Dilemma, while in previous works the subject play a game, one-shot or finitely repeated, only once. By letting the subjects play more games allow us to study the evolution and sustainability over time of cooperation.

[1]We refer to the survey of Dal Bó & Fréchette (2018) for an exhaustive analysis on the determinants of cooperation in a Prisoner's Dilemma.

Many theories have been developed to explain the framing effects, among those there is *Team Reasoning*, proposed by Bacharach (1999, 2018), a model that theorize the individuals within a team pick the strategy profile that is the best outcome for the team. Other models conjectures that the framing activates social preferences that are otherwise absent, it influences the way others may interpret certain behaviors, or it acts as equilibrium selection device[2]. In some way or another, all this models require that a players care about the well being or opinion of others. We, instead, propose a model that works also for self-interested individuals and predicts higher levels of cooperation in the tournament. The main intuition behind this mechanism is that the presence of an opposing team, an enemy, can induce weak links between team members aligning incentives toward cooperation. The player with whom you are playing the PD now become your ally, when it would have been normally your opponent. Moreover we can conjecture that players will attach a non monetary utility to winning the competition. This mechanism is extensively used in work places, sports and personal relationship.

In this study, we want to investigate if it is possible to obtain a better level of cooperation even in the controlled environment of the laboratory, furthermore, we will provide a theoretical justification to our intuition and heuristic observations. The main idea about the theoretical justification is that with the introduction of the tournament, and a related utility from winning it, there is a decrease in thresholds of the discount factors necessary to have cooperation in a sub-game perfect and risk dominant equilibria. Although, we propose an alternative explanation, this work is not designed to prove or falsify existing models. Our primary goal is to document the effect that a tournament has on behavior.

Our study contributes to the literature of framing and of Prisoner's Dilemma in multiple ways. It contributes to the literature on the theory of framing by proposing a model that does not rely on the assumption that players must care about the payoffs or opinions of others. Moreover, the experiment differentiate itself from previous ones. The participants in our experiment play multiple instances of the game, while in previous works they play the game only once[3]. This allow us to study the evolution of cooperation over time, showing that the effectiveness of competitive framing increases as the subjects earn experience. We find that the introduction of the tournament increases considerably cooperation among players, and most surprisingly, this effect

[2]Ellingsen et al. (2012) presents the relevant literature in a more structured way and test the different hypothesis with their experiment.

[3]In both Ellingsen et al. (2012) and Engel & Rand (2014) the subjects play a one-shot PD once, while in Lieberman et al. (2004) they play a 7 round PD once.

increases over time. This suggests that players learn to coordinate during the experiment and tournament setting is a reliable mechanism for achieving a desirable level of cooperation among members of the same group.

The paper is organized as follows: Section 2 will provide theoretical justifications regarding the effect of a competitive framing in a infinitely repeated PD. In Section 3, we describe in detail the experimental design. The results are presented in Section 4 and Section 5 concludes.

2 Theory

In this section, we discuss the theory of the Prisoner's Dilemma and how it reflects in the behavior observed in a laboratory. After defining the relevant mathematical objects we look at the existing experimental literature. This process will help us to understand and it will guide our predictions about the behavior of subjects during and experiment. Finally, we present a theoretical model that gives a possible justification to our experimental design. Our model, differing from other already present in the literature, works even for self-interested individuals[4].

2.1 Infinitely repeated PD and Determinants of Cooperation

Game theory offers us a tool to model the tension between selfish incentives and social efficiency, the prisoner dilemma (PD from now on). PD is 2×2 game in which players can choose between cooperation and defection. Joint cooperation leads to a reward payoff (R), the tension is introduced by a temptation payoff (T) achieved by defecting while the other player cooperates, leaving the other player with the sucker payoff (S). Mutual defection leads to a punishment payoff (P). In order to define a PD it is required that T>R>P>S. Often it is also required that 2R>T+S, this ensures that cooperation generates a higher combined outcome, and therefore, alternating between cooperation and defection is not more profitable than joint cooperation. In order to simplify the exposition, we perform the transformation adopted by Dal Bó and Fréchette (2011), allowing us to define the game using only two parameters, g which is the gain from defection when the other

[4]With self-interested individuals, we mean subjects that care only about themselves, but not necessarily only about their material payoff, which are usually called selfish in the literature. In our model, the players care about their material payoff and the utility they derive from winning a competition, hence they are self-interested, but not selfish.

player cooperates and ℓ which is the loss from cooperation when the other player defects.

Table 1: PD Row Player's Payoffs, Original and Normalized

1/2	**C**	**D**
C	R	S
D	T	P

1/2	**C**	**D**
C	$\frac{R-P}{R-P} = 1$	$\frac{S-P}{R-P} = -\ell$
D	$\frac{T-P}{R-P} = 1+g$	$\frac{P-P}{R-P} = 0$

Since cooperation is a dominated action in the one-shot game, standard game theory tells us that repeated interaction is necessary for a rational and payoff maximizer player in order to have credible punishments and rewards that can lead to cooperation in a subgame perfect equilibrium (SPE).

The first wave of experiments that investigated the role of repetition in PD were conducted by Roth and Murnighan (1978) and Murnighan & Roth (1983). They introduced a random termination rule in which at every round there is a probability δ that the game will continue to the next round. This probability δ replaces the discount factor and allows the experimenter to implement an infinitely repeated game in the laboratory. These authors found that cooperation increases with δ, but not monotonically. A second wave of experiments confirmed those findings with stronger evidences. Dal Bò (2005) found that cooperation increases fourfold from an one shot PD to a indefinitely repeated PD with $\delta = 0.75$. The effect is stronger also because in that experiment participants played several supergames, implying that learning is also a driver of cooperation. A more detailed meta-analysis is available in Dal Bò & Fréchette (2018). In this paper the authors conclude that *"Cooperation is increasing in the probability of future interactions, and this effect increases with experience"*.

The continuation probability is not the only determinant for cooperation. Since a PD is defined by its parameters g and l, it is logical to assume that also these parameters have an important role. For any payoff matrix we can calculate the minimum δ required to sustain cooperation in a SPE:

$$\delta^{SPE} = \frac{g}{1+g}.$$

In a similar way, we can compute the minimum delta such that cooperation is part of a risk-dominant equilibrium:[5]

$$\delta^{RD} = \frac{g+l}{1+g+l}.$$

[5] Harsanyi & Selten (1988) define risk dominance for 2×2 games. It is possible to

In the same aforementioned survey Dal Bò & Fréchette (2018) conclude that on average cooperation is greater in treatments in which it can be supported in equilibrium, and even greater when cooperation is risk dominant, but these factors do not imply that a majority of subjects will cooperate. Moreover has been shown that the signs and the magnitudes of $(\delta - \delta^{SPE})$ and $(\delta - \delta^{RD})$ are statistically significant and predict the amount of cooperation achieved in a treatment. Moreover, in Dal Bò & Fréchette (2018) the authors study also the evolution of cooperation in relation to the game parameters, in this case expressed using δ^{SPE} and δ^{RD}. They find that cooperation decreases with experience when it is not risk dominant but increases with experience when it is risk dominant. We will rely on these findings to justify and predict the effects of our treatment.

Despite of the statistical significance of the indexes $(\delta - \delta^{SPE})$ and $(\delta - \delta^{RD})$, a large amount of variation among treatments remains unexplained, moreover there is a lot of heterogeneity among participants. Therefore, it is obvious to expect that personal traits and preferences could be a driver of cooperation. Those determinants have been deeply studied in the vast literature on the Prisoner's Dilemma, but we decide to do not focus on them and to try to find an explanation that can work even for self-interested individuals.

2.2 Competitive Framing in infinitely repeated PD

In this section, we investigate how a competitive framing can affect the equilibria of the game. Theory of framing studies how different labeling of the game or the actions affects the behavior. The possible explanations are numerous and they rely on a multitude of general principles. Ellingsen et al. (2012) summarize and develop the existing theory and we defer to this paper for more detailed analysis. In synthesis, the most prominent theories assume that players have altruistic traits or care about the opinion of others, but they are frame dependent and they are triggered only if the framing of the game suggests so. Alternatively, other theories posit the framing affects the beliefs and not the preferences, and it acts as coordination device for the possible equilibria. Notice that also this class of theories assumes that the players have other regarding preferences, therefore even if the game form is a PD, the actual game resembles a different one. The model proposed here differs from the existing one because we don't assume any type of other regarding preferences or image concerns. We assume that the players are purely self-interested. Although we make less assumption about players' preferences

extend the concept of risk dominance to repeated games using auxiliary 2×2 games that implement specific equilibrium strategies. For more reference see Blonski & Spagnolo (2015).

than the previous theories, it must be noted that our model relies on a particular setting, a direct competition among groups of players. From now on we refer to this competition as tournament. Previous theories assumed that very few aspects of the game were changed, usually only the labeling of the game or actions. Our changes to the game are more drastic, but it doesn't means that our results are less applicable to real life situations. Given the fact that re-framing a situation is cost-less, our setting can be efficiently implemented in social context in which a social dilemma can arise, let alone all the situations in which competition is naturally present. After this preamble we proceed to present our model.

The Model In the tournament two pairs, teams from now on, of players play an infinitely repeated PD. Players are informed about the presence of an opposing team. In order to win the competition a pair of players must achieve the highest cumulative sum of aggregate payoffs (Points from now on). Winning the tournament does not give any additional material payoff to the winners, moreover the actions of one team don't have any direct effect on the payoffs of the other team. The payoff matrix is the same for all players.

Let now assume that each player assigns a positive non monetary utility upon winning the tournament, $W \geq 0$, in addition to the monetary payoff of the game. Therefore, a player will receive this extra utility only if the points of his team are higher than the ones achieved by the other team. Moreover, we assume that each player has a conjecture about the cooperation achieved by the other team, [6] we will call it X and it will represents the points believed to be necessary to beat the other team [7]. In the presence of the tournament a player must consider the utility W provided by the winning when he decides his strategy. This translate in two main results.

Proposition 1. *Let W and X be the utility given by winning the tournament and the conjecture about other team's points, respectively, then the minimum discount factor necessary to have cooperation as part of a SPE in the presence of a tournament δ^{SPE^*} is lower than δ^{SPE} in absence of the tournament. Moreover δ^{SPE^*} is equal to:*

$$\delta^{SPE^*} = \frac{g - W(\mathbb{1}_{(\frac{2}{1-\delta}>X)} - \mathbb{1}_{(1+g-l>X)})}{1+g-W(\mathbb{1}_{(\frac{2}{1-\delta}>X)} - \mathbb{1}_{(1+g-l>X)})} \leq \frac{g}{1+g} = \delta^{SPE}.$$

[6] We assume for simplicity a degenerate (i.e. Dirac's Delta) belief. Results generalize to any distribution.

[7] We assume that W and X are homogeneous across player for sake of simplicity. Results will hold also with heterogeneous player because we will simply take $\delta^{SPE^*} = \max\{\delta_1^{SPE^*}, \delta_2^{SPE^*}\}$.

Proposition 2. *Let W and X be the utility given by winning the tournament and the conjecture about other team's points, respectively, then the minimum discount factor necessary to have cooperation as part of a risk-dominant strategy in the presence of a tournament δ^{RD^*} is lower than δ^{RD} in absence of the tournament. Moreover δ^{RD^*} is equal to:*

$$\delta^{RD^*} = \frac{g + l - W(\mathbb{1}_{(\frac{2}{1-\delta} > X)} - \mathbb{1}_{(0>X)})}{1 + g + l - W(\mathbb{1}_{(\frac{2}{1-\delta} > X)} - \mathbb{1}_{(0>X)})} \leq \frac{g+l}{1+g+l} = \delta^{RD}.$$

To prove the first proposition, we followed the proof of Nash reversion introducing the utility W and taking into account the points generated by each strategy. We followed the same logic to prove proposition 2, while following the proof of Blonski & Spagnolo (2015). The detailed proofs can be found in the appendix A.

In light of these two results and the evidences from previous experimental studies, we can justify our expectation of a positive effect of the treatment if the continuation probability δ above δ^{SPE}, but below δ^{RD}. If the utility from winning the tournament is high enough for the participants, we will observe levels of cooperation and learning patterns that resemble those found in game in which cooperation is a risk-dominant strategy.

3 Experimental Design

In our between-subject experiment, the participants play an indefinitely repeated prisoner's dilemma in a lab-experiment. We implement the design adopted in one of the treatments of Dal Bò & Fréchette(2011), namely one in which cooperation can be sustained in a SPE but not in a risk dominant-strategy. The indefinitely repeated prisoner's dilemma is a multi-stage game in which, at each round, the participants play a PD, choosing between two actions, *Cooperate* or *Defect*[8]. At the end of each round, there is a fixed and known probability δ that the game will continue to the next round and the participants will play again the same game with the same partner. We call supergame the series of consecutive stage games played with the same partner. Each stage game has the following game parameters: Reward payoff (*Cooperate, Cooperate*) 32, Punishment payoff *(Defect, Defect)* 25, Temptation payoff (*Defect, Cooperate*) 50, Sucker payoff (*Cooperate, Defect*) 12. These payoffs are expressed in Experimental Currency Units (ECU). These

[8]During the experiment the actions will be labeled as action 1 and 2 respectively. This is done to avoid unwanted framing effects that may arise when a non neutral labeling of the actions is used.

parameters remain fixed during the whole experiment and they are the same in the every treatment. The game form of each PD game is represented in Table2.

Table 2: Game payoffs

		The other's choice	
		Cooperate	*Defect*
Your choice	*Cooperate*	Reward payoff (32, 32)	Sucker payoff (12, 50)
	Defect	Temptation payoff (50, 12)	Punishment payoff (25, 25)

At the end of every stage game, each player receive a feedback about the action played by his partner and the corresponding outcome. These information are store until the end of the supergame and they are displayed on screen in a history box that contains the actions played in previous rounds by both players and relative outcomes.

When a supergame ends, new pairs are randomly formed and a new supergame, with the same rules, starts. We set the continuation probability to 0.75. The participants have 50 minutes to play as many supergame as possible, and their earning is computed as the sum of the outcome of every stage game. We refer to the subjects that play using this set of rules as *Control* group, or simply *Control*.

Out experimental design consists of a single treatment manipulation. In the treatment group (henceforth *Tournament*) the rules of the game are identical to those in the *Control*, with a single exception: we set up a competition among pairs of players (henceforth *Teams*). The rules of the competition are simple, two teams are matched randomly and the team that achieves the highest cumulative sum of payoffs at the end of the supergame is elected winner. The result of the competition, win, loss or tie, is displayed at the end of each supergame. Beware that winning the competition does not grant any additional monetary payoff, and participants are explicitly informed about that. Moreover the competition is strengthened by using a different language in the instructions; the experiment is explicitly called tournament, supergames are called matches, the pairs are called teams and the person with whom participants play the game is called teammate. See the differences in the instructions in appendix B.

Since the team that wins doesn't earn extra money, the tournament must be considered a framing effect. This is crucial to our investigation. Our goal is to study if it is possible to achieve more cooperation in situations similar to a PD by simply introducing a competition, deflecting the tension toward a common foe. If we let the winner earn more, we won't be able to disentangle the two effects, since it would have been impossible to understand if the subjects cooperated more due to the framing or the economic incentives.

3.1 Issues and Concerns

Infinite Repetition in Laboratory: Clearly, it is impossible to implement a real infinite repetition in a laboratory, therefore we adopt the methodology used in Roth & Murnighan (1978). We introduce a random termination rule, namely at the end of each round, there is a probability δ that the game continues and a probability $1 - \delta$ that the game ends. This probability is known to the players and it remains fixed for the whole duration of the experiment. Under the assumption of risk neutrality this termination rule induces the same preferences over outcomes as if the game were played with infinite repetition. The first issues with this methodology is that players potentially are not able to understand correctly probabilities and how these relate to the expected length of the supergame. Experimental evidences reported in Murninghan & Roth (1983) and Dal bò (2005) shows that participants, although not perfectly, have a good understanding of how δ relates to the average length of a supergame.

In Sabater-Grande & Georgantzis (2002), the authors find that subjects during the experiment react differently to the presence of a continuation probability based on their level of risk aversion. Although acknowledging this fact, we still believe that this doesn't undermine the validity of our design. All the parameters of the game, including the continuation probability, are the same in the *Control* and in the *Tournament*, this means that the effect observed in Sabater-Grande & Georgantzis (2002) is present in both groups. Moreover, the balance test confirms that the two samples don't differ significantly in risk attitudes. Since we are primarily interested in the effect of the treatment variable, and the aforementioned effect is present and equally relevant in both groups, it should not jeopardize our results.

3.2 Experimental Procedure

We recruited 94 participants (46 participants in control and 48 in treatment) from the subjects pool of the university of Côte d'Azur (Nice, France) using ORSEE (Greiner, 2015). The subjects pool includes students from many disciplines. The experiment was programmed using zTree (Fishbacher,

2007) and run at the Laboratoire d'Economie Expérimentale de Nice (LEEN). The payoffs are expressed in Experimental Currency Units (ECU), and, at the end of the experiment, participants are paid 0.005€ for each ECU earned during the experiment. The average payment was 21.42€, including the 5€ show up fee, and the experiments lasted on average 75 minutes. We ran 6 sessions, 3 for the *Control* and 3 for the *Tournament*. Each participant played exclusively in one of the two groups.

The experiments took place between September 23^{rd} and September 24^{th} 2020. At that moment, there were in places rules to ensure the safety of the participants and the experimenters, which were meant to minimize the risk of spreading the virus. Masks were mandatory during the experiment, the work stations were sanitized before and after each session and there was a limit of 16 people inside the laboratory. At the end of the experiment participants filled a brief questionnaire in which they self reported about: socio-demographics, generalized trust, risk aversion, altruism and rivalry. [9]

[9]See the questionnaire in the appendix section B.3.

4 Results

In this section, we are going to test our hypothesis analyzing the data we gathered during the experimental sessions. Firstly, we proceed with a description of the sample and we run a balance test in section 4.1. Then, we test our main hypothesis looking for a treatment effect over cooperative behavior. The analysis of a treatment effect is exhibit in section 4.2. In section 4.3, we study the evolution of subjects' decisions over time, looking for learning processes similar to those found in Dal Bò & Fréchette (2011). Next, in section 4.4 we investigate the strategic behavior. In addition, in section 4.5, we investigate if demographics and self-reported personal traits, may influence the subjects' choices. We end in section 4.6 with an exhaustive regression analysis.

4.1 Descriptive Statistics

We begin our preliminary investigation by depicting the descriptive statistics of our variables in Table 3. Afterward, we run a balance test, in order to demonstrate that our results are driven by the treatment effect and they are not due to an unbalanced distribution of relevant variables between control and treatment. Table 4 reports the results of the balance test, which confirm the robustness of our results.

Table 3: Summary of the descriptive statistics.

Variables	N	mean	s.d	min	max
Subject	10664	50.030	27.685	1	94
Treatment	10664	0.480	0.499	0	1
Choice	10664	1.666	0.472	1	2
Session	10664	3.632	1.750	1	6
Period	10664	4.250	3.523	1	21
Match	10664	75.084	43.702	1	158
Age	10664	23.977	5.004	18	49
Gender	10664	1.621	0.485	1	2
Occupation	10664	1.282	0.812	1	5
Disciplines	10664	3.406	2.151	1	6
Studies	10664	4.191	0.879	2	6
Experience in lab	10664	3.018	2.764	0	10
Trust (Q1)	10664	0.404	0.491	0	1
Trust (Q2)	10664	5.776	1.804	1	9
Risk loving	10664	5.617	1.881	0	10

Table 4: Balance test.

	Control vs Treatment	
Variables	*Z*	*p-value*
Age	1.017	0.309
Gender	1.105	0.269
Occupation	0.672	0.502
Discipline	1.412	0.158
Studies	1.480	0.139
Experience in lab	-0.130	0.897
Trust (Q1)	0.375	0.707
Trust (Q2)	-0.065	0.948
Risk loving	0.686	0.492

4.2 Testing treatment effect

The main objective of our study is to examine whether inducing a competitive frame (without additional economic remuneration) is sufficient to foster cooperative behavior, in a game were parameters are such that *Cooperate* is part of a SPE but it is not a risk-dominant strategy. In order to obtain a preliminary intuition, we present, in Figure 1, an histogram that shows the frequency of each choice in each treatment. We observe that in both treatments *Defect* is the predominant choice, in line with the literature Croson et al. (2005). Nevertheless, in the tournament treatment the cooperation is higher.

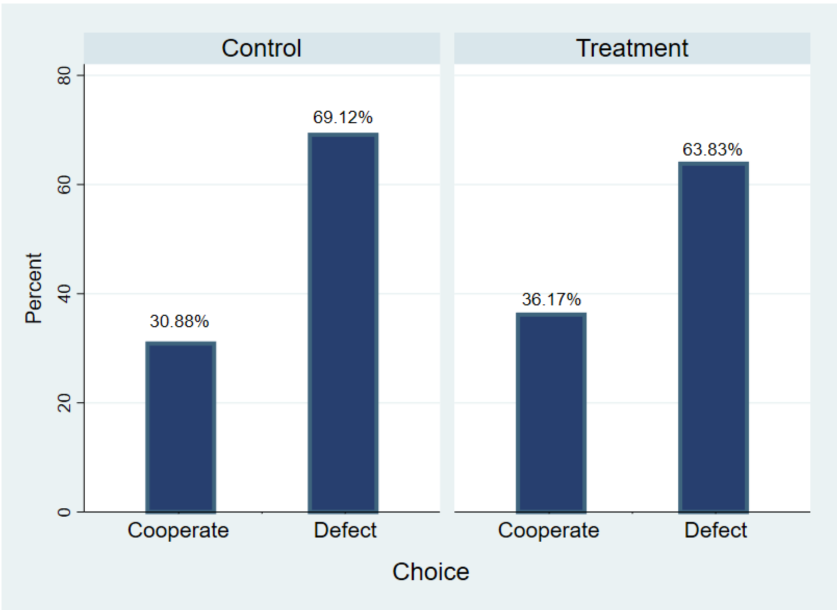

Figure 1: Percentage of cooperation in the control and in the Tournament treatment.

The average cooperation goes from 30.88% in the Control to 36.17% in the Treatment. The difference between Control and Treatment is statistically significant (p-value=0.000; Two-sample Wilcoxon rank-sum test). Our results suggest that the framing has a positive effect on cooperation, despite the fact that the Tournament offers no monetary incentives to do so. The presence of a common opponent induces the subjects to coordinate in order to beat the opponent team. Since cooperation gives a greater amount of points, the desire to beat the other team translates in a higher cooperation.

R1. *Framing the social dilemma in a competitive environment foster cooperative behavior.*

4.3 Evolution of Cooperation

We are also interested in studying the evolution of cooperation over the time in order to check whether the subjects learn and adjust their behavior. Table **??** shows the percentage of subjects that choose to cooperate in the first round of each repeated game in this treatment, with the repeated games aggregated according to the interaction in which they started. We follow the same procedure adopted by Dal Bò & Fréchette (2011).

Table 5: Percentage of cooperation by treatment.

Repeated games	Control		Treatment	
begin in interactions	*First period*	*All*	*First period*	*All*
1-10	50.00%	34.59%	50.00%	32.92%
11-20	44.20%	27.11%	55.21%	40.63%
21-30	42.53%	29.77%	52.09%	37.09%
31-40	43.75%	31.49%	58.34%	29.79%
41-50	41.01%	38.10%	55.73%	38.75%
51-60	36.61%	29.82%	50.52%	33.75%
61-70	37.50%	27.23%	49.48%	32.08%
71-80	39.98%	32.39%	54.17%	37.09%
81-90	33.09%	29.97%	54.86%	35.84%
91-100	33.53%	30.24%	58.33%	44.17%
101-...	33.86%	22.73%	65.63%	44.42%

To compare inexperienced versus experienced players, we compare behavior in the first ten interactions with those last interactions 102 to 145.[10] We can observe that experience in Control leads to more free riding, because the percentage of subjects' choosing to cooperate decreases with experience. The

[10]We do have data on repeated games that started even later, but because there are slight variations in the total number of interactions across sessions, the sample size is stable only up to interactions 102–145.

opposite is found in the Tournament Treatment, where the percentage of cooperation increases respect the first range of interactions (1-10). These results are statistically significant (p-value=0.000; Two-sample Wilcoxon rank-sum test).

R2. *Experienced subjects reduce cooperation in the Control, while in the Tournament cooperation is sustained and increases over the time.*

The results for the control group are in line with those found by Dal Bò & Fréchette (2011). If the parameters are such that cooperation is not risk-dominant we observe a decline over time. Instead, with the introduction of the framed Tournament, we observe a pattern that resemble the one observed by the two authors in games in which cooperation is risk-dominant. It shows that the framing is able to promote a desirable level of cooperation even in situations in which the game's parameters are not favorable enough.

4.4 Strategic behavior

We are also concerned about the outcomes of the stage games and check if they are consistent with the results previously found. Figure 2 shows the frequencies of the payoffs obtained in the Control and Treatment, respectively. The punishment payoff (*Defect, Defect*) is predominant in both treatment, although it is significantly less frequent in the Treatment (p-value=0.000; Two-sample Wilcoxon rank-sum test). Conversely the reward payoff (*Cooperate, Cooperate*) is more frequent in the Treatment, the difference is statistically significant (p-value=0.000; Two-sample Wilcoxon rank-sum test). This is in agreement with the results previously found, cooperation is more frequent in the presence of the tournament. Despite the difference in the frequency of reward and punishment payoffs there is no statistical difference in the frequencies of sucker/temptation payoffs between the two treatments (p-value=0.237; Two-sample Wilcoxon rank-sum test).

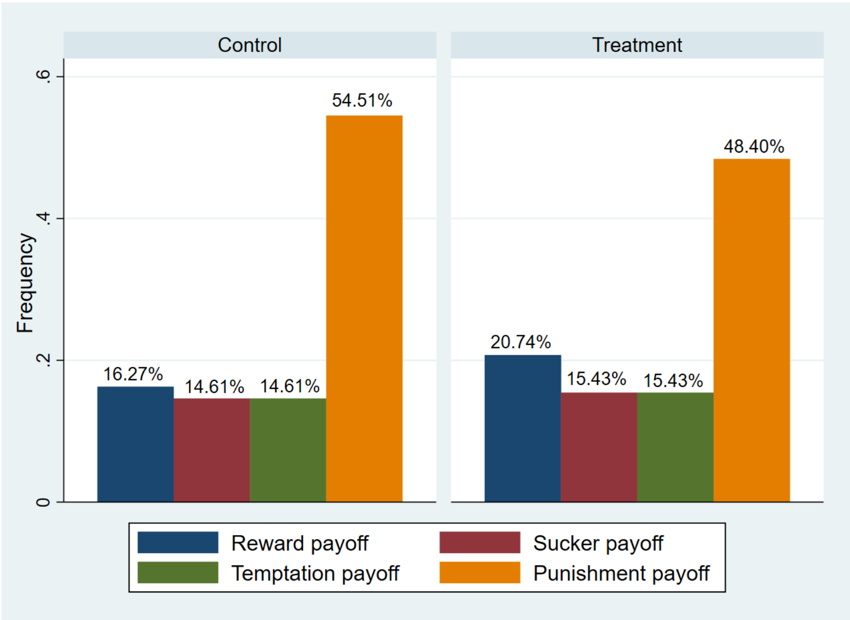

Figure 2: Frequency of the outcomes by treatment.

Now we investigate the percentage of those who keep cooperating even after observing a defection from their partner. In the control 29.57% of the times *Cooperate* is played after observing defection, while it is played 29.11% of the times in the treatment, the difference is not statistically significant (p-value=0.862; Two-sample Wilcoxon rank-sum test). This means that in the tournament subjects are not willing to sacrifice their own payoff in exchange for a higher chance of winning (remember that the sucker payoff gives more points than mutual defection). Based in our results we can suggest that the tournament seems to act as a coordination device that bolster cooperation.

4.5 Personal Traits

At the end of the experiment, subjects replied to a brief questionnaire, along with their demographics, they self reported some personal traits. The traits reported are generalized trust, and risk attitude. Here we investigate how these traits are reflected in behaviors.

Generalized trust seems to play an important role. Both questions about generalized trust conclude that subjects who trust more, significantly play *Cooperate* more often (p-value=0.000; Two-sample Wilcoxon rank-sum test). This result is in line with the theoretical literature on the basin of attraction of AD, as presented in Dal Bò & Fréchette (2018). In the same vein, subjects' more risk loving significantly cooperate more (p-value=0.000; Two-sample Wilcoxon rank-sum test).

Moreover, we study whether the demographic variables play a role in the decision process between cooperation of defection. We found evidence of woman playing *Defect* more often, while man are more cooperative (p-value=0.000; Two-sample Wilcoxon rank-sum test). Subjects with higher level of formation select more often to *Defect* (p-value=0.000; Two-sample Wilcoxon rank-sum test). Furthermore, our results suggest that subjects that have more experience in lab-experiments are more prone to defect (p-value=0.000; Two-sample Wilcoxon rank-sum test).

4.6 Main results

In this section we run a more accurate in order to better understand the dynamics of the learning process. Table 6 presents a Fixed effect model by within-group estimator[11] with cluster-robust standard errors at the subjects level.[12] There are two models one for control and another for treatment, which dependent variable is subject's choice related with the followinf independent variables: autoregressive process AR(1) of choice introduce by a lag, period (trend), first period, and just for treatment the fact of winning the tournament.[13]

[11] We have run the F-test confirms that fixed effects is prefered to pooled OLS (control p-value=0.000; treatment p=0.0000), because we reject the null hypothesis, which confirms the existence of unobservable heterogeneity. Therefore, pooled OLS will be a biased estimator and Fixed effect is be more appropriate. After, we proceed to confront Fixed effect with Randon effects by the Hausman test which reports a p-value of 0.000, then, we reject the null hypothesis of difference in coefficients not systemic. Thus, we conclude that the most appropirate estimator is Fixed effects.

[12] We cluster the standard errors at the level of subjects, because participants are engage in a sequence of prisioner's dilemma (Moffat, 2015). The main motivation behind the clustering is to solve the problem of heteroskedasticity and serial correlation AR(1) found by Green's test for groupwise heteroskedasticity (p-value=0.000) and Wooldridge test for serial correlation AR(1) (p-value=0.000). Furthermore, we runned the Pesaran(2004) CD test to control for cross-sectional correlation but we have not find any evedence (p-value=0.257).

[13] We have not implement a dynamic panel data by difference or system Generalized Method-of-moments, because of the structure of our data. David Roodman (2009) claimed "Apply the estimators GMM to "small T, large N" panels. If T is large, dynamic panel bias becomes insignificant, and a more straightforward fixed-effects estimator works." For our data, we have an N equal to 94 subjects, and T (the cummulative interataction inside the session) which is equal to al least 102 and at maximum 145, which overcome the standars of length of time variable which is around 10, and also T>N. Hence following the former

Table 6: Fixed effects by within-group estimator explaining choices.

Variable	Control	Treatment
Lag of choice	0.302***	0.216***
	(0.038)	(0.036)
Period	0.001	0.015***
	(0.003)	(0.003)
1st Period	-0.084*	-0.148**
	(0.045)	(0.041)
Win		-0.150***
		(0.014)
Constant	1.1200***	1.397***
	(0.068)	(0.055)
Observations	5498	5072

The variable choice takes 1 if the subject decides to cooperate and 2 if he/she decides to defect. The variable win takes 2 when the subject's team wins the tournament, in case of tie takes 1, and 0 if their team lose it. Robust standard errors in parenthesis ***p<0.01, **p<0.05, *p<0.1

From the Table 6, we reach the following conclusions. We found a significant and positive value of the AR(1) coefficient which is greater in the case of control in confront to treatment. This lead as to conclude that the choices in the previous period bring to more defect, whihc is more salient in the case of control regard treatment. While in the case of the variable period, which represents the trend, it is only significant for treatment. This reinforce the salience of the effect of the framed trounament and refinate *Result 2*, because the increasing trend seems to be stastiscally relevent just in case of treatment. While, the first period has a negative and significant effec for control and treatment. As expected, the results suggest that in the first period is more likely to cooperate. Finally, the variable win has a significative effect over treatment, which means that subjects cooperate more when the win more. The outcome support that the framed tournament seems to elicit cooperative behaviour.

suggestion, we implement instead a Fixed effect estimator.

5 Conclusions

Many studies investigated the framing effects on a Prisoner's Dilemma, documenting how a competitive framing decreases the cooperation among partners. In this work we design an experiment in which the competition is diverted towards an opposing team. The partner, that was seen as an enemy, becomes a friend in virtue of being an ally against different opponents. We achieve this by implementing a tournament, in which the goal is to accumulated more payoff as a team, but there are no economic incentives to do so.

We find that cooperation is significantly higher with the introduction of the tournament, this finding is robust and it persist upon further investigations. The tournament is in essence a framing, since it does not modify the payoffs or the game form in a meaningful way for a selfish and risk-neutral player. Framing effects are well documented in the literature, and experimenters are aware of those when they design an experiment. Having said that, the most surprising of our findings is that the positive effect of the tournament persist, and get stronger, over time. One could argue that this is a demand effect, namely subjects do what it is asked by the experimenter. The results do not support this argument, since the difference between the two treatments become more evident as subjects gain experience. This suggest that introducing competition in a situation in which there is a possibility for free-riding significantly reduces these problems. Moreover its effect don't vanishes over time, instead become stronger, suggesting that competition could be implemented as a long term solution.

Our results are in agreement with some findings of Dal Bó and Fréchette (2011) that studied the amount and evolution of cooperation is various PD with different game's parameters. They found that cooperation is higher in game where the parameters are such that cooperation is risk-dominant. Moreover, they found that cooperation increases with experience when it is risk-dominant, while it decreases over time in all other cases. We observe the same pattern for the control group that uses the same game form employed in Dal Bó and Fréchette (2011) for the treatment where cooperation is part of an SPE but not risk-dominant. Surprisingly, we observe for the tournament the same pattern that the authors found for treatment with risk-dominant cooperation.

Furthermore, we found that some of the personal characteristics of the subjects influence cooperation. Generalized trust is found to have a positive effect on cooperation. It is not unexpected to notice a greater willingness to cooperate among those inclined to trust others. In the same fashion, risk loving subject are more willing to cooperate, because they have less fear to the other subject taking advantage of them by free-riding. Our results suggest to policy-makers that framing competition is efficient strategy to sustain cooperation over time, because it is less costly respect the alternative by offering greater returns.

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A Proofs

A.1 Proof of Proposition 1

In order to prove proposition 1, we follow the proof of Nash reversion and we add to each strategy the value of winning the tournament W weighted by the subjective probability of winning given a conjecture about the other team's points. Therefore the equation become the following:

$$\sum_{t=0}^{\infty} \delta^t \cdot 1 + W\mathbb{1}_{(\frac{2}{1-\delta} > X)} \geq 1 + g + \sum_{t=1} \delta^t \cdot 0 + W\mathbb{1}_{(1+g-l>X)}$$

where $\frac{2}{1-\delta}$ are the points obtained by cooperating every round and $1 + g - l$ are to point obtained by the first round of defection, and mutual defection onward. Rearranging the formula we obtain:

$$\delta^{SPE^*} = \frac{g - W(\mathbb{1}_{(\frac{2}{1-\delta}>X)} - \mathbb{1}_{(1+g-l>X)})}{1 + g - W(\mathbb{1}_{(\frac{2}{1-\delta}>X)} - \mathbb{1}_{(1+g-l>X)})}.$$

A.2 Proof of Proposition 2

In order to prove proposition 2, we follow Blonski and Spagnolo (2015). To asses when coordination is risk-dominant we focus only on two equilibria in pure actions, the grim trigger strategy (GT), which is the least risky among cooperative equilibria (proof in Blonski and Spagnolo 2015), and always defect (AD). We build an accessory 2×2 game using only these two pure strategy equilibrium points. According to Harsanyi and Selten (1988) risk dominance in 2×2 games can be determined by comparing the Nash-products of the two equilibria, namely the product of both players' disincentives not to behave according to the equilibrium under consideration. We call these disincentives u_i for GT and v_i for AD, and they are defined as:

$$u_i = \sum_{t=0}^{\infty} \delta^t \cdot 1 - (1+g) - \sum_{t=1} \delta^t \cdot 0 \geq 0$$

$$v_i = \sum_{t=0}^{\infty} \delta^t \cdot 0 - (-l) - \sum_{t=1} \delta^t \cdot 0 \geq 0.$$

The grim trigger strategy is risk dominated by AD iff $v_1 v_2 \geq u_1 u_2$. From these relations we find that the threshold for δ below which GT is risk dominated is the following:

$$\delta^{RD} = \frac{g+l}{1+g+l}.$$

Similarly to proposition 1, we add the weighted value of winning the tournament, therefore the relations become:

$$u_i = \sum_{t=0}^{\infty} \delta^t \cdot 1 + W\mathbb{1}_{(\frac{2}{1-\delta}>X)} - (1+g) - \sum_{t=1} \delta^t \cdot 0 - W\mathbb{1}_{(1+g-l>X)} \geq 0$$

$$v_i = \sum_{t=0}^{\infty} \delta^t \cdot 0 + W\mathbb{1}_{(0>X)} + l - \sum_{t=1} \delta^t \cdot 0 - W\mathbb{1}_{(1+g-l>X)} \geq 0.$$

Using the the same procedures as before we get,

$$(l+W(\mathbb{1}_{(0>X)}-\mathbb{1}_{(1+g-l>X)}))^2-(\frac{1}{1-\delta}-(1+g)+W(\mathbb{1}_{(\frac{2}{1-\delta}>X)}-\mathbb{1}_{(1+g-l>X)}))^2 \geq 0$$

rearranging the formula we obtain:

$$\delta^{RD^*} = \frac{g+l-W(\mathbb{1}_{(\frac{2}{1-\delta}>X)} - \mathbb{1}_{(0>X)})}{1+g+l-W(\mathbb{1}_{(\frac{2}{1-\delta}>X)} - \mathbb{1}_{(0>X)})}.$$

B Appendix B: Instructions

B.1 Control Treatment

Welcome

You are about to participate in a session on decision-making, and you will be paid for your participation with cash vouchers, privately at the end of the session. What you earn depends partly on your decisions, partly on the decisions of others, and partly on chance.

General Instructions

1. In this experiment, you will be asked to make decisions in several rounds. You will be randomly paired with another person for a sequence of rounds. Each sequence of rounds is referred to as a match.

2. The length of a match is randomly determined. After each round, there is a 75% probability that the match will continue for at least another round. This probability is always the same regardless of the round. So, for instance, if you are in round 2, the probability there will be a third round is 75% and if you are in round 9, the probability there will be another round is also 75%.

3. At the beginning of a new match, you will be randomly paired with another person for a new match.

4. The choices and the payoffs (expressed in points) in each round are as follows:

	The other's choice	
Your choice	**1**	**2**
1	(32 , 32)	(12 , 50)
2	(50 , 12)	(25 , 25)

The first entry in each cell represents your payoff, while the second entry represents the payoff of the person you are matched with.
For example, if:

- You select **1** and the other selects **1**, you each make 32.
- You select **1** and the other selects **2**, you make 12 while the other makes 50.

- You select **1** and the other selects **2**, you make 50 while the other makes 12.
- You select **2** and the other selects **2**, you each make 25.

5. At the end of the 50 min, you will be payed 0.005€ (half of euro cent) for every point you scored individually in every round played during the whole experiment.
6. Are there any questions?

B.2 Tournament treatment

All the framing introduced in the instructions of the treatment that do not appear in control is indicated in italics.

Welcome

You are about to participate in a session on a tournament, and you will be paid for your participation with cash vouchers, privately at the end of the session. What you earn depends partly on your decisions, partly on the decisions of others, and partly on chance.

General Instructions

1. In this experiment, you will be asked to make decisions in several rounds. You will be randomly paired with a teammate for a sequence of rounds. Each sequence of rounds is referred to as a match.

2. **During each match your team will compete against one adversary team randomly chosen between the other teams in this experiment. The team that earns more points at the end of the match will be declared winner.**

3. The length of a match is randomly determined. After each round, there is a 75% probability that the match will continue for at least another round. This probability is always the same regardless of the round. So, for instance, if you are in round 2, the probability there will be a third round is 75% and if you are in round 9, the probability there will be another round is also 75%. **The match will end for both teams at the same time.**

4. At the beginning of a new match, you will be randomly paired with another **teammate and you will play against a new adversary team.**

5. The choices and the payoffs (express in points) in each round are as follows:

   The first entry in each cell represents your payoff, while the second entry represents the payoff of your **teammate**. **The sum of your payoff and your teammate's payoff in each round during the whole match will determine your total team's points in the match.**
   For example, if:

	Teammate's choice	
Your choice	1	1
1	(32 , 32)	(12 , 50)
2	(50 , 12)	(25 , 25)

- You select 1 and the **teammate** selects 1, you each make 32. **The team's points in the round will be equal to 64.**
- You select 1 and the **teammate** selects 2, you make 12 while the **teammate** makes 50. *The team's points in the round will be equal to 62.*
- You select 2 and the **teammate** selects 1, you make 50 while the **teammate** makes 12. *The team's points in the round will be equal to 62.*
- You select 2 and the **teammate** selects 2, you each make 25. **The team's points in the round will be equal to 50.**

If the total points of your team are higher than the total points of the adversary team, your team wins the match, otherwise your team loses.

6. At the end of the 50 min you will be payed 0.005€ (half of euro cent) for every point you scored individually in every round played during the whole experiment. ***Notice that you will not earn any additional money for winning a match.***

7. Are there any questions?

B.3 Questionnaire

Socio-Demographics

- How old are you?
- What is your gender? Male Female
- What is your occupation?
  ☐ Student
  ☐ Employee
  ☐ Unemployed
  ☐ Retired
  ☐ Other
- If you are a student, what is your field of study?
  ☐ Economy and management
  ☐ Social Sciences
  ☐ Arts and Humanities
  ☐ Engineering Sciences
  ☐ Medical studies
  ☐ Other
- What is your level of study?
  ☐ Elementary school license
  ☐ Middle school license
  ☐ High school license
  ☐ Bachelor's degree
  ☐ Post-graduate degree
- How much experience have you had with LEEN before?

Psychological questions: First

- Generally, do you have confidence in the majority of the people, otherwise for nothing "it is better not trust them"? ☐ Yes ☐No
- From 0 to 10, how much do you trust people in general, where 0 indicates "better not trust none" and 10 means "better completely trust"?

  0 1 2 3 4 5 6 7 8 9 10

- For scale from 0 to 10, how do you evaluate your behaviour in front of risk: you are person who avoids risk (1) or you love risk (10)?

0 1 2 3 4 5 6 7 8 9 10

Psychological questions: Second

- Feel indifference to others' misfortunes

  ☐Never ☐Almost Never ☐Sometimes ☐Frequently ☐Almost Always ☐ Always

- Try not to do favors for others

  ☐Never ☐Almost Never ☐Sometimes ☐Frequently ☐Almost Always ☐ Always

- Feel sympathy for those who are less fortunate than me

  ☐Never ☐Almost Never ☐Sometimes ☐Frequently ☐Almost Always ☐ Always

- Love to help others

  ☐Never ☐Almost Never ☐Sometimes ☐Frequently ☐Almost Always ☐ Always

- Avoid competitive situations

  ☐Never ☐Almost Never ☐Sometimes ☐Frequently ☐Almost Always ☐ Always

- Feel that winning or losing doesn't matter to me

  ☐Never ☐Almost Never ☐Sometimes ☐Frequently ☐Almost Always ☐ Always

- Drawn to compete with others

  ☐Never ☐Almost Never ☐Sometimes ☐Frequently ☐Almost Always ☐ Always

- Feel that I must win at everything

  ☐Never ☐Almost Never ☐Sometimes ☐Frequently ☐Almost Always ☐ Always