

EVERYONE IS A WINNER: PROMOTING COOPERATION THROUGH ALL-CAN- WIN INTERGROUP COMPETITION

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ABSTRACT

We test if cooperation is promoted by rank-order competition between groups in which all groups can be ranked first, i.e. when everyone can be a winner. This type of rank-order competition has the advantage that it can eliminate the negative externality a group's performance imposes on other groups. However, it has the disadvantage that incentives to outperform others are absent, and therefore it does not eliminate equilibria where all groups cooperate at an equal but low level. We find that all-can-win competition produces a universal increase in cooperation and benefits a majority of individuals if the incentive to compete is sharp.

Keywords: intergroup competition, cooperation, public goods, experiment

JEL-codes: H41, M52, C92

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1. Introduction

Teamwork is often beset with the notorious free-rider problem, and promoting cooperation within teams is therefore a key governance issue in a broad range of organizations. Because of its importance, a considerable literature in experimental economics has investigated the effects of alternative institutions in promoting cooperation.¹ One such institution is intergroup competition, where cooperation within teams is promoted by introducing competition between a set of intrinsically independent teams. Well-known examples include the use, by J. Robert Oppenheimer, of competing teams to motivate scientists in Los Alamos during the Manhattan Project (Gosling, 1999) and large automobile companies that make several teams compete in order to develop the design of a new car.

In this paper, we study the effectiveness of intergroup competition in promoting cooperative behavior. We focus on a rank-order competition where a group's rank depends on the number of other groups that have a *strictly* lower level of cooperation. Groups with inferior ranks are penalized, but if all groups are equally cooperative then all of them are ranked first and no punishment is meted out—that is, everyone wins.²

The advantage of 'all-can-win' intergroup competition is that it reduces the potentially demoralizing effect of competition by mitigating the negative externality a winning team imposes on other teams. In particular, in equilibria where all groups cooperate at the same level, players can enjoy the benefits of cooperation without incurring or making others incur the costs of competition. This can be important as the possibility of hurting others and being hurt by others can crowd out motivations such as positive reciprocity and altruism (Gächter and Fehr, 2002; Fehr and Rockenbach, 2003).³ Großer and Sausgruber (2005) show that such crowding out is

¹ Examples include communication (e.g., Isaac and Walker, 1988), peer pressure (e.g., Fehr and Gächter 2000), tax and subsidy mechanisms (Falkinger et al. 2000), redistribution (Sausgruber and Tyran, 2007), and leadership (Levati et al. 2007).

² This type of ranking is used in, for example, in Olympic sports in which ties are not broken.

³ For an extensive review of monetary incentives and the crowding out of pro-social behavior see Frey and Jegen (2001).

present in intergroup competition and that the introduction of competition can discourage pro-social individuals from cooperating. With all-can-win competition, if groups are in a situation in which nobody is losing, prosocial individuals have no reason to stop cooperating.

All-can-win intergroup competition, however, has an important disadvantage as a mechanism for the promotion of within-group cooperation. Namely, it does not give groups a strict incentive to outcompete others. In other words, it makes it an equilibrium for all groups to cooperate at the *same* level, even if this level is very low. This characteristic makes it theoretically unclear whether this type of competition can successfully promote cooperative behavior.

To explore the conditions under which all-can-win competition effectively promotes cooperation, we implement three treatments varying the degree to which groups are penalized as they fall in the ranking. Larger penalties are desirable as they give groups an incentive to not fall behind. However, if groups miscoordinate then severe penalties can wipe out the gains from higher cooperation. Importantly, in our first two treatments (T1 and T2) incentives to compete are sharp and the maximum cooperation level is supported in equilibrium whereas this is not the case in our third treatment (T3). This is an interesting difference if there are groups that are intrinsically motivated to cooperate (e.g., due to a high fraction of prosocial individuals). In treatments T1 and T2, the high cooperation level of the intrinsically-motivated groups can be matched in equilibrium by the other groups. Hence, competition can increase cooperation without penalizing the less intrinsically motivated individuals. In treatment T3, however, there is the possibility that highly cooperative groups could produce miscoordination if they cooperate at levels that are no longer supported in equilibrium. If this is the case, intergroup competition could end up having only a small effect on cooperation and would imply the constant punishment of many individuals.

To the best of our knowledge, experimental work on intergroup competition has focused on competition schemes in which there can be only one winning group. Most of this literature shows that this type of competition can promote cooperation in social dilemmas (Bornstein et al., 1990; Bornstein and Erev, 1994; Nalbantian and

Schotter, 1997; van Dijk et al. 2001) and can facilitate coordination on Pareto-dominant equilibria in coordination games (Bornstein et al., 2002; Riechmann and Weimann, 2008).⁴ However, recent studies have also found that with repetition the gains from competition can be small (Tan and Bolle, 2007) or non-existent (Großer and Sausgruber, 2005). These studies suggest that, by and large, competition is effective as long as free-riding is no longer a dominant strategy.

Our main finding is that all-can-win competition is highly effective in increasing cooperation. The effect is particularly strong if incentives to compete are sharp and full cooperation can be sustained as an equilibrium. In these cases, all-can-win competition produces near-perfect cooperation while the effects are less pronounced if full cooperation is not sustained as an equilibrium. Implementing sharp incentives in all-can-win competition has some desirable properties: It makes full cooperation by all groups an equilibrium, and, as a result, the effect of competition is robust in the sense that it does not depend on the presence of many intrinsically-motivated cooperators. Importantly, all-can-win competition under sharp incentives produces a majority of groups that win the competition, i.e. are ranked first, and a majority of individuals that fare better with than without competition. This suggests that all-can-win competition is an institution that is more likely to gain political acceptance than other forms of intergroup competition.

The paper is organized as follows. In section 2 we describe the experimental design and discuss the theoretical differences between treatments. In section 3 we present the results, and in section 4 we conclude.

2. The experiment

The experiment consists of two parts, each lasting 10 periods. In part 1, participants play a standard linear public goods game in groups of n subjects (Isaac et al., 1984). In each period, subjects receive an endowment $y = 20$ and decide how much of it they want to keep and how much they want to contribute to their group's output.

⁴ For an excellent review see Bornstein (2003).

TABLE 1 – TREATMENT PARAMETERS

Treatment	MPCR α	Group Size n	Number of groups K	$f(r_k)$ for different values of r_k				
				1	2	3	4	5
T1	0.40	4	5	1.00	0.80	0.60	0.40	0.20
T2	0.50	3	5	1.00	0.50	0.50	0.50	0.50
T3	0.50	3	5	1.00	0.95	0.90	0.85	0.80

Period earnings are determined by $\pi_i = y - c_i + \alpha \sum_j c_j$, where c_i is subject i 's contribution to group output and α is the marginal per-capita return of group production. In all treatments, $\alpha < 1$ and $n\alpha > 1$, ensuring both an individual incentive to free ride and an efficiency gain from cooperation.

In part 2, competition between K groups is introduced. In each period, groups are ranked according to their total contributions and groups that are not ranked 1st have their earnings reduced—with the reduction (weakly) increasing with their distance to 1st place. Specifically, a group's ranking is given by: 1 + number of other groups with *strictly* higher contributions. In other words, in all-can-win competition, groups that contribute the same amount share the same rank. Thus, unlike in other intergroup competition schemes, we allow for more than one winner. In fact, if all groups contribute equally, all groups are ranked 1st and no group is penalized.

The penalty for not being ranked 1st is given by the function $f(r_k)$, which transforms group k 's rank, denoted r_k , into a number less than or equal to one.⁵ Specifically, the earnings of subject i who is member of group k equal $\pi_{ik} = \pi_i \times f(r_k)$. In the experiment, we ran three treatments, which we label T1, T2, and T3. Each treatment uses a different $f(r_k)$. The specific parameters used in each treatment are shown in Table 1.⁶

⁵ This kind of intergroup competition scheme is used in the production of broiler chicken (Knoeber and Thurman 1994). The principal (a large firm called integrator) subcontracts with smaller firms ("growers") to raise the chicks. The growers are provided with baby chicks and feed by the integrator. The growers deliver the mature chicken to the integrator and are paid according to their relative productivity. That is, growers who used less feed per pound of chicken get a higher price per pound.

⁶ Table 1 also shows that the MPCR and the group size vary between T1 on the one hand and T2 and T3 on the other hand. The reason is that T1 was run in St. Gallen whereas T2 and T3 were run in

We conducted 3 sessions per treatment. Each session consisted of 5 groups that played individually in part 1 and then competed with each other in part 2. T1 was conducted in the University of St. Gallen with 60 MBA students as subjects. T2 and T3 were conducted at the University of Copenhagen with 45 undergraduate students of various fields each. The experiment was programmed and run with z-Tree (Fischbacher, 2007), and we used the usual experimental procedures of anonymity, incentivized payments, and neutrally worded instructions (see appendix for sample instructions). Overall, 150 subjects participated in our experiment, and they earned US\$23.75 on average.

2.1 Theoretical predictions

In part 1, under the assumption that all players are own-payoff maximizers, the unique subgame-perfect Nash equilibrium is for all subjects to keep their entire endowment. However, based on the evidence from previous public-goods experiments, we expect there will be some voluntary contributions to the public good. In particular, we anticipate to see the typical pattern of substantial positive contributions in early periods that decline to low levels with repetition (see, Ledyard 1995). Importantly, as shown by Fischbacher and Gächter (forthcoming), contributions do not decline because there are no prosocial individuals. Instead, it is the result of heterogeneity in individual preferences for conditional cooperation.

The introduction of all-can-win competition in part 2 considerably enlarges the set of Nash equilibria. We describe them below focusing on equilibria in the one-shot version of the game. Furthermore, we highlight the theoretical differences between the treatments.

We start by discussing symmetric equilibria. We refer to an equilibrium as a symmetric equilibrium if all competing groups have the same total contributions. Note that this set of equilibria includes equilibria where individuals within a group contribute different amounts. Moreover, the set also includes the full-defection

Copenhagen, and in Copenhagen, due to space and time constraints, it was not possible to use 20 subjects per observation.

equilibrium, in which nobody contributes to the public good, as well as the Pareto-dominant equilibria that we discuss later on. These equilibria have the desirable property that all groups are ranked 1st and therefore nobody is penalized. Furthermore, it is in these equilibria that all-can-win competition differs most from the other types of intergroup competition in the literature.

Note that in order to play a symmetric equilibrium individuals must overcome two coordination problems: one between groups, as all groups need to coordinate on the same total contributions, and the other within groups, as the contributions of individuals must be such that their group's total contributions matches that of the other groups. It is unclear *a priori*, it is unclear whether subjects will successfully resolve these coordination problems. In this respect, there is an important asymmetry embedded in all-can-win intergroup competition. Namely, if there is miscoordination between groups then the groups that are penalized the most are those who contribute the least. In other words, if there is uncertainty concerning the total contributions of other groups, it is costlier to err on the side of contributing too little rather than too much. This asymmetry could help groups move up to equilibria with high contribution levels. For this reason, the size of the penalty incurred by groups when their ranking is not 1st is particularly important.

In both T1 and T2, groups incur severe penalties if they miscoordinate. However, the consequences of miscoordination vary between the two treatments. On the one hand, a negative deviation from a symmetric equilibrium, which would change a group's ranking from 1st to 5th, is relatively more costly in T1. Specifically, the earnings of all individuals in the deviating group are reduced by 80% in T1 compared to 50% in T2. On the other hand, a positive deviation from a symmetric equilibrium, which causes the rank of other groups to drop from 1st to 2nd, is relatively more costly in T2. Specifically, the earnings of individuals in other groups are reduced by 50% in T2 compared to only 20% in T1. In other words, the effect of uncertainty concerning the actions of others is more pronounced in T2. Compared to T1 and T2, miscoordination is less costly in T3. This difference could be a disadvantage if it produces less coordination. However, it is an advantage if groups

in T1 or T2 fail to coordinate on a symmetric equilibrium in spite of the severe penalties.

A particularly focal set of equilibria are Pareto-dominant equilibria (Harsanyi and Selten, 1988). In this game, Pareto-dominant equilibria correspond to the symmetric equilibria where the amount contributed by each group is the *highest* amount at which individual group members do not have an incentive to switch to zero contributions.⁷ Pareto-dominant equilibria are particularly attractive since they deliver the highest possible equilibrium welfare, which gives subjects a good reason to try to coordinate on one of them.

The strong competition schemes of T1 and T2 have the desirable property that they produce a unique Pareto-dominant equilibrium that consists of full cooperation by all subjects in all groups. In contrast, in T3 full cooperation is not an equilibrium. To see why, suppose that everyone is contributing their whole endowment to the public good. Furthermore, suppose that an individual is considering a unilateral switch from twenty to zero contributions. In both T1 and T2, this switch would reduce his earnings compared to not switching.⁸ This is not the case in T3 where his earnings would increase slightly from $(20 - 20 + 0.5 \times 60) \times 1 = 30$ to $(20 + 0.5 \times 40) \times 0.8 = 32$. In T3, the highest level of contributions per group that can be supported in equilibrium is 40. Thus, in T3 there are in fact numerous Pareto-dominant equilibria. For example, a group can attain contributions of 40 by having either all its group members contribute 13.3 or by having two group members contribute 20 and one member contribute 0.

As mentioned in the introduction, the difference in Pareto-dominant equilibria between treatments can be particularly important in the presence of heterogeneous preferences for conditional cooperation. In T1 and T2, there is only one Pareto-

⁷ Consider the incentives for player i to reduce contributions if all players are in a symmetric equilibrium and, therefore, all groups are ranked 1st. If player i reduces his contribution, his group will switch from being ranked 1st to being ranked 5th, and therefore, he will only do so if: $f(1) \times (y - (1-\alpha)c_i + \alpha \sum_{j \neq i} c_j) < f(5) \times (y + \alpha \sum_{j \neq i} c_j)$.

⁸ In T1, the individual's earnings decrease from $(20 - 20 + 0.4 \times 80) \times 1 = 32$ to $(20 + 0.4 \times 60) \times 0.2 = 8.8$. In T2, they decrease from $(20 - 20 + 0.5 \times 60) \times 1 = 30$ to $(20 + 0.5 \times 40) \times 0.5 = 20$.

dominant equilibrium that also maximizes total welfare and produces no within-group inequality. Therefore, it ought to satisfy individuals that are conditional cooperators as well as those that are not. In T3, earnings are not maximal in the Pareto-dominant equilibria. Consequently, a group that is composed of individuals with strong preferences for conditional cooperation could attain higher payoffs by contributing more than the Pareto-dominant equilibria prescribe. If this occurs, the other less-cooperative groups will not be able to support the same level of cooperation, which could then trigger the typical downward spiral in contributions that is observed in public good games with no intergroup competition.

Lastly, we shortly discuss asymmetric equilibria, which are defined as Nash equilibria where groups have differing contribution levels. These equilibria could arise if individuals in some groups manage to coordinate on a high contribution level while individuals in other groups do not manage to do so. For example, it is an equilibrium (in T1 and T2) for four groups to contribute everything and for one group to contribute nothing to the public good. In this case, individuals in the non-contributing group receive very low earnings because their group is ranked 5th. However, since an individual cannot unilaterally change his group's ranking by increasing his contribution, he does not have incentive to do so. Note that this is a coordination problem since all group members would be better off if they simultaneously increased their contribution to twenty.

Treatments differ slightly with respect to the number of asymmetric equilibria. In T2, the one-step change in the penalty as rankings change restricts the set of asymmetric equilibria to equilibria with two contribution levels. Specifically, equilibria in which a set of groups coordinate on a positive contribution level and the rest coordinate on zero contributions. In T1 and T3, the gradual change in the penalty across rankings supports asymmetric equilibria with up to three cooperation levels.

In summary, negative deviations from symmetric equilibria are severely penalized in T1 and T2 but not in T3. In addition, full cooperation is supported in equilibrium in T1 and T2 but not in T3. If these differences lead to better coordination, one can expect intergroup competition to produce higher cooperation

levels in treatments T1 and T2 compared to T3 (and compared to the no-competition part). However, if there is considerable miscoordination so that asymmetric equilibria are common or individuals do not coordinate on an equilibrium at all, T3 might produce higher earnings than T1 and T2.

3. Results

We present the experimental results in the following order. First, we analyze the effect of intergroup competition on average contributions in all treatments. Second, we focus on the behavior of groups. Third, we report how the different competition schemes affect overall earnings.

3.1 Overall cooperation

Figure 1 shows average contributions to the public good in the three treatments. In periods 1 to 10 subjects play without intergroup competition whereas groups compete in periods 11 to 20. Table 2 presents the mean contributions for each part and treatment in addition to Spearman's rank correlation coefficients to indicate how contributions evolve over time. As expected, we observe a significant decline in contributions with repetition ($p < 0.001$). We also see in part 1 that average contributions in T1 are somewhat lower than those in T2 and T3.⁹ However, if we do pair-wise comparisons with Wilcoxon-Mann-Whitney tests (WMW), we cannot reject the hypotheses that contributions in all treatments come from the same distribution ($p > 0.100$).¹⁰

⁹ One can expect differences in contributions between T1 and the other treatments due to differences in the subject pool. In particular, there is evidence that economics and business students tend to be less cooperative (e.g., Marwell and Ames, 1981; Engelmann and Strobel, 2006; Fehr et al., 2006).

¹⁰ We opted for non-parametric tests because the number of observations is small and distributions seem to deviate from a normal distribution (e.g., in the distribution of group means, normality can be rejected in T1 and T2 with Shapiro-Wilk tests, $p < 0.05$). Throughout this section, we apply two-sided test statistics and use group averages across all periods of a part as independent observations. Moreover, when we test the same hypothesis in multiple treatments or when we do pair-wise comparisons, we adjust p -values with the method of Benjamini and Hochberg (1995) to minimize the

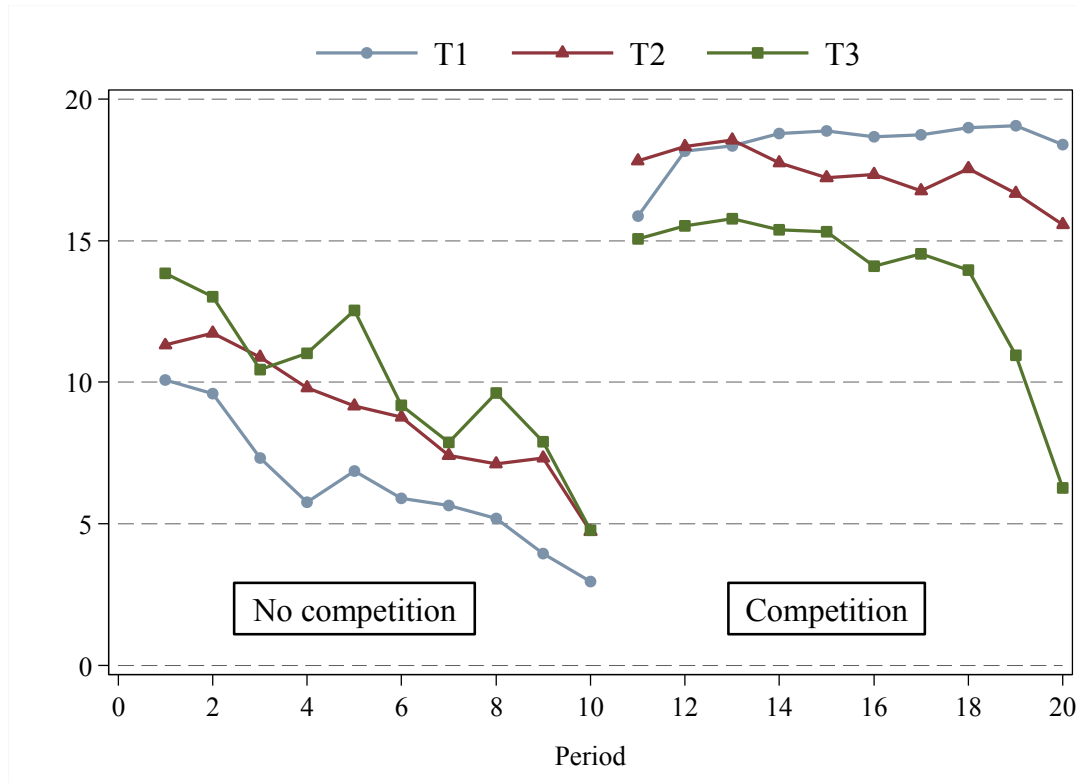


FIGURE 1 – MEAN CONTRIBUTIONS

Note: The figure shows mean contributions to the public good by treatment. In the first 10 periods groups do not compete whereas in the last 10 periods they do.

As soon as competition is introduced, we see a steep increase in contributions in all treatments. Averaging over all ten periods of part 2, contributions increase by a striking 191% in T1, 97% in T2, and 37% in T3. Wilcoxon signed-rank tests (WSR) confirm that the change in contributions is statistically significant in all treatments ($p < 0.003$). In addition, in T1 and T2, contributions no longer display a significantly decreasing trend ($p < 0.001$ in T1 and $p = 0.385$ in T2). In T3, contributions still significantly decrease with time ($p < 0.001$).

If we compare contributions across treatments in part 2, we find them to be significantly lower in T3 relative to T1 and T2 (WMW tests, $p < 0.030$). This difference is consistent with the theoretical predictions in the sense that full contribution by all subjects in all groups is not supported in equilibrium in T3. In

chance of false positives due to multiple testing. This method has an advantage over multiple-population tests (e.g., the Kruskal-Wallis test) in that, in addition to controlling for multiple testing, it reveals which are the specific treatment comparisons that drive the significant differences.

TABLE 2 – SUMMARY STATISTICS

	No Competition			Competition		
	T1	T2	T3	T1	T2	T3
<i>Contributions</i>						
Mean	6.33	8.83	10.00	18.40	17.36	13.69
Time trend (Spearman's ρ)	-0.44	-0.39	-0.39	0.39	0.07	-0.30
<i>Earnings</i>						
Mean	23.80	24.41	25.01	24.48	24.04	24.66
Time trend (Spearman's ρ)	-0.43	-0.39	-0.39	0.34	0.07	-0.21

Note: For each treatment and part, the table shows for contributions and earnings, the mean over all periods and the value of Spearman's rank correlation coefficient between periods and the respective statistic.

fact, it is interesting to see that average contributions are fairly close to the Pareto-dominant in all treatments (20.0 in T1 and T2, and 13.3 in T3).

Next, we look at whether intergroup competition increases the contributions of all groups or just of some. We find that, in T1 and T2, competition produces an increase in average contributions in all 15 groups. In T3, average contributions increase in 12 out of 15 groups, they remain constant in 1 group, and decrease in 2 groups. A similar picture emerges if we look at the effect of intergroup competition on individual contributions. In T1, competition produces an increase in contributions for 98% of individuals; in T2 for 93% and in T3 for 80% of individuals.

In summary, in spite of the fact that groups do not have an incentive to outperform others, intergroup competition results in a large increase in cooperation.

3.2. Relative performance and cooperation

The increase in cooperation can also be illustrated by comparing group performance holding ranks constant. That is, we compare the average difference in contributions between groups that are ranked k^{th} with and without competition. This difference can be seen in Figure 2, which shows average contributions by rank for each treatment (see lines with circles). Periods with no competition are displayed in the top part of the figure and periods with competition are displayed in the bottom part.

Without competition, average contributions in T1, T2, and T3 range from 2.0, 2.8, and 3.7 for groups ranked 5th to 12.6, 15.0, and 17.0 for groups ranked 1st (see right scale in Figure 2). Once competition is introduced, contributions increase at all ranks: average contributions now range from 13.3, 9.3, and 7.3 for groups ranked 5th to 20.0, 20.0, and 19.8 for groups ranked 1st.¹¹ Hence, we can conclude that all-can-win intergroup competition produces a universal increase in cooperation.

Nevertheless, since an increase in contributions does not necessarily translate into higher earnings, it is yet unclear whether most groups would find it desirable to compete. In order to guarantee themselves a higher payoff, groups also have to be ranked 1st. Ideally, all groups are ranked 1st and nobody suffers a payoff loss. In other words, we must also take a look at the distribution of rankings.

Figure 2 also contains bar diagrams. The height of the bar shows the average number of groups (across periods) that attained a given rank. For example, the rightmost bar in the bottom left diagram shows that about 3 (out of 5) groups were ranked first in a typical period of treatment T1 with competition. We can see in the top part of Figure 2 that there is usually one group per rank without intergroup competition in all treatments. In other words, cooperation levels are dispersed absent competition such that, in an average period, one group has the highest cooperation level, another group the second highest, yet another one the third highest, and so on.

With intergroup competition, the distribution of rankings changes considerably. In particular, there is an increase in the number of groups that are ranked 1st. In an average period with competition, 3.1 groups are ranked 1st in T1, 3.2 in T2, and 1.7 in T3 (up from 1.0, 1.1, and 1.3, respectively). The change in the number of groups that are ranked 1st is statistically significant in T1 and T2 but not in T3 (WSR tests, $p < 0.007$ in T1 and T2, and $p = 0.288$ in T3). The number of groups ranked 1st is even bigger and the differences between T3 and the other treatments are more pronounced if we consider only periods close to the end. For example, in

¹¹ With one exception, the change in cooperation between no competition and competition is statistically significant for all ranks in all treatments (WMW tests, $p < 0.022$ for all comparisons except for of groups ranked 2nd in T3 where $p = 0.389$).

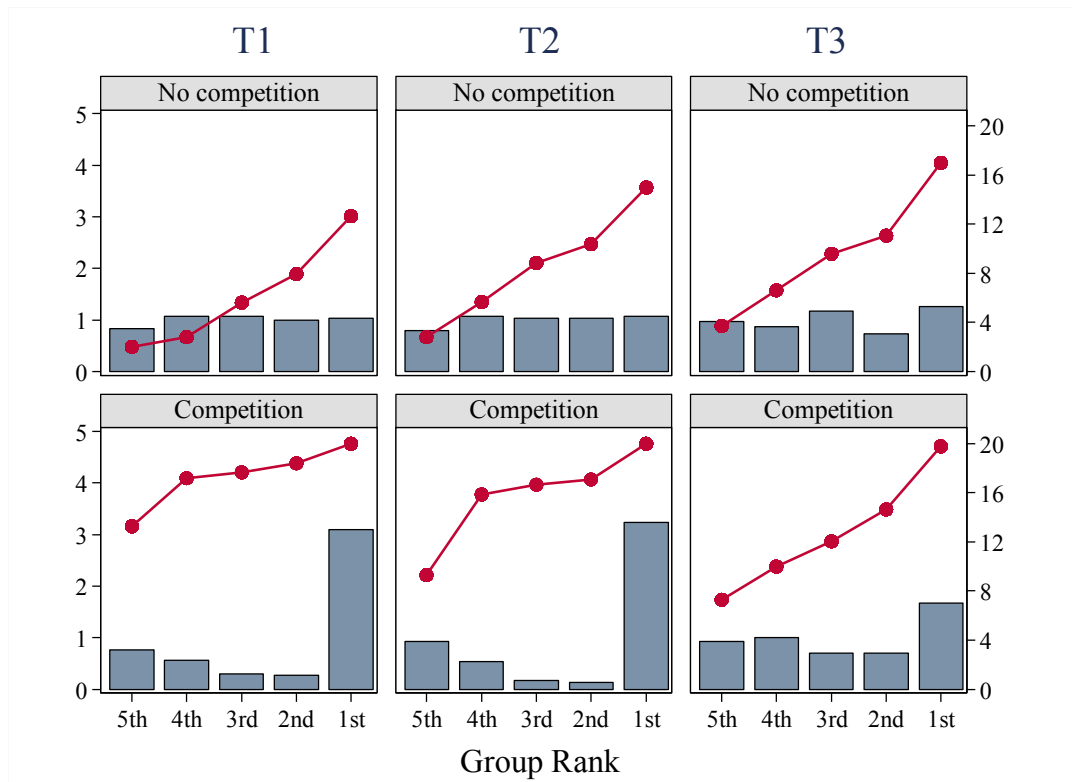


FIGURE 2 – GROUP RANKINGS

Note: The circles (and lines) indicate for each treatment and part, the average contribution to the public good (right-hand axis) depending on the group's rank. The bars show the average number of groups per period (left-hand axis) that attained a given rank. Periods without competition are displayed in the top part of the figure and periods with competition are displayed in the bottom part.

the last five periods with competition, the number of groups ranked 1st is 3.9 in T1, 3.5 in T2, and 1.5 in T3.

Note that, in T1 and T2 not only are a substantial number of groups attaining the top rank, they attain it at the maximum cooperation level (i.e., at 20.0). This virtually perfect cooperation is consistent with groups trying to coordinate on the Pareto-dominant equilibrium. In T3, competition stimulates contributions but groups fail to coordinate on the same cooperation level. This could be due to the fact that there are numerous Pareto-dominant equilibria and hence coordinating in one of them is harder than in T1 and T2. However, given that groups ranked 1st are clearly contributing more than the maximum amount supported in equilibrium (17.0 vs. 13.3 on average), it appears that, in line with the theoretical discussion,

there is heterogeneity in the degree of cooperativeness between groups and some groups manage to cooperate at levels that other groups cannot match.

3.3 Group and individual cooperation

We now check whether cooperation in periods without competition predicts cooperation in periods with competition. This is important as it allows us to observe if the effect of intergroup competition is robust or depends on individual preferences for (conditional) cooperation. In other words, we check whether the increase in contributions is due to groups or individuals who are intrinsically motivated to cooperate or whether those with more selfish preferences also react with higher cooperation. We start the analysis at the group level.

A simple way of observing whether relatively cooperative groups remain cooperative once intergroup competition is introduced is to look at the correlation between the groups' average ranking with and without competition. In T1, Spearman's correlation coefficient between these two variables is $\rho = 0.25$ ($p = 0.547$). In T2 it is $\rho = 0.15$ ($p = 0.595$), and in T3 it is $\rho = 0.74$ ($p = 0.005$). Hence, in both T1 and T2, cooperativeness without competition is not a good predictor of cooperation with competition, unsurprisingly perhaps, as competition increases contributions in all groups to very high levels. The opposite is true for T3. In this treatment, a group's ranking with no competition is an excellent predictor of the group's ranking once competition is introduced. In other words, competition increases contributions in all groups but does not alter the groups' relative position in T3.

We reach a similar conclusion when considering contributions by individuals. We calculate for each individual in each treatment, group, and period their ranking within the group. Rankings are calculated using the same procedure as for groups. We then calculate the correlation between the individuals' average ranking with and without competition. In T1 and T2, Spearman's correlation coefficients are low and not significantly different from zero (for T1 $\rho = -0.09$, $p = 0.509$, and for T2 $\rho = 0.15$, $p = 0.477$). In other words, both cooperative and uncooperative individuals start cooperating substantially with competition in T1 and T2. In T3 this is not the

case as relatively cooperative individuals (within their group) keep on being the most cooperative during periods with intergroup competition ($\rho = 0.53, p = 0.001$).¹²

We think these findings are exciting because they show that the success of intergroup competition does not necessarily rely on the presence of many intrinsically-motivated individuals that reliably generate high levels of cooperation. However, the results from T3 remind us that this desirable robustness depends on the use of sharp incentives for competition. In particular, if heterogeneity in the cooperativeness of individuals produces groups that cooperate at levels above those supported in equilibrium, we might see a smaller increase in the cooperation rate of the less intrinsically-motivated individuals.

3.4. Competition and welfare

The previous discussion has shown that intergroup competition increases overall contributions in all treatments, and that the effect is particularly strong in T1 and T2. Contributions to the public good are directly proportional to a measure of efficiency, namely, the output produced by all groups. This measure is relevant if we consider how competition improves overall output in a firm, say. However, a more conservative measure of efficiency is to consider the sum effective earnings of participants and treating the sanctions as “waste”. This measure is relevant if we ask how much popular support the introduction of competition may enjoy.

We find that intergroup competition has an ambiguous effect on earnings. Average earnings for each treatment and part are shown in Table 2. As can be seen, compared to the part without competition, there is a slight increase in earnings in T1 and a slight decrease in T2 and T3. However, these differences are not statistically significant in any of the treatments (WSR tests, $p > 0.100$). We do see some differences when we look at how earnings change with repetition. Without competition, earnings display a significantly decreasing trend. In contrast, in T1 we find that earnings significantly increase over time ($p = 0.001$) and in T2 they do not

¹² Note that we do not find that competition crowds out contributions by ‘pro-social’ individuals—that is, individuals who are high contributors in the absence of competition.

show a significant decrease ($p = 0.385$). In T3, it is still the case that earnings exhibit a significantly decreasing trend ($p = 0.017$).

Figure 3 shows average earnings for periods with competition as a percentage of earnings in the equivalent period without competition. In both T1 and T2, earnings with competition are initially well below earnings without competition. However, after three periods, the opposite is true. In T1, the effect is particularly strong. Thus, one could argue that, given enough repetition, competition will eventually produce a positive effect on earnings in T1.¹³ In T2, earnings with competition seem to stabilize at slightly above 100% (109% in the last five periods). Therefore, it is less clear in T2 than in T1 that earnings with competition will unambiguously surpass those without competition (or at least it will require a much longer time span).

Instead of comparing average earnings, another way of evaluating the welfare effect of intergroup competition is to look at the number of individuals who benefit from it. In T1, averaging across all periods, 42 out of 60 subjects (70%) earned more with competition whereas 18 (30%) earned more without competition. In T2, 25 out of 45 (56%) earned more and 20 (44%) earned less, and in T3, 22 out of 45 (49%) earned more, 22 (49%) earned less, and 1 (2%) earned the same amount. Hence, in T1 and T2, a majority of subjects benefit from competing whereas in T3 winners and losers are balanced out. If we test whether significantly more subjects benefit from competition than suffer from it, we find that this is the case in T1 but not in T2 and T3 (Sign tests, $p = 0.008$ for T1, $p = 0.827$ for T2, and $p = 1.000$ for T3).

In summary, consistent with the theoretical predictions, competition in T1 and T2 produces high levels of cooperation and substantial coordination in the Pareto-dominant equilibrium. However, the predictions do not carry over to earnings because the severe penalty incurred by groups that are not ranked 1st coupled with a small degree of (initial) miscoordination result in a statistically insignificant welfare difference between competition and no-competition. In T3, we observe more

¹³ A similar pattern is seen if one compares public good games without punishment to those with punishment (Fehr and Gächter, 2000). In this case, Gächter et al. (2008) have shown that in the long run punishment does deliver significantly higher earnings.

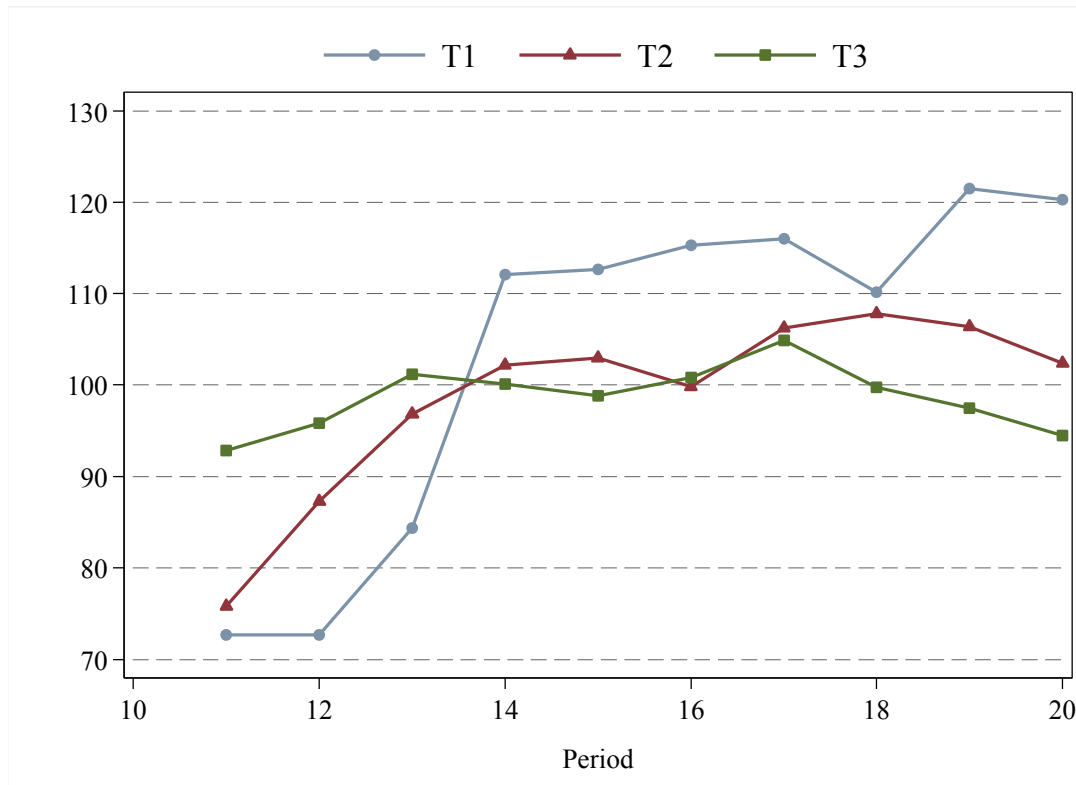


FIGURE 3 – RELATIVE EARNINGS

Note: The figure shows mean earnings for periods with competition as a percentage of earnings in the equivalent period without competition.

miscoordination than in T1 and T2, which implies that more groups are penalized for not being ranked 1st. However, since the penalty is smaller the welfare loss seems to be compensated by the slightly higher level of cooperation.

4. Conclusions

In this paper, we study the effectiveness of intergroup competition in promoting cooperative behavior. In particular, we focus on intergroup competition in which everyone can be a winner. We report results of a laboratory experiment where we vary the incentives to compete. We find that intergroup competition produces a universal increase in cooperation. Hence, we find it to be an effective way of increasing overall group output. Furthermore, when incentives to compete are strong, intergroup competition benefits a majority of individuals, albeit it falls short of increasing earnings for every single participant.

The type of intergroup competition considered in this paper does not provide groups with a strict incentive to outcompete others. However, in spite of this fact, intergroup competition increased contributions in 93% of the groups. A systematic effect is present even in the treatment with relatively weak incentives to compete (T3), in which 80% of the groups increased their average contribution. Thus, for the purpose of increasing group output, all-can-win competition works remarkably well.

In treatments with strong incentives to compete (T1 and T2), intergroup competition generally produced the desired result, that is, many winners and few (or no) losers, which is consistent with subjects attempting to coordinate on the Pareto-dominant equilibrium. In T3, where there are less incentives to compete, groups fail to coordinate on the same cooperation level. Interestingly, this miscoordination seems to be due to the fact the highest-paying equilibrium is no longer the Pareto-dominant outcome. This gives 'naturally' cooperative groups an incentive to deviate from it, as by doing so they can obtain higher earnings. The downside is that groups which are less cooperative are not able to match those contribution levels and thus end up with cooperation levels that are below those that could be supported in equilibrium.

To some extent, the effectiveness of all-can-win competition could be explained by equilibrium concepts that take into account the possibility that individuals make mistakes. In particular, the quantal-response equilibrium (QRE), posits that mistakes are more likely to occur if they are less costly (McKelvey and Palfrey, 1995). As discussed in section 2, if groups are tied in T1 and T2, the payoff loss to an individual of decreasing his contribution is generally bigger than the loss of increasing it. Therefore, QRE predicts that individuals are more likely to err on the side of higher rather than lower contributions, which may induce groups to ratchet up cooperation in these treatments. In T3, this is the case only at low cooperation levels and therefore QRE predicts a smaller effect. Yet, QRE provides no plausible explanation for the very high contributions we observe by some groups in T3—these contribution levels are well outside supported equilibria and would

therefore require very frequent mistakes. However, a model that integrates noisy decision making and altruism may narrow this gap (e.g., Anderson et al., 1998).

The effect of intergroup competition on individual earnings is less straightforward. While a majority of participants and groups benefit from competition in T1 and T2, participants in the few losing groups are severely penalized. To illustrate, we compare the earnings of the best- and worst-performing groups. In T1 and T2, the average earnings of the worst-performing group decrease from 21.8 without competition to 14.2 with competition. In contrast, the earnings of the best-performing group increase from 27.0 to 30.4. In other words, intergroup competition increases the earnings of a majority but strongly reduces those of a minority. As a result, in T1 and T2 average earnings across all participants are about the same with and without competition. When groups compete in T3, the penalty for losing is smaller but so are the gains from cooperation, which results again in statistically indistinguishable earnings with and without competition.¹⁴

In summary, we find that the strong all-can-win competition produces a robust increase in cooperative behavior and can benefit a majority of individuals. However, it also produces a few individuals that are severely disadvantaged by competition.

We think an interesting direction for further research is to investigate the popularity or political acceptance of alternative forms of intergroup competition. For example, participants in an experiment could be allowed to vote on whether to subject themselves to all-can-win competition at all, and, if so, how sharp incentives should be (see Putterman et al. 2009 for an experiment in which participants vote on sanction schemes in public goods games). Based on our results, we speculate that all-can-win competition is likely to be more popular than rank-order competition with forced breaking of ties. The reason is that all-can-win competition produces a majority of winning groups and a majority of individuals earning more with competition than without.

¹⁴ In this treatment, the difference between worst- and best-performing groups is affected less by competition. With competition, the average earnings of the worst-performing group decrease from 22.5 to 20.3, and those of the best-performing group increase from 27.6 to 28.9.

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Appendix – Instructions

Below we reproduce the instructions used in T3. Instructions for other treatments are available upon request.

General Instructions

You are now taking part in an economic experiment. Depending on your decisions and the decisions of other participants you can earn a considerable amount of money. How you can earn money is described in these instructions. It is therefore important that you read these instructions carefully.

During the experiment you are not allowed to communicate with other participants in whatever way. If you have any questions please raise your hand. One of us will come to your table to answer your question.

During the experiment your earnings will be calculated in points. At the end of the experiment points will be converted to Danish kroner (DKK) at the following rate:

$$25 \text{ points} = 10 \text{ DKK}$$

After the experiment your total earnings from the experiment will be paid out to you anonymously and in cash.

In the experiment, all participants are randomly divided into groups of 3. This means that you are in a group with two other participants. You will be part of the same group throughout the experiment. Nobody knows which other participants are in their group, and nobody will be informed who was in which group after the experiment.

The experiment today consists of two parts. You will receive detailed instructions of each part of the experiment before the start of the respective part. The following pages describe in detail part one of the experiment.

Instructions for part one

Your decision

The first part of the experiment has 10 periods. In each period, everyone will be given an endowment of 20 points. Then, you and the other group members simultaneously decide how to use the endowment of 20 points. You have two possibilities:

1. You can allocate points to a group account.
2. You can allocate points to a private account.

You have to use your entire endowment in each period. That is, the points you put into the group account and the points you put into the private account have to sum up to 20. You will be asked to indicate the number of points you want to put in the group account. The remaining points will be automatically allocated to the private account.

How to calculate your income

Your total income depends on the total number of points in the group account, and the number of points in your private account.

Your income from your private account is equal to the number of points you allocated to the private account. For each point you put into the private account you get an income of 1 point. The income of other group members is not affected by the points you allocate to your private account. For example, your income from the private account is 3 points if you put 3 points into it.

Your income from the group account is the sum of points allocated to the group account by all 3 members multiplied by 0.5. For each point you put into the group account you and all other group members get an income of 0.5 points. For example, if the sum of points in the group account is 24, then your income from the group account and the income of each other group member from the group account is 12.

Your income in points

$20 - (\text{points you allocate to the group account}) + 0.5 \times (\text{the sum of points allocated by all 3 group members to the account})$

You get an income of 1 point for each point you allocate to your private account. If you instead allocate 1 extra point to the group account, your income from the group account increases by $1 \times 0.5 = 0.5$ points and your income from your private account decreases by 1 point. Note that by doing this the income of other group members increases by 0.5 points. Therefore, the total group income increases by $3 \times 0.5 = 1.5$ points. Other group members therefore also obtain income if you allocate points to the group account. Note that, you also obtain income from points allocated to the group account by other members. You obtain $1 \times 0.5 = 0.5$ points for each point allocated to the group account by another group member.

Examples

Suppose you allocate 10 points to the group account, the second member of your group allocates 20 points and the third group member allocates 0 points. In this case, the sum of points on the group account will be 30 points, and all group members get an income of $30 \times 0.5 = 15$ points from the group account.

Your income in that period is: $(20 - 10) + 15 = 25$ points.

The second group member's income is: $(20 - 20) + 15 = 15$ points.

The third group member's income is: $(20 - 0) + 15 = 35$ points.

Instructions for part two

In this part of the experiment, everything is the same as in part one, except that your income will be influenced by the "rank" that your group has relative to the other groups.

The ranking is based *on the number of points on the group account of your group compared to the other groups*. This will be explained in more detail later.

In the experiment there are 5 groups in total. Group composition will be the same as in part one. That is, the two other members of your group will be the same

as before. Except for the ranking everything is the same. In particular each participant decides how to allocate 20 points in each period as before.

How to calculate your income

Here is an illustration of, how your decision determines your income, note that it is *the points allocated to the group account by all members* that determine the rank of the group.

Your decision → Points in the group account → Rank → Conversion → Income

Your decision, that is, the number of points you allocate to the group account, influences the total number of points on the group account. The total number of points on the group account determines the rank of your group. The rank determines the conversion factor. The conversion factor influences all your period's income.

Your income in points

$$[20 - (\text{points you allocate to the group account}) + 0.5 \times (\text{the sum of points allocated by all 3 group members to the account})] \times \text{conversion factor}$$

The size of the conversion factor, is determined by the points allocated to your group account compared the group account of other groups. *Note that all of your income is multiplied by the conversion factor.*

For a given contribution, the higher the conversion factor of your group, the higher your income. The group with the highest number of points on the group account is assigned rank 1, which means that this group gets the highest conversion factor of 1.0. The group with the second highest number of points on the group account is assigned rank 2, which means that this group gets a conversion factor of 0.95, and so on. The conversion factor for a given rank is given in the following table.

Rank	Conversion factor
1	1.00
2	0.95
3	0.90
4	0.85
5	0.80

If more than one group contributes the same number of points to the group account, then they get the same conversion factor. For example if all groups have the same number of points in the group account, they all have the same rank (that is, rank 1) and the same conversion factor (that is, 1.00).

If two groups are ranked 1, the group with the third highest number of points in the group account will have the rank 3 and a conversion factor of 0.90 (see table below).

Examples

Group number	Number of points in the group account	Rank	Conversion Factor
1	29	3	0.90
2	32	1	1.00
3	32	1	1.00
4	29	3	0.90
5	11	5	0.80

Suppose you are a member of group 1 and suppose you have allocated 10 points to the group account, suppose the other two members allocated 19 points in total. In this case the sum of points on the group account is 29, and the rank of your group is 3. The conversion factor of your group is 0.90. As a consequence your income is: $(20 - 10 + 0.5 \times 29) \times 0.90 = 22.05$ points.

Now, suppose you are a member of group 2 and suppose you have allocated 0 points to the group account, suppose the other two members allocated 32 points in total. In this case the sum of points on the group account is 32, and the rank of your group is 1. The conversion factor of your group is 1.00. As a consequence your income is: $(20 - 0 + 0.5 \times 32) \times 1.00 = 36$ points.

As a further example, suppose you are a member of group 5 and suppose you have allocated 11 points to the group account, suppose the other two members allocated 0 points in total. In this case the sum of points on the group account is 11, and the rank of your group is 5. The conversion factor of your group is 0.80. As a consequence your income is: $(20 - 11 + 0.5 \times 11) \times 0.80 = 11.6$ points.