Let's (not) escalate this!
Intergroup leadership in a group contest

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Abstract

In this article we present an experiment investigating leadership types in a group contest. In specific, we compare two levels of leader authority and the effect of communication between leaders, with respect to conflict expenditures and overall welfare. Our results indicate that contest spending in treatments with a leader are higher, unless there is communication. Moreover, leaders with authority fan the flames of between group competition by allocating a relatively larger share of the prize to players that have delivered more input to the competition. When allowing for communication between leaders of competing groups, those who manage to agree on taking turns for delivering input to the contest, exert a mitigating effect on spending levels.

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1 Introduction

On various layers of society and with different degrees of hostility, competitive situations are ubiquitous in society. Be it the competition for publishing scientific papers, lobby groups vying for their interests, or rivalry on an inter-country level. What all these examples have in common is the fact that there is a considerable amount of unproductive resources spent in this rat race. Consider for example the global total military budget of $1.822 billion in 2018 (source: Stockholm International Peace Research Institute (SIPRI) Military Expenditure Database), which is equivalent to 2.1 per cent of global gross domestic product (GDP). This enormous sum of money is dedicated solely to being adequately equipped to face outside (or inside) challenges to the national interest.

One of the most widespread models for (group) contests is the lottery game by Tullock (1980) or Katz, Nitzan, and Rosenberg (1990), where the winning probability increases with higher relative spending.[1] The vast majority of experiments on rent-seeking or contest games find contributions that are significantly higher than the Nash equilibrium prediction (Sheremeta, 2018, 2013; Dechenaux, Kovenock, & Sheremeta, 2015; Öncüler & Croson, 2005), causing rent over-dissipation and inefficiency. Sheremeta (2018) reviews the types of explanations that have been offered for this behaviour: Most prominently, there is evidence for a motivational drive for coming out ahead of the other party. Herrmann and Orzen (2008) call this the *homo rivalis* – an agent driven by spiteful, envious or malevolent preferences. Next to costly over-contribution, empirical results commonly show a substantive degree of heterogeneity of behaviour both within and between groups.

In this article we present an experiment designed to examine whether a leader can curtail over-contribution and improve group welfare in a group contest for a group prize. In games where contributing is socially beneficial (like in a public goods game, for example), empirical results often find that leaders help coordinate towards higher contribution levels and earnings (Kosfeld & Rustagi, 2015; Arbak & Villeval, 2013; van der Heijden, Potters, & Sefton, 2009; Potters, Sefton, & Vesterlund, 2007). Rondeau and List (2008) find evidence for this in a field experiment in the context of charitable donations. If a leading donor is mentioned having invested a considerable amount in a given project, following donations from individuals are up to 71 % higher than in control treatments.[2] In a group contest, however, things might very well look different: Pittinsky and Simon (2007), for example, point out that "(t)he very foundations of strong leadership, such as fostering strong group cohesion, can become stepping stones to intergroup conflict." The reason for this is the existence of an ingroup / outgroup leadership trade-off, where strong leadership comes to the detriment of outgroup relations.

There is only little evidence on the effect of leadership in a contest game. Loerakker and van Winden (2017) introduce leading-by-example leaders and emotional leadership. In the former treatment, one player makes her contribution decision before the others. For the latter treatment, leaders choose an emotion to be induced onto their followers by the means of a video clip. Loerakker and van Winden (2017) find no significant treatment effect in terms of contribution levels. A second example of a contest game with some form

[1] See Konrad (2009, 2007) for a detailed discussion of this game concept.

[2] There are only a few examples of experimental studies with a group leader, in which individual contributions have negative externalities onto other players, like public bad games and common-pool resource games. Also here, treatments with a leader show a lower degree of negative externalities (Moxnes & van der Heijden, 2003; Vyrastekova & van Soest, 2003).

of leadership is Eisenkopf (2014), who employs a contest game between pairs of two players and an external consultant (manager). In the treatment setup, a manager is added to each pair, who does not contribute herself, but gives advice via free form text messages, individual chat, and typing a number to be displayed on the followers' screen. Eisenkopf (2014) varies the manager's incentives from fixed compensation to being partly contingent on her group's (or the other group's) success in the contest. The author finds no strong effect on behaviour between the incentive schemes.

The results of our study show that leaders tend to increase contest investments. This is driven by a strong positive correlation between leaders' and followers' investment (while theory would predict a negative correlation) and a positive correlation between followers' contribution and the share of the prize allocated to them by the leaders. By contrast, intergroup leadership through free form chat communication between leaders of competing groups can mitigate the contest.

This article is structured as follows: First in Section 2 we explain the setup of our study and give details on the procedures. We discuss equilibrium strategies for the treatments in Section 3, as well as alternative hypotheses. In Section 4, we present the results of this study, which will be followed by this study's implications and conclusion in Section 5.

2 Experimental Design

We employ a design with four experimental treatments and one control benchmark. We will first introduce the *baseline treatment*, followed by each of the other treatments. For each treatment we manipulate one aspect of the game, which makes it possible to make clear inferences. Table 1 provides an overview of the treatments.

Baseline Treatment

Participants are sorted into groups of four, with two groups competing for a fixed prize for 15 periods. They interact with the same other players throughout the experiment (partner matching).

Each period consists of the following stages:

1. Every player receives an endowment of $E = 120$ tokens and decides how much of it to invest in order to buy lottery tickets, which translate into probabilities of winning the contest. The price for a ticket is one token. Investment of player k of group K and m of group M are labelled v_k and v_m, respectively. All tokens that a player does not spend on lottery tickets are added to her private account.
2. The winning probability, or contest success function (CSF), is as in Tullock (1980)

and Katz et al. (1990) and given by

$$p_K\left(\sum_{k\in K} v_k, \sum_{m\in M} v_m\right) = \begin{cases} \dfrac{\sum\limits_{k\in K} v_k}{\sum\limits_{k\in K} v_k + \sum\limits_{m\in M} v_m} & \text{if } \max\limits_{i\in K\cup M}\{v_i\} > 0 \\ {}^1\!/_2 & \text{otherwise} \end{cases}$$

where p_K is the probability that group K wins over group M, which is given by the sum of all lottery tickets of group K divided by the total lottery tickets bought by both groups. After the investment phase, one ticket will be drawn out of a ballot box to determine the winner. Hence, the more tickets a group buys, the higher the chances of winning the lottery, ceteris paribus. Note to Arno: I keep taking 'ceteris paribus' in and out. If I have it in, you strike it out, if it is not in, you note it down. I am fine with both.

Information of each player's contribution is made available to all members of the same group at the end of a period. Also, information of the opposing group's aggregated contribution will be revealed, as well as the corresponding winning probability. The winning group receives a fixed prize of 1,920, which will be divided equally, such that players of the winning group each receive $z = 480$ tokens as premium – the losing group gets nothing. I replaced the word 'team'with 'group' everywhere (except for fixed terms like team sports and the instructions, where we did use the term 'team'). The word 'contribution', by contrast, is very typical for contest literature, and I personally find it also more fitting than 'investment'.

2.1 Experimental Treatments

In the experimental treatments, pairs of groups engage in a contest game as in the baseline treatment. What is different here is that there is one player who moves before others in all four experimental treatments. In two of the four experimental treatments, the leader receives the entire prize and may redistribute it among her group mates. Also, in two of the four experimental treatments, the leaders of two competing groups may communicate via a free form chat window in every period, prior to making the contribution decision. This will be explained in detail below.

Ingroup leading-by-example treatment (Ingroup lbe)

Before the first period, one participant in each group is randomly selected to be the leader and stays in this role for the rest of the game. Other players know that there is a leader and that this will be the same person throughout the experiment. Note, though, that we did not use the term "leader" in the instructions, or anywhere else in the experiment. We referred to this participant simply as "member 1". In both groups, the leader buys lottery tickets first and the amount she purchases is made public to the other members of the own group before everyone else decides simultaneously how much to spend. Players of the winning group each receive $z = 480$ tokens as premium, the other group gets nothing.

Ingroup transactional leader treatment (Ingroup trans)

As in the ingroup leading-by-example treatment, a leader is determined at random before the first period. In each period, she buys lottery tickets before everyone else and the amount she purchases is made public to all members of the own group before the followers decide how much to spend, as in the baseline. In contrast to the Ingroup lbe treatment, here the leader of the winning group receives $4z = 1,920$ tokens as premium, nobody else receives anything. However, the leader can redistribute the 1,920 among own group members and herself, as she wishes. The redistribution is made public to other group members.

Intergroup leading-by-example treatment (Intergroup lbe)

This treatment is the same as the ingroup leading-by-example treatment with one adaption: In every period the leaders of competing group pairs now can privately communicate for 45 seconds via a free form chat window prior to their contribution decisions. They both still decide individually about their investment before everyone else and information on the level of their investment will be available to the own group.

Intergroup transactional leader treatment (Intergroup trans)

This is a combination of the aforementioned treatments. As in the Intergroup lbe treatment, the two leaders can privately chat before making the contribution. Also in this experimental treatment, the leader makes her contribution decision before the followers do. Lastly, the leader receives $4z = 1,920$ if the own group wins and has the option to redistribute the prize in the same way as in the Ingroup trans treatment.

Table 1: Treatment overview

	Leader moves first	Leader receives prize and may redistribute	Leaders communicate
Baseline			
Ingroup leading-by-example	✓		
Ingroup transactional leader	✓	✓	
Intergroup leading-by-example	✓		✓
Intergroup transactional leader	✓	✓	✓

2.2 Procedures

For this computerised experiment, which was programmed with z-tree by Fischbacher (2007), we use ORSEE (Greiner, 2004) to recruit 360 participants (which is 9 pairs of groups per treatment). Each participant sat in a cubicle, physically and visually separated from other participants. The experiment consisted of 3 parts. Prior to the group contest we measure individual risk preference (called “part 1” in the instructions) using techniques by Eckel and Grossman (2002), and individual social value orientation (SVO) (part 2) by Murphy, Ackermann, and Handgraaf (2011).[3] Towards the participants we refer to the group contest game as “part 3”. When entering the laboratory, participants found a printout of both general and part 1 instructions at their seat. Instructions for parts 2 and the main game (part 3) were distributed after the respective previous part has been completed by everyone.[4] After reading the instructions for the main game (part 3), all players encountered three screens presenting the layout of the upcoming part of the experiment. Further, on each of the three said screens, there was one understanding question, which participants had to answer correctly before they could proceed. After part 3, participants filled in a questionnaire on, i.a., demographics, risk preferences (as in Dohmen et al., 2005), and reciprocity (as in the German Socio-Economic Panel (SOEP)).

The sessions took place in the BEElab at Maastricht University, between September and November 2015. Each participant received a financial compensation for each part of the game as follows. For the risk elicitation task, we paid out the result of the gamble that the player chose. For the SVO measure, we follow the payment procedures of Murphy et al. (2011)'s “ring matching” procedure. Participants $[i \dots I]$ are ordered on a virtual ring, where i is connected as sender to $i+1$, $i+1$ is connected as sender to $i+2$ etc., which makes everyone a sender *and* a receiver. One choice *per participant* is randomly selected and paid out as a sender. For part 3 the sum of all earnings over all periods was paid out. The payment procedures were public knowledge among the participants. The experiment took about 80 minutes in total.[5] Average earnings were €11.75 across all treatments.[6]

3 Equilibrium Strategies

We start with the *Baseline treatment* and discuss the experimental treatments thereafter. We then provide a general overview of the equilibria in the treatments in Table 2. The sub-game perfect equilibrium of the single-shot game constitutes a natural benchmark to compare our data with. For this, assuming risk-neutrality and that each player $i \in K$ maximises her individual expected earnings, which is

$$\pi_i \left(\sum_{k \in K} v_k, \sum_{m \in M} v_m \right) = E + \frac{v_i + \sum\limits_{k \in K \setminus i} v_k}{v_i + \sum\limits_{k \in K \setminus i} v_k + \sum\limits_{m \in M} v_m} \cdot z - v_i,$$

where E is the initial endowment, v_i is the player's own contribution, $\sum_{k \in K \setminus i} v_k$ is the total contribution of her other three group mates, $\sum_{m \in M} v_m$ is the total contribution of the other group, z is the prize to win.

For this type of group contest game with homogeneous groups, a unique equilibrium only results with regard to the aggregate group contribution. Concerning individual level

[3] See Appendices A and B for more details on the risk preference and SVO measure we employ.

[4] A copy of the instructions is provided in Appendix C.

[5] Due to technical problems, we shortened the game to eight periods for two group pairs in the *Intergroup lbe* treatment. This has been announced clearly before the start and results are robust to dropping the data of this session.

[6] About \$ 12.80 or £ 8.90 at the exchange rate at the time of the experiment.

contributions, multiple equilibria exist (Abbink, Brandts, Herrmann, & Orzen, 2010; Konrad, 2007, 2009).Note to Arno: According to APA rules, multiple references within the same parentheses get separated by semicolon. Hence, I would prefer to keep it like this. The equilibrium contribution level for each group is $\sum_{k \in K} v_k = \frac{z}{4}$.[7] For this experiment with $z = 480$, this results in 120 tokens per group. All combinations of individual contribution that add up to 120 tokens per group constitute an equilibrium. In the repeated game, the set of equilibria is not only restricted to sequences of single-shot equilibria. For example, the use of grim-trigger strategies would enable off-equilibrium behaviour in particular rounds. For our analysis, we do not employ these latter equilibrium strategies as benchmarks, as for the immense amount of coordination needed to establish them. I read you think this is a weak argument. What do you propose?

As the game is symmetric, a reasonable selection criterion could be that every player contributes equally (cf. Katz et al., 1990). This would result in an individual contribution of $v_i = \frac{z}{4 \cdot K}$ or 30 tokens, given a group size of $K = 4$. So in this case, a risk neutral player would contribute 25% of the endowment $E = 120$ to the project.

When loosening the assumption of risk-neutrality and assuming homogeneity of risk preferences, contribution to the contest decreases with increasing risk-aversion. See Appendix E for a discussion of most conventional functional forms, such as constant absolute risk aversion (CARA) and constant relative risk aversion (CRRA). Katz et al. (1990) also show that for differing levels of risk aversion between the groups, the one with higher risk aversion contributes less. Furthermore they show that for an individual player, the added expected utility gain from an additional unit of investment decreases with the level of risk aversion. By the nature of this game's equilibrium, players with a relatively lower level of risk aversion would contribute relatively more.

In the experimental treatments, some of the subgame perfect equilibria described above can be excluded. The leader (l) in the *ingroup leading-by-example treatment* would contribute $v_l = 0$ in the subgame perfect Nash equilibrium. She can expect the followers to fully compensate for this and spend $\sum_{i \in K \setminus \{l\}} v_i = \frac{z}{4} - v_l$, which is $\sum_{i \in K \setminus \{l\}} v_i = 120$ under the given parameters of the game. As before, if every follower contributes equally, each would invest $v_i = \frac{z}{4(K-1)} - v_l$, or $v_i = \frac{120}{3} = 40$. Note to Arno: You say "unnecessary notation". I do think the notation is rather helpful for understanding where the 120's and 40's come from, for example in Table 2.

If the risk-neutral leader is faced with risk averse followers, given (the leader's belief of) the followers' level of risk aversion, she would contribute $v_l = 120 - \sum_{i \in K \setminus \{l\}} v_i$, where $\sum_{i \in K \setminus \{l\}} v_i$ decreases with the level of risk aversion of followers (Appendix E; Abbink et al., 2010; Katz et al., 1990). Also, v_l will be lower for higher levels of the leader's risk aversion.

In the *ingroup transactional leader treatment*, a leader motivated by only her own earnings would not redistribute the prize, but keep it for herself. Knowing this, followers would not contribute to the contest. The leader, moving before her group mates contributes $v_l = 120$ tokens. Note that in this treatment, the leader behaves as if she was a one-person competing party, delivering all tokens to the contest by herself and also keeping the prize, if won. As before, under risk aversion, the leader's contribution would decrease with her level of risk aversion. Followers, however, would not chip in for a lowered contribution of the leader, as they would still not expect the leader to redistribute the prize, if won.

[7]See Appendix D for the derivation of the equilibrium.

In both *intergroup treatments*, communication between leaders is cheap talk and equilibrium predictions are the same as in the treatments without communication.

Table 2 illustrates the following: The strategy that would maximise total monetary welfare across groups would be for all parties to invest nothing and have a 50 % chance of winning (Social Opt.). The reason for this is that contributing in the contest only influences winning probabilities without further productive benefit. Under risk neutrality, the equilibrium contribution on group level stays the same for every treatment (Group level). In the subgame perfect equilibrium of all treatments but the *Baseline*, either of the following situation emerges: *a*) In the leading-by-example treatments, the leader would contribute zero while the followers fully chip in, providing more than they would in the *Baseline* treatment. *b*) In the transactional treatments, by contrast, the leader delivers as much input by herself, as the group would deliver as a whole in the *Baseline* treatment and the followers contribute zero.

Table 2: Overview of Equilibrium predictions

	Group level	Leader	Followers tot.	Followers each if symmetric	Social Opt.
Baseline	120	–	120	30	0
Ingroup leading-by-example	120	0	120	40	0
Ingroup transactional leader	120	120	0	0	0
Intergroup leading-by-example	120	0	120	40	0
Intergroup transactional leader	120	120	0	0	0

(Subgame perfect) Nash equilibria under risk neutrality. The *Baseline treatment* has no leader.

3.1 Alternative Hypotheses

As consequence of the equilibrium strategies under assumptions of selfishness, followers observing a leader who contributes a lot, would only spend a small amount (or nothing) for the contest. Equally, when observing a leader contributing very little, followers would contribute a high amount of points. By contrast, though, as the leader's contribution decision is observed by all others in the group, we expect followers to perceive the leader's contribution as signal or sacrifice and follow her example (cf. Hermalin, 1998; Potters, Sefton, & Vesterlund, 2001; Meidinger & Villeval, 2002). Accordingly, we expect a high leader-contribution to spur followers to contribute as well and a low leader-contribution to dissuade followers from contributing to the contest. What this means for the overall contribution level depends on the leader's motivation.

Hypothesis 1. *In all leader treatments, there exists a positive relationship between leader and follower contribution.*

The leaders may not only care about the monetary value of the prize, but winning as such may be a component in individual utility (Schmitt, Shupp, Swope, & Cadigan, 2004).[8] To increase the chance of winning, a leader might use her contribution as signal for how followers should behave, rewarding those who do follow. This strategy is viable in the treatments where the leader actually can redistribute the prize won (i.e. *ingroup transactional leader* and *intergroup transactional leader treatment*). In this case, acting in accordance with the leader's investment can be in a follower's own economic interest. If this is the case, leaders' prize allocation patterns should deviate significantly from the standard benchmark predictions. Here, a leader would redistribute positive amounts to followers and distribute more to followers who behave according to the leader's benchmark.

Another motivation for prize redistribution would be leaders willing to incur costs in order to reduce inequality.[9] Accordingly, leaders would allocate a larger chunk of the prize to high contributing followers. Because of their high spending levels, this kind of followers is relatively poor and inequality averse leaders would try to close the earnings gap through the prize allocation.

Hypothesis 2. *In the transactional leader treatments, there exists a positive relationship between a follower's contribution and the prize redistributed towards this player.*

There exists a stream of literature showing that communication – even when just "cheap talk" – can improve coordination in experimental games (e.g. Leibbrandt & Sääksvuori, 2012; Sutter & Strassmair, 2009; Blume & Ortmann, 2007; Van Huyck, Battalio, & Beil, 1993). Cason, Sheremeta, and Zhang (2012) present a counterexample using within- and inter-group communication embedded in a weakest-link contest between groups. In a weakest-link contest, the lowest contribution in a group determines the overall contribution level of the group. While inter-group communication leads to significantly lower efforts and higher payoffs, within-group communication causes higher efforts and substantially lower payoffs.

In our study we only employ inter-group communication, and furthermore only leaders communicate with each other.

Hypothesis 3. *Contributions levels are lower in the intergroup treatments.*

4 Results

This section is divided into four parts. First we present general contribution patterns and corresponding treatment differences, before turning to the leaders' behaviour and the followers' behaviour, respectively. Then in Subsection 4.4 we study leaders' chats and how this communication channel pans out for the between group contest.

We apply non-parametric methods for hypotheses testing: Mann-Whitney U tests (MWU) (Mann & Whitney, 1947) for independent sample tests and Wilcoxon signed-rank test (Wilcoxon, 1945) for paired tests. Furthermore we use the Kruskal-Wallis test (KW test) (Kruskal & Wallis, 1952) and Dunn's test (Dunn, 1964) with a false discovery rate (FDR) adjustment by Benjamini and Hochberg (1995) for tests involving three or more

[8] Sheremeta (2010) shows that more than 40% of experiment participants were willing to submit positive contest contributions to a contest with a prize value of $0.

[9] Bolton and Ockenfels (2000); Fehr and Schmidt (1999) present models of self-centred inequality aversion.

groups. We use a non-parametric test for trend developed by Cuzick (1985). Unless specified differently, we use data on paired group level (eight players) as independent observation and apply two-sided tests. For each treatment we have nine group pairs.

4.1 General Contest expenditures

Figure 1 provides a graphical impression of contest contributions for all treatments. The dashed horizontal line at 120 represents the (risk neutral, standard preferences) Nash equilibrium benchmark as reference. In all treatments we observe strong overcontribution with groups on average contributing almost three times the risk neutral equilibrium prediction (Wilcoxon test: H0: group contr. $= 120$, $N = 45$, $p < 0.001$). However, the results from a KW test indicate that there exists difference between the treatments (KW test: $N = 45$, $p = 0.023$). More specifically, a Dunn's pairwise comparison (see Table 3) finds that contribution levels in the *Baseline* treatment are significantly lower than in the *Ingroup trans* treatment ($p = 0.095$). Furthermore, contribution levels in the *Intergroup lbe* treatment are lower than in all other treatments ($p \leq 0.032$), with the exception of the *Baseline*, which is statistically not different ($p = 0.219$).

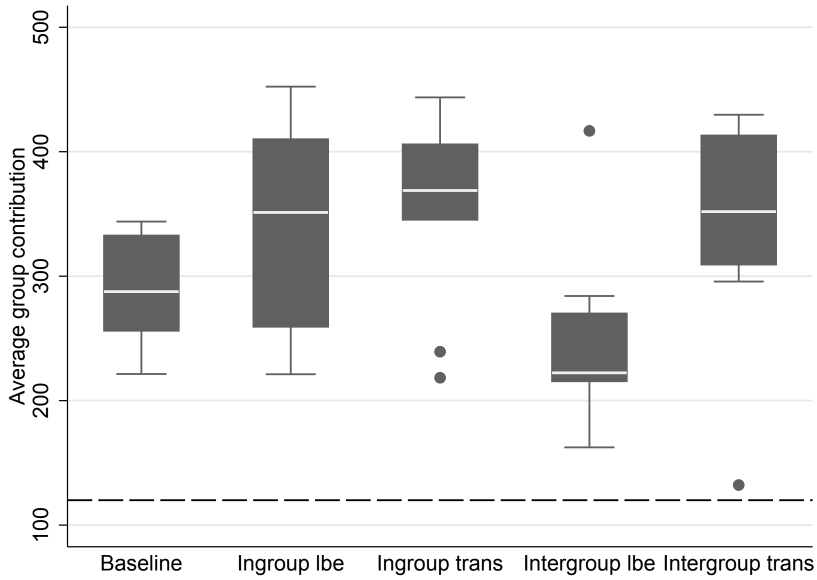

Figure 1: Contribution to the contest. The white horizontal line indicates the median, boxes stretch from upper to lower quartile. Whiskers indicate largest and lowest value, excluding outliers, which are indicated by single dots.

Result 1 Leading by example with intergroup communication leads to a decrease in investments. Other differences are not significant.

Accordingly, our results deliver some evidence in favour of Hypothesis 3 in the *intergroup lbe* treatment only. For the *intergroup trans* treatment, contribution levels are on an equally high level as in the other treatments.

Table 3: Pairwise comparison of group contribution by treatment (Dunn's test with Benjamini-Hochberg FDR correction)

Column mean - row mean z test statistic (p-value)	Baseline	Ingroup lbe	Ingroup trans	Intergroup lbe
Ingroup lbe	-1.364 (0.144)			
Ingroup trans	-1.777^{*} (0.095)	-0.413 (0.425)		
Intergroup lbe	1.023 (0.219)	2.387^{**} (0.028)	2.800^{**} (0.026)	
Intergroup trans	-1.472 (0.141)	-0.108 (0.457)	0.305 (0.422)	-2.495^{**} (0.032)

* p<0.10, ** p<0.05, *** p<0.01

Figure 2 depicts the average group contribution to the contest over the periods per treatment. Again, the risk-neutral Nash equilibrium is indicated at a contribution level of 120. Looking at spending levels in period 1, we see that except for the *Intergroup lbe treatment*, which displays a significantly lower round-one contribution, all treatments start out on a fairly similar level (KW test: $N = 45,\ p = 0.074$. Dunn's test: H0 rejected for each pairwise comparison iff *Intergroup lbe treatment* involved). In both *Intergroup treatments* there exists a significant time trend over the course of the game. While there is a positive trend for the *Intergroup trans treatment* (Cuzick test: $N = 9,\ z = 1.80,\ p = 0.072$), *Intergroup lbe* displays a decreasing contribution level over time (Cuzick test: $N = 9,\ z = -2.30,\ p = 0.022$). The other three treatments display no trend (Cuzick tests, $p \geq 0.24$).

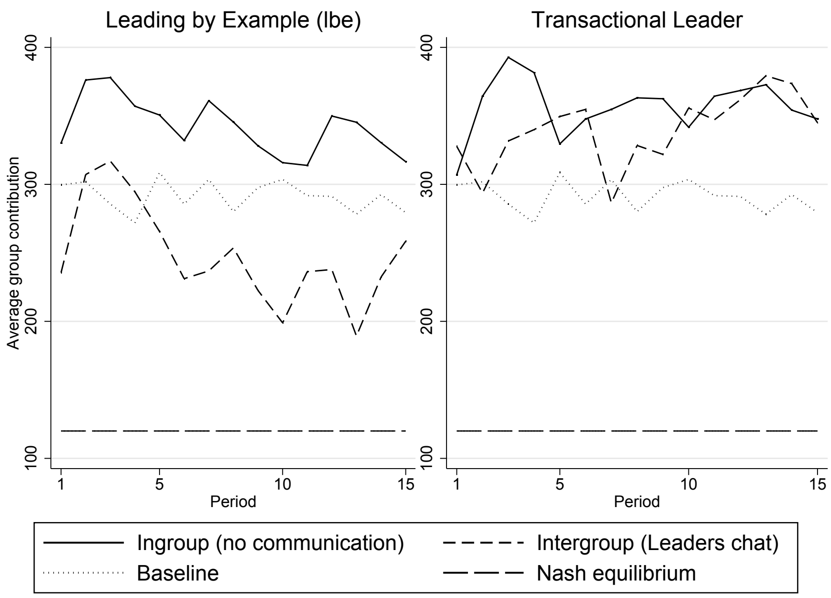

Figure 2: Contribution to the Contest over the Periods

4.2 Leader Behaviour

We start with a look at leaders' contribution levels across all periods. As depicted in Figure 3, leaders contribute at an overall comparable level for almost all treatments (KW test: $N = 36,\ p = 0.126$. All Dunn's pairwise comparisons with $p \geq 0.062$). There exists some weak common directionality for the *Intergroup lbe* treatment being lower than the others at p-values between $6.2 - 15\%$.

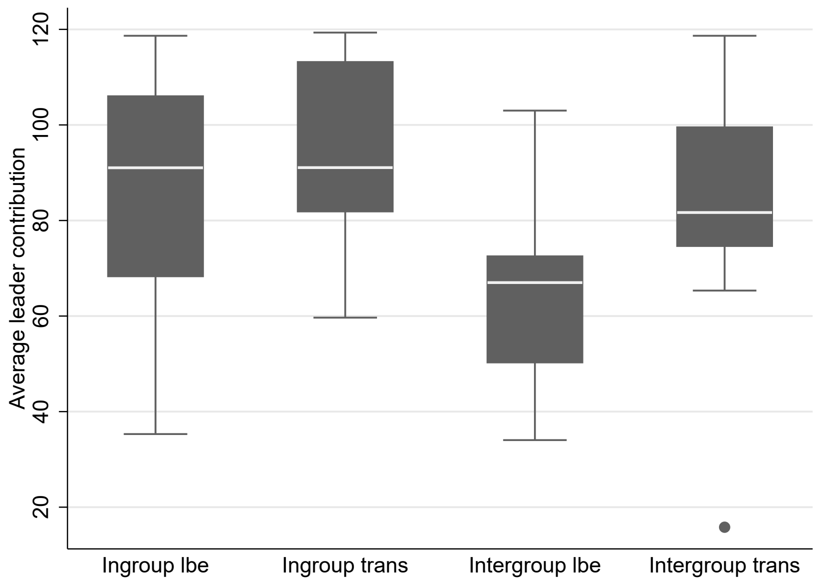

Figure 3: Leader contribution to the contest. The white horizontal line indicates the median, boxes stretch from upper to lower quartile. Whiskers indicate largest and lowest value, excluding outliers, which are indicated by single dots.

Figure 4 depicts average leader contribution levels per period for each treatment with a leader. On the left hand side we have the *leading by example* treatments, in which the leader is merely a first mover in the game, and on the right hand side we group the *transactional leader* treatments, in which the leader can redistribute the prize, if won. As reference, the dashed straight line represents the respective Nash equilibrium. Notice the difference in subgame perfect Nash equilibria for leaders (cf. Table 2), which do not seem to have any effect on behaviour. While it seems that *Ingroup* leaders contribute more than *Intergroup* leaders, pairwise tests fail to support this (see KW and Dunn's tests above). In terms of period trend, however, we find some evidence for a difference between leading-by-example and transactional leaders. While leader contribution levels for both transactional treatments display a significant positive trend (Cuzick tests at group pair level, $N = 9,\ z \geq 1.78,\ p \leq 0.063$), among the two other treatments with a leader, only *intergroup lbe* has a significant and negative trend (Cuzick test at group pair level, $N = 9,\ z = -1.74,\ p = 0.083$).

Table 4 presents results of OLS fixed-effects models with error terms clustered at group-pair level (two competing groups), regressing a leader's contribution in period t on a number of factors.[10] This panel data regression method allows us to investigate how

[10] A Hausman specification test (Hausman, 1978) rejects GLS random effects model as inconsistent with

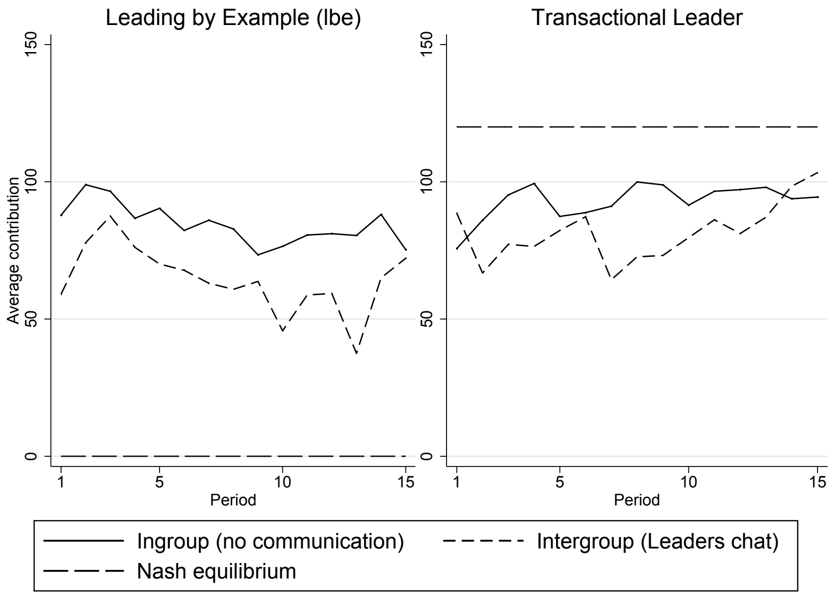

Figure 4: Contribution to the Contest by Leaders only

leaders' contribution decisions are influenced by other players' behaviour in this game and whether this differs between treatments. These only include data from treatments with a leader, hence omitting the *baseline treatment*. Our results indicate that the autoregressive factors "Contribution lag 1" and "... lag 2" barely carry any significance. By contrast, there indeed exists a positive relationship between leader and follower contribution levels in two of the four regressions (the *intergroup* treatments) and a common directionality in all four regressions. This delivers evidence in favour of Hypothesis 1. Furthermore, the competing group's contribution level in $t-1$ positively influences a leader's contribution in t for two of the four treatments (*Ingroup lbe* and *Intergroup trans* treatments). In the other two treatments, however, this effect seems to be very close to zero. As it concerns the two orthogonal experimental treatments, interpretation of this effect, or the lack thereof in particular treatments, is not obvious. Lastly, lagged earnings from the contest only have some small negative effect in the *Intergroup trans* treatment.

Result 2 We find some weak evidence for lower contribution levels of leaders in the *intergroup lbe* treatment. Furthermore, follower contribution levels have a positive effect on their leader's contribution.

In the transactional treatments, leaders can redistribute the prize. If this instrument is used to incentivise a reduction in contest spending, resources would need to be distributed towards those followers that adhere to low contribution levels. Using a density-distribution sunflower plot (Dupont & Plummer, 2003), Figure 5 depicts the relationship between the prize received from the leader and a player's contribution relative to the leader in the same period. Circles represent individual observations, light sunflowers are accumulations of entries within a bin of 8.571,[11] where each petal stands for one observation, dark sunflowers

$p < 0.001$.

[11]For our x-axis $[-120, 120]$, this creates exactly 28 bin ranges. See Dupont and Plummer (2003) for details on the determination of bin sizes.

Table 4: Leader contribution – OLS fixed-effects model using treatments with leaders only. *Baseline* treatment omitted, standard errors clustered to allow for intra-pair correlation.

VARIABLES	(1) Ingroup lbe	(2) Ingroup trans	(3) Intergroup lbe	(4) Intergroup trans
	Leader contribution in period t			
Contribution lag1	0.044	0.369*	0.067	−0.138
	(0.19)	(0.17)	(0.11)	(0.08)
Contribution lag2	0.074	−0.026	0.000	0.092
	(0.09)	(0.08)	(0.09)	(0.17)
Average follower contribution Lag1	0.290	0.291**	0.138	0.233**
	(0.19)	(0.11)	(0.13)	(0.09)
Other group's contribution Lag1	0.056**	−0.003	0.004	0.052**
	(0.02)	(0.01)	(0.03)	(0.02)
Earnings from contest lag1	−0.006	0.002	−0.005	−0.021**
	(0.01)	(0.00)	(0.01)	(0.01)
Constant	30.097	36.602***	51.640***	55.347**
	(30.85)	(10.06)	(13.51)	(17.76)
Number of observations	234	234	206	234
Number of individuals	18	18	18	18
Within model R-squared	0.116	0.354	0.024	0.113
Between model R-squared	0.755	0.890	0.742	0.572
Overall R-squared	0.489	0.704	0.185	0.229

* p<0.10, ** p<0.05, *** p<0.01
Clustered standard errors in parentheses.

constitute a further aggregation, with a petal for each 13 observations, using the same bin size. We add two reference lines: *1*) a horizontal line at 480, which represents an equal redistribution of the prize among all group members and *2*) a vertical line at 0, where a follower contributes at the same level as her leader does.

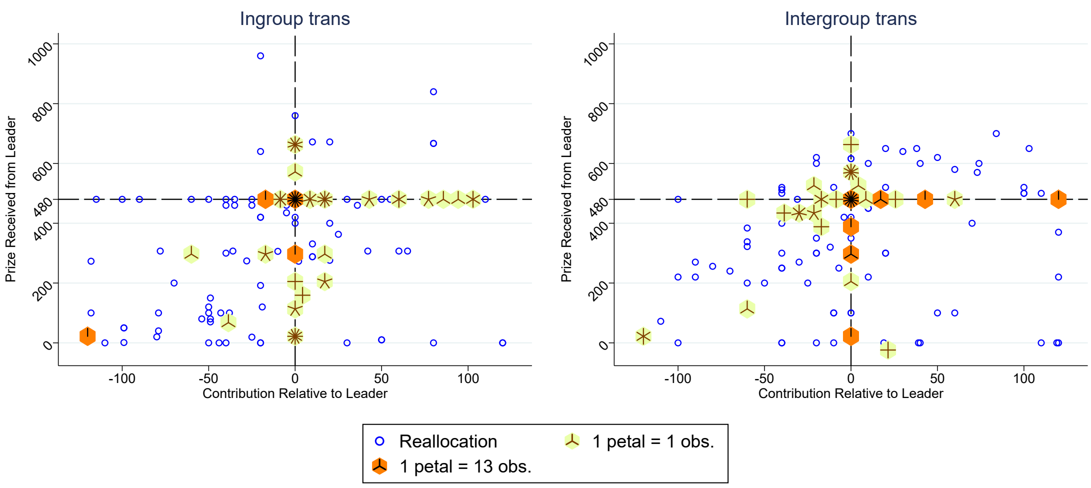

Figure 5: Reallocation of Prize by Transactional Leaders

In Figure 5 two dominant strategical patterns can be recognised: *First*, followers tend to contribute at the same level as the leader, which is illustrated by the high density of observations along a relative contribution of 0. *Second*, leaders reallocate an equal share of the prize, which can be seen by the accumulation of observations on the horizontal line of 480. This creates a cross, establishing four domains. The north-western and north-eastern domains contain only a few observations. This means that leaders tend to not reallocate more than the equal share, even to those that contribute more than the leader. By contrast, it is in the south-western domain where by far the most observations lie. This area represents the situation where leaders reallocate less than the equal share to followers with a negative relative contribution. Furthermore, for an extremely low level of relative contribution (-120), we observe a high clustering on zero redistribution. This means that followers who fall far below their leader's benchmark do not receive anything from the leader.

In addition, consider Regressions (5) and (6) in Table 5. Using fixed-effects models we find a positive relationship between followers' individual contribution levels and the share in the prize received by her leader. This means that leaders tend to allocate more to high contributors, which supports Hypothesis 2. At the same time, the level of other group members' contribution has no significant effect. This suggests that leaders do look at individual contribution levels when deciding on the prize allocation within a group. Note further from Table 5 that leaders who contribute more themselves, also tend to allocate more of the prize to their followers. This delivers more evidence in favour of the hypothesis that leader contribution behaviour serves as a cue for how followers should behave, and that compliance with this cue will be rewarded. These patterns are true for both treatments.

Table 5: Transactional Leadership – OLS fixed-effects models using data from followers in groups that have won in a given period. Standard errors clustered to allow for intra-pair correlation.

	(5)	(6)
	Ingroup trans	Intergroup trans
VARIABLES	Prize Received from Leader	
Contribution	1.475^{**}	1.647^{**}
relative to leader	(0.45)	(0.66)
Other followers'	0.037	-0.448
contr. this period	(0.37)	(0.27)
Leader contribution	1.026^{**}	1.394^{**}
	(0.44)	(0.51)
Constant	282.237^{***}	358.121^{***}
	(57.39)	(48.02)
Number of observations	405	405
Number of individuals	54	54
Within model R-squared	0.109	0.107
Between model R-squared	0.337	0.024
Overall R-squared	0.266	0.061

* p<0.10, ** p<0.05, *** p<0.01
Clustered standard errors in parentheses.

Result 3 In transactional treatments, many leaders reallocate an equal share of the prize, 480. Furthermore, there exists a positive relationship between follower contribution levels and prize reallocation.

4.3 Follower Behaviour

Again, we start with a look at overall follower contribution levels in Figure 6. Similar to results discussed in previous subsections, behaviour in the *intergroup lbe* treatment stands out from the other treatments with lower contribution levels than each of the other treatments. A KW test indicates that at least one treatment is different from the other ones (KW test: $N = 36,\ p = 0.047$). Dunn's pairwise comparisons show that follower contributions in the *intergroup lbe* treatment are indeed lower than any of the other treatments with a leader ($p \leq 0.040$). All other pairwise comparisons display no evidence for significant difference ($p \geq 0.473$). This confirms Hypothesis 3 partially. We find evidence in favour of said hypothesis for the *Intergroup lbe*, but not the *Intergroup trans* treatment.

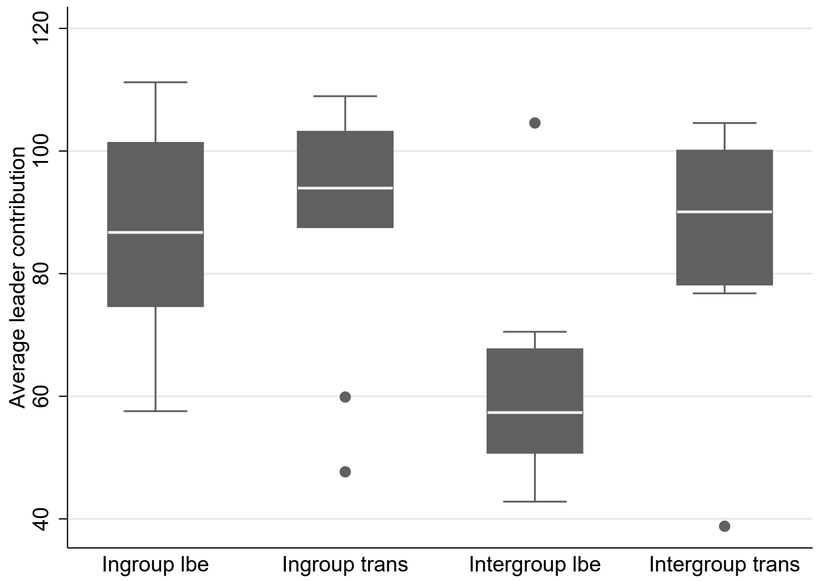

Figure 6: Follower contribution to the contest. The white horizontal line indicates the median, boxes stretch from upper to lower quartile. Whiskers indicate largest and lowest value, excluding outliers, which are indicated by single dots.

In Figure 7 we depict average group contribution for followers per period for each treatment with a leader. As before, with *leading by example* treatments on the left and *transactional leader* treatments on the right hand side. The dashed straight lines represent the respective Nash equilibria at follower level. This image visually illustrates that the Nash equilibrium does not have any bearing on the contribution levels of the treatments. Most notably, contribution levels in the *intergroup lbe* treatment are lower than for the other treatments, despite having a higher Nash equilibrium than both transactional leader treatments. For the followers, we only find a significant trend for both intergroup treatments. While this trend is negative for the *intergroup lbe* treatment (Cuzick test at group pair level, $N = 9,\ z = -2.33,\ p = 0.020$), it is positive for the *intergroup trans* treatment (Cuzick test at group pair level, $N = 9,\ z = 1.68,\ p = 0.092$). For both ingroup treatments, follower contributions do not seem to systematically change over time (Cuzick tests at group pair level, $N = 9,\ p \geq 0.299$).

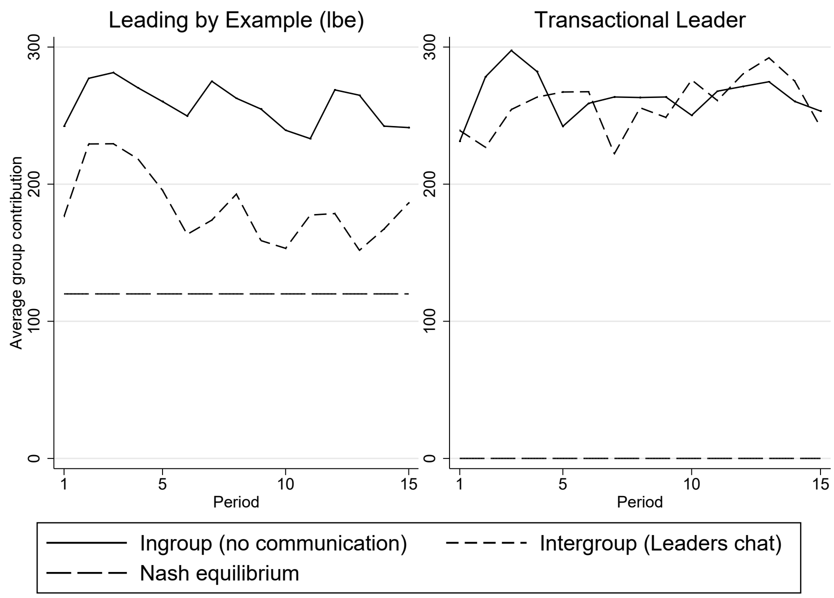

Figure 7: Contribution to the Contest by Followers only.

In Table 6 we presents results of an OLS fixed-effects model with error terms clustered at group-pair level (two competing groups), regressing a follower's contribution in period t on a number of factors. For this we omit data from the *baseline treatment*, focussing on treatments with a leader only. We use this panel data analysis method to look into which dynamics of the game have an effect on followers' contribution behaviour and whether this differs between treatments. Again, like in the regressions on leader behaviour in Table 4, the lagged own contributions are not significant. There exists, however, a robust positive relationship between leader and follower contribution levels in all four treatments. Indeed, in all four treatments, the leader's contribution level is perceived as a signal and followers tend to follow her example. This result delivers additional evidence in support of Hypothesis 1. Other factors of the game have only minor or no influence on follower contribution levels. The lagged contribution level of the other group has no significant effect for all four treatments. The lagged contribution level of other fellow followers and the prize received in the previous period both have a small positive effect in the *ingroup trans* treatment, but not in the other three treatments. From this analysis it appears that the leader's contribution level is the strongest and most robust factor influencing followers' behaviour.

Result 4 We find robust evidence for lower contribution levels of followers in the *intergroup lbe* treatment. Furthermore, the leader's contribution has a positive effect on her followers' contribution levels.

Figure 8 uses a density-distribution sunflower plot to illustrate how a follower's willingness to contribute (relative to the leader) relates to the leader's prize reallocation in the previous period. For this analysis we focus on groups in the transactional treatments

Table 6: Follower contribution – OLS fixed-effects model using treatments with leaders only. *Baseline* treatment omitted, standard errors clustered to allow for intra-pair correlation.

VARIABLES	(7) Ingroup lbe	(8) Ingroup trans	(9) Intergroup lbe	(10) Intergroup trans
	Follower contribution in period t			
Contribution lag1	0.044	0.117	0.093	0.031
	(0.05)	(0.08)	(0.07)	(0.07)
Contribution lag2	−0.019	−0.003	−0.044	0.059
	(0.03)	(0.04)	(0.05)	(0.04)
Leader Contribution	0.397**	0.258*	0.446***	0.561***
	(0.17)	(0.13)	(0.07)	(0.07)
Other group's contribution lag1	0.012	0.023	0.003	−0.000
	(0.01)	(0.03)	(0.02)	(0.01)
Other followers' contribution lag 1	0.038	0.092*	0.038	0.008
	(0.04)	(0.05)	(0.03)	(0.03)
Prize received from contest lag1	0.000	0.013**	−0.013	0.009
	(0.01)	(0.01)	(0.01)	(0.01)
Constant	39.855***	26.763***	26.738***	30.317***
	(7.77)	(6.71)	(4.27)	(8.45)
Number of observations	702	702	618	702
Number of individuals	54	54	54	54
Within model R-squared	0.167	0.127	0.218	0.361
Between model R-squared	0.572	0.739	0.353	0.542
Overall R-squared	0.378	0.472	0.270	0.424

* p<0.10, ** p<0.05, *** p<0.01
Clustered standard errors in parentheses.

that have won in the previous period.[12] It illustrates the relationship between a follower's relative contribution and the prize received from the leader in the previous period. We use the same reference lines as before. We observe that followers frequently contribute at the same level as the leader. These dominant behaviour patterns serve as boundary for creating four domains in the graph, as in the earlier analysis. The south-eastern domain remains nearly empty, and if there are entries, they lie very close to the delimiters. Accordingly, individuals who receive more than the equal split of the prize tend to not contribute less than the leader in the subsequent period. The vast majority of observations off the cross fall into the south-western domain: Followers who have received less than the equal share in the preceding period, tend to display a lower contribution than the leader. The two northern domains display a few entries, any behaviour off the cross does not seem to be very widespread here.

Consider also Table 7. Using fixed-effects models we find that for both *transactional* treatments, followers who receive a larger piece from the prize also display higher contribution levels in the subsequent period. Furthermore, while there is some evidence of a positive effect from other fellow followers' contribution in Regressions (11) and (13), the negative effect from *leader contribution* in all treatments seems to capture some regression

[12] For groups that have lost in the period before, there is no prize to reallocate. Also, this part only includes data from 14 periods, dropping period 1 contribution data.

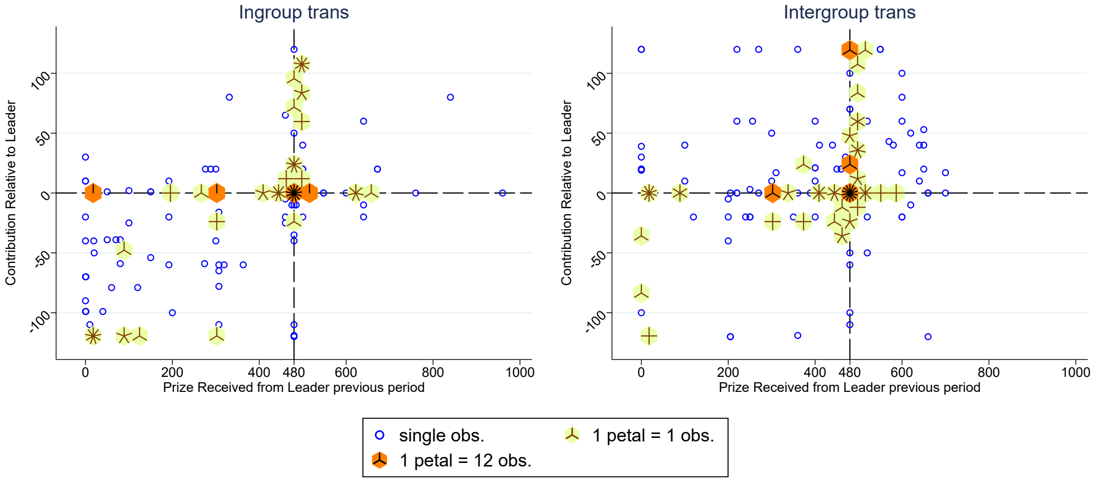

Figure 8: Followers' Relative Contribution in Relation to the Prize they Received from the Leader in the Previous Period

to the mean effect.

Table 7: Transactional Leadership – OLS fixed-effects models using data from followers in groups that have won the period before (in $t-1$). Standard errors clustered to allow for intra-pair correlation.

	(11)	(12)	(13)	(14)
	Ingroup lbe	Ingroup trans	Intergroup lbe	Intergroup trans
VARIABLES	Contribution relative to Leader			
Prize received from leader previous period		0.057^{**}		0.072^{***}
		(0.02)		(0.02)
Other followers' contribution lag1	0.183^{***}	0.092	0.145^{**}	0.041
	(0.03)	(0.06)	(0.05)	(0.05)
Leader contribution	-0.747^{***}	-0.806^{***}	-0.678^{***}	-0.502^{***}
	(0.13)	(0.06)	(0.12)	(0.09)
Constant	35.942^{***}	37.057^{**}	20.886^{*}	10.181
	(8.71)	(14.13)	(10.68)	(11.31)
Number of observations	378	378	336	378
Number of individuals	54	54	54	54
Within model R-squared	0.277	0.379	0.352	0.331
Between model R-squared	0.315	0.421	0.453	0.324
Overall R-squared	0.401	0.499	0.395	0.345

* p<0.10, ** p<0.05, *** p<0.01
Clustered standard errors in parentheses.

Result 5 The relationship discussed under Hypothesis 2 seems to also hold in the inverse: Redistribution from the leader has a positive effect on followers' subsequent contribution levels.

4.4 Intergroup Leadership: The chat contents

Prior to deciding on her contribution level, each leader in the *intergroup* treatments has the opportunity to communicate with the leader of the competing group via a chat window for 45 seconds each period. These conversations have been documented by the software and categorised by a research assistant who is not involved with this project in any other way. The assistant was not informed about the research question or about the hypotheses of this study. She read the entire chat history of all groups and sorted the messages according to categories, provided by us. Table 8 gives an overview of the categories we employ here. Some messages fall into multiple categories at a time. Figure 9 depicts the prevalence of chat categories per treatment. We see that "low contribution" messages are being sent more frequently in the *Intergroup lbe* treatment, while "bonding" or "small talk" are relatively less commonly used here.

Table 8: Chat categories employed

Category	Criterion, i.e. "Conversation about..."
Low contribution	Contributing an amount between 0-40 points
Medium contribution	Contributing an amount between 41-80 points
High contribution	Contributing an amount between 81-120 points
Alternate	Taking alternating turns in contributing
Bonding	Creating an emotional bond with each other
Small Talk	Non-game related casual conversations
Understanding	The rules of the game, clarifications
Efficiency	Deliberations about what would be the most "efficient" way to play
Followers' behaviour	What the followers do / what they contribute
Give much to followers	Redistributing a significant sum of points to followers
Give little to followers	Redistributing only a minor sum of points to followers
Other	Any message that does not fall into any of the categories above

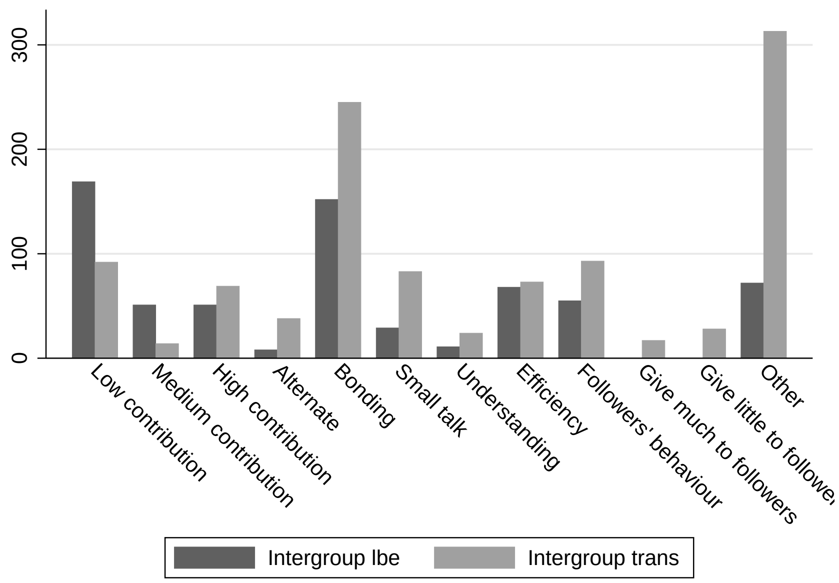

Figure 9: Prevalence of Chat Messages per Treatment

Using a GLS random effects model with error terms clustered for intra-pair correlation, we regress a leader's contribution level on the number of messages sent in a given period, which fall into one of the categories, as discussed below. Furthermore, we use lagged values for own contribution and a lagged group win term as controls. Table 9 contains the regression results for the *Intergroup lbe* treatment in Regression (15) and for *Intergroup trans* in Regression (16). The last column in Table 9 indicates whether a particular factor is significantly different between the two treatments. For this, we use interaction terms to determine treatment differences (Find the corresponding regression in Table 11 in Appendix F).

First of all, sending messages discussing low contribution levels (e.g. between 0 - 40 points), has a reducing effect on contribution levels. Inversely, leaders discussing high contribution levels (e.g. between 81 - 120 points) contribute more to the contest, subsequently. This is true for both treatments with chat function, and we also observe no significant difference in effect sizes. As expected, discussing a medium level of contest spending has neither a lowering nor increasing effect in this regard. Furthermore, transactional leaders who discuss coordinating on taking alternating turns, manage to alleviate the between-group contest. This result is not the case for leaders in the *intergroup lbe* treatment, however. Somewhat surprisingly, bonding or small talk messages incite a higher spending level in Regression (15). By creating an emotional tie with the other group representative, we would have expected a degree of mitigation towards the inter-group contest. Furthermore, while bonding messages indeed feature an escalating character towards leaders in the *Intergroup lbe* treatment, this effect appears to be non-existent in the *Intergroup trans* treatment.

Understanding has a weak positive effect in Regression (16), delivering some suggestive evidence that leaders in the *intergroup trans* treatment, who had understanding questions, tended to contribute a little more. This effect is not significant for the other intergroup treatment and has a comparably high p-value of 0.094. Further, efficiency concerns do not seem to be a driving factor for leaders' decision making. While this could have been expected to have an abating effect on contest expenditures, discussing this topic had no influence on their contribution behaviour. General conversation on the followers' behaviour, by contrast, constitutes a subject matter with escalating influence on leader contribution decisions in both treatments. Concerning the reallocation of the prize, leaders who articulate their intention to allocate open-handedly towards followers (Give much to followers), are also the ones who spend more resources to the contest. The inverse is also true, leaders talking about giving only little to their followers, also spend little in the contest.

Apart from the chat categories, there is some difference in leaders' reaction on having won in the previous round. While a transactional leader whose group won the preceding period drastically reduces her contributions, this is not the case for leaders in the *Intergroup lbe* treatment. This could have to do with the fact that alternating seems to work a lot better in the *Intergroup trans* treatment.

Result 6 Leaders that coordinate on taking turns manage to reduce contest expenditures significantly. Moreover, the prevalence of subject matters structurally differs between the treatments, favouring more mitigating messages in the *Intergroup lbe* and more escalating messages in the *Intergroup trans* treatment. This contributes at explaining the strong treatment difference in contest spending.

Table 9: Leader Contribution as Function of Chat Contents – GLS random effects models. Standard errors clustered to allow for intra-pair correlation.

VARIABLES	(15) Contribution Intergroup lbe	(16) Contribution Intergroup trans	Difference Significant
Low contribution	-14.009^{***}	-22.113^{***}	
	(5.33)	(4.64)	
Medium contribution	3.521	4.452	
	(3.54)	(4.82)	
High contribution	17.715^{***}	12.550^{***}	
	(5.02)	(4.26)	
Alternate	-0.059	-11.494^{***}	
	(7.95)	(3.70)	
Bonding	10.037^{***}	0.683	***
	(2.75)	(1.45)	
Small talk	10.619^{***}	4.019	***
	(2.42)	(3.27)	
Understanding	2.234	8.452^{*}	
	(10.42)	(5.04)	
Efficiency	-0.522	-3.645	
	(2.48)	(4.13)	
Followers' behaviour	6.101^{**}	5.562^{**}	
	(2.45)	(2.75)	
Give much to followers		12.773^{***}	
		(4.25)	
Give little to followers		-15.280^{***}	
		(3.54)	
Other	4.939	0.997	
	(6.43)	(2.48)	
Contribution previous period	0.279^{***}	0.298^{***}	
	(0.08)	(0.11)	
Group won previous period	-4.782	-23.154^{**}	*
	(5.11)	(9.11)	
Constant	44.592^{***}	70.737^{***}	
	(9.90)	(14.12)	
Number of observations	224	252	
Number of individuals	18	18	
Within model R-squared	0.177	0.151	
Between model R-squared	0.807	0.858	
Overall R-squared	0.397	0.360	

* p<0.10, ** p<0.05, *** p<0.01
Clustered standard errors in parentheses.

5 Conclusion

This study provides one of the first (experimental) study on leaders in a group contest, complementing studies by Loerakker and van Winden (2017); Eisenkopf (2014). In a $2 \times 2 + 1$ setup, we investigate leaders who are either mere first movers (as in Loerakker & van Winden, 2017), or who have large financial authority over followers. Furthermore, we explore the effect of communication between leaders via free form chats. Hence, we explore the effect of having the institution of a central authority entrusted with setting a benchmark or with pecuniary say. Does this lead to mitigation of wasteful contest spending and lead to a de-escalation?

Our results substantiate a considerably pessimist view overall: Most leadership types actually prompt an escalation of the contest and leaders tend to incentivise their group mates to chip in resources to the competition, confirming Hypothesis 2. While the establishment of intergroup leadership through free form text communication between leaders of competing groups can contribute at abating the rat race – which confirms Hypothesis 3 – general spending levels do not constitute a significant improvement from the baseline level. Leaders who manage to coordinate through the chat on taking turns at chipping in resources are most successful in guiding their groups towards more efficient play.

In contrast to the set of risk-neutral subgame perfect equilibria, outlined in Section 3, we find followers' contribution levels to be depending positively on the leader's spending level. This confirms Hypothesis 1. A leader's spending pattern serves as benchmark / signal towards her followers.

The primary application for these results are twofold: *First*, there is scope for operationalisation in the context of socio-economic conflict or between-country struggles for a natural resource. *Second*, in a corporate context, commercial tenders are of widespread use for the procurement of public projects, like major or medium-sized construction ventures. In fact, public procurement represents more than 10 % of EU GDP as of 2007 (Bovis, 2012). Given the starkly contrasting nature of these two fields of application, policy recommendations, based on insights gained in this article, would fundamentally differ with respect to which goal is considered achievable. While in the former scenario, a de-escalation of conflict expenditures would be desirable, firms in the latter scenario might wish to increase engagement into the procurement tender. The hierarchical nature of the group setup in this experiment has potential for a closer resemblance to group structures which are characterised by having a superordinate leader. Examples for this are most businesses, political parties or sports teams. In a competitive scenario, a proper understanding of the role of managers in a firm or commanders in a military platoon, can be of utmost importance for a smooth functioning of the group as a whole.

We see a couple of fruitful opportunities for future research. In our study we allow for communication between leaders of competing parties. One conceivable extension would be to consider one-sided text messages from the leader towards her followers, or even an interactive chat between leader and followers. Further, side-payments (as in Kimbrough & Sheremeta, 2013, 2014) or costly commitment (e.g. Kimbrough, Rubin, Sheremeta, & Shields, 2015) could constitute a promising vehicle for coordination between the groups. Prior research has employed these latter conflict resolution mechanisms for contests or other conflict models between individuals, only. The richer dynamics of a group setting with a leader could be an interesting litmus test for their robustness.

Appendix A Measuring Risk Aversion

Prior to the group contest we take an individual risk preference measure. To this end we use an extended version of the method designed by Eckel and Grossman (2002). Players are confronted with a gamble choice as in Dave, Eckel, Johnson, and Rojas (2010). They opt for one out of 11 gambles as presented in Table 10.[13] Each gamble has a 50:50 chance to either receive a low or a high payoff, respectively. While for Gamble 1 both payoffs are identical (representing the safe option), the alternatives gradually become more risky towards Gamble 11. At the same time, expected returns gradually increase from Gamble 1 to Gamble 9, with Gambles 9, 10 and 11 having an identical expected return. The gamble choice is designed such that risk averse players would choose a Gamble 1-8, a risk neutral player would go for Gamble 9 and a risk seeking player would opt for Gambles 10 or 11.

Table 10: Gamble choices

	Low Payoff	High Payoff	Expected Return	Standard Deviation	Implied CRRA Range
Option 1	28	28	28	0	$0.99 < r$
Option 2	26	32	29	3	$0.99 < r$
Option 3	24	36	30	6	$0.99 < r$
Option 4	22	40	31	9	$0.99 < r$
Option 5	20	44	32	12	$0.78 < r \leq 0.99$
Option 6	18	48	33	15	$0.64 < r \leq 0.78$
Option 7	16	52	34	18	$0.54 < r \leq 0.64$
Option 8	14	56	35	21	$0.46 < r \leq 0.54$
Option 9	12	60	36	24	$0 \leq r \leq 0.46$
Option 10	7	65	36	29	$r < 0$
Option 11	2	70	36	34	$r < 0$

This gamble choice method allows to elicit risk preferences in one step that is easy to understand and easy to implement. Furthermore, it allows for a parameter estimation giving an interval for the player's constant relative risk aversion (CRRA) of the form $u(x) = x^{1-r}$ with x being the wealth and r the coefficient of relative risk aversion (where $r < 0$ is risk seeking, $r = 0$ risk neutral and $r > 0$ risk averse). Dave et al. (2010) compare this method with other, more complex elicitation methods and find that it delivers a less noisy estimate for risk preferences.

Appendix B Measuring Social Value Orientation

We take measures of individual social preferences. For this we make use of the SVO slider measure by Murphy et al. (2011).[14] Individuals set 15 sliders determining how to allocate

[13] The gambles were called "Option" in the experiment.

[14] Crosetto, Weisel, and Winter (2012) provide a helpful tool for implementation.

tokens between themselves and another player, some of which are represented in Figure 10. This provides us with a measure for the most commonplace social orientations (for example altruistic, prosocial, individualistic, and competitive) and their relative weighing for the player.

The SVO slider measure constitutes a simplification and adjustment of the circle test employed by Brandts, Riedl, and van Winden (2009); Sonnemans, van Dijk, and van Winden (2006); Van Lange, De Bruin, Otten, and Joireman (1997). It has demonstrated reliable psychometric properties, yields scores for individuals at the ratio level and is quick and easy to implement (cf. Murphy & Ackermann, 2014).

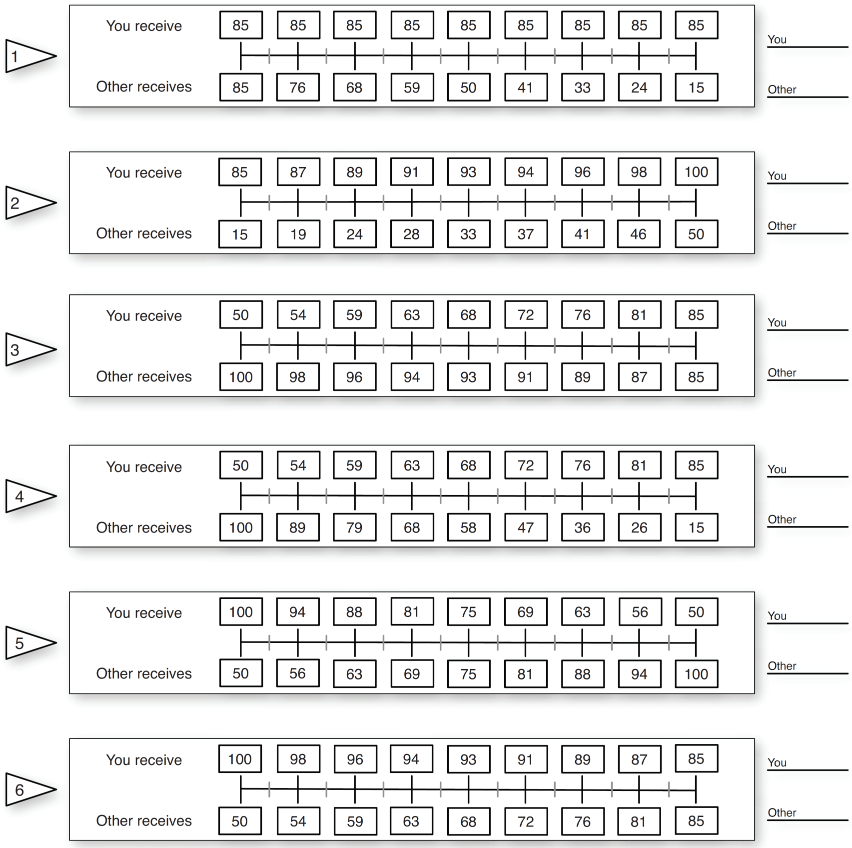

Figure 10: Examples for the slider questions as seen by the participants to measure Social Value Orientation.

Appendix C Instructions

The instructions consisted of three parts. Participants found part 1 with general information and introductions for the risk aversion measure[15] at their place when entering the laboratory. Once everyone was finished with this part of the experiment, the following set of instructions were distributed, which outlined the measurement of individual social value orientation.[16] After this part, participants received instructions for the main part of the experiment,

[15]Find details in Appendix A
[16]see Appendix B

which differed somewhat between the treatments, as outlined below. Paragraphs beginning with a treatment name in square brackets were only given to participants of that particular treatment.

General Instructions

Welcome and thank you for participating in this experiment. In the experiment you can earn money with the decisions you make. Please read these instructions carefully. If you have any questions, please raise your hand and one of the experimenters will come to your cubicle to answer your question.

Talking or using mobile phones or any other electronic devices is strictly prohibited. Mobile phones and other electronic devices should be switched off. If you are found violating these rules, you will both forfeit any earnings from this experiment, and may be excluded from future experiments as well.

This is an experiment about decision making. The instructions are simple and if you follow them carefully you can earn a considerable amount of money which will be paid to you privately and in cash at the end of the experiment. The amount of money you earn will depend on your decisions, on other participants' decisions and on random events. You will never be asked to reveal your identity to anyone during the course of the experiment. Your name will never be associated with any of your decisions.

During the experiment you can earn points (the experimental money unit), which will be converted into cash at the end of the experiment, using an exchange rate of

40 points = 10 cent.

Thus, the more points you earn, the more cash you will receive at the end of the session.

This experiment consists of three parts. The following instructions explain part 1. After finishing that part, you will receive instructions for part 2 and after the end of part 2 you will receive instructions for part 3. None of your (or anyone else's) decisions for one part are affecting your (or anyone else's) earnings in the other parts.

All of your choices are completely confidential. You will learn your results of part 1 and part 2 after part 3 has finished. Points earned in each of the three parts will be added up to determine your total earnings.

Instructions part 1

This is an individual decision task and your choice will only affect you. You will be presented with six payoff options, of which you will have to choose one. Each option is associated with a low and a high payoff and both the high and low payoff are equally likely. At the end, after part 3 the computer will randomly pick either the low or the high payoff of the option you chose.

Instructions part 2

In this task you will be randomly paired with one other person in this room. You will make a series of decisions about allocating points between you and this other person.

One of your decisions will be picked randomly and you receive what you allocated to yourself and the other person receives what you allocated to her in this decision. Note that any of your decisions is equally likely to be chosen. Therefore you should treat each decision as if it is the one that counts.

One other person in the room will make such decision towards you. This is not the person you are randomly paired with.

Instructions part 3

In part 3, all participants are assigned to teams of four and your team will be randomly matched with another team. None of you will learn the identities of own team members or other team members. Part 3 will consist of 15 periods, and in each period you and the other participants can obtain a prize in the following way:

At the beginning of each period you will receive an endowment of 120 points. Then you can use none, parts or all of these points to buy lottery tickets for your team. Each lottery ticket costs 1 point. Any of your points not spent on lottery tickets will be accumulated in your private point balance. Likewise, each of your team members receives 120 points which they may use to buy lottery tickets for your team. Similarly, each member of the other team will receive 120 points and may buy tickets for their team in exactly the same way.

[Ingroup leading-by-example & Ingroup transactional leader] In your and the other group, one participant – member 1 – makes her / his decision before the others. Own team members will see, how many tickets this participant bought, before they make their decisions.

[Intergroup leading-by-example & Intergroup transactional leader] In your and the other group, one participant – member 1 – has been randomly selected to be able to communicate with one participant of the other group in private, via a chat window. This communication possibility will automatically expire after 45 seconds. Unless you are member 1, neither you nor any other participant will ever learn the contents of this communication. After that chat window has been closed, member 1 makes her / his decision. Own team members will see, how many tickets this participant bought, before they make their decisions.

After everybody has made the decision, a lottery will determine whether your team, or the team you are matched with, wins. The likelihood that a team wins depends in a proportional way on the total number of tickets, the team bought and on the total number of tickets, the other team bought. That is, if you and your team members bought in total X tickets, and the team members of the other team bought in total Y tickets, the likelihood that your team wins is $\frac{X}{X+Y}$ and the likelihood that the other team wins is $\frac{Y}{X+Y}$. Hence, the more tickets your (the other) team has, the higher is your (the other) team's chance of winning.

Examples: If your team and the other team have bought the same amount of tickets then each team is equally likely to win. If your team has bought three times as many tickets as the other team, then your team is three times more likely to win than the other team. If only one of the teams has bought tickets, then this team wins for sure. If neither your team nor the other team has bought any tickets, then each team is equally likely to win.

[Baseline, Ingroup leading-by-example & Intergroup leading-by-example] The winning team will receive a prize of 1,920 points in total, which will be split equally among group members. This delivers 480 points for each player of the winning group.

[Ingroup transactional leader & Intergroup transactional leader] The winning team will receive a prize of 1,920 points in total and member 1 will determine how the prize will be split among the group members. The losing team will receive nothing.

Summary: In part 3, your earnings in each period are determined as follows:

Winning team:

	Your Endowment (= 120)
-	Your tickets bought (between 0 and 120)
[Baseline, Ingroup leading-by-example & Intergroup leading-by-example]	
+	Prize (480)
[Ingroup transactional leader & Intergroup transactional leader]	
+	Share of the prize allocated by member 1 (between 0 and 1,920)
=	Your earnings

Losing team:

	Your Endowment (= 120)
-	Your tickets bought (between 0 and 120)
=	Your earnings

The points you earn in each period accumulate and your earnings in part 3 will be the total point earning from all 15 periods.

This part starts with a trial period in which you will be asked to answer some questions in order to check your understanding and to give you the opportunity to get acquainted with the setup. Points earned in this trial period will not be paid out.

Appendix D Risk Neutral Equilibrium

Player i maximises expected profit π_i by setting own contribution $v_i = (v_i)_{i \in K}$. Investment of players $k \in K$ of own group K is labelled $\sum_{k \in K} v_k$, while players $m \in M$ in the other disjoint group M invest $\sum_{m\in M} v_m$. Individual prize for winning a round is z. Solve individual optimisation problem for any period t, time indices are omitted.

$$\pi_i\Big(\sum_{k\in K} v_k, \sum_{m\in M} v_m\Big) = \frac{v_i + \sum\limits_{k\in K\setminus\{i\}} v_k}{v_i + \sum\limits_{k\in K\setminus\{i\}} v_k + \sum\limits_{m\in M} v_m} \cdot z - v_i$$

Deriving with respect to v_i delivers the best response function for any player i of group K:

$$\frac{\partial \pi_i\big(\sum_{k\in K} v_k, \sum_{m\in M} v_m\big)}{\partial v_i} = 0 \quad \Leftrightarrow \quad v_i = \sqrt{\sum_{m\in M} v_m \cdot z} - \sum_{m\in M} v_m - \sum_{k\in K\setminus\{i\}} v_k$$

Checking the second order condition confirms that we find a maximum:

$$\frac{\partial^2 \pi_i}{\partial v_i^2} = \frac{-2\sum\limits_{m\in M} v_m \cdot z}{\left(\sum\limits_{k\in K} v_k + \sum\limits_{m\in M} v_m\right)^3} < 0$$

Using the first order condition of group M, we find a multiplicity of equilibria, characterised by $\sum_{m\in M} v_m = \frac{z}{4}$ and $\sum_{k\in K} v_k = \frac{z}{4}$. If we assume symmetry in own group: $v_i = \frac{z}{16}$.

Appendix E Risk Aversion

In this analysis we use techniques presented in Abbink et al. (2010); Katz et al. (1990). Let every agent maximise her individual concave utility function $u(\cdot)$, being identical for all players. For brevity, let $X = \sum_{k\in K} v_k$ and $Y = \sum_{m\in M} v_m$.

$$\frac{X}{X+Y} u(z + E - v_i) + \frac{Y}{X+Y} u(E - v_i) \tag{E.1}$$

As before, z is the individual prize to win, E is the individual endowment and v_i is a player's own contribution. Differentiating (E.1) with respect to v_i and setting equal to zero:

$$\frac{Y}{X+Y}\big(u(z + E - v_i) - u(E - v_i)\big) = Xu'(z + E - v_i) + Yu'(E - v_i) \tag{E.2}$$

For symmetric equilibria $X = Y$, so

$$\frac{u(z + E - v_i) - u(E - v_i)}{u'(z + E - v_i) + u'(E - v_i)} = 2X \tag{E.3}$$

CARA Under constant absolute risk aversion (i.e. exponential utility), let $u(\pi_i) = -e^{-\alpha\pi_i}$, with α being the measure of risk aversion. Set in to (E.3):

$$\frac{-e^{-\alpha(z+E-v_i)} + e^{-\alpha(E-v_i)}}{\alpha e^{-\alpha(z+E-v_i)} + \alpha e^{-\alpha(E-v_i)}} = 2X \tag{E.4}$$

We divide both numerator and denominator by $e^{-\alpha(E-v_i)}$ and rearrange:

$$X = \frac{1}{2\alpha} \cdot \frac{1-e^{-\alpha z}}{1+e^{-\alpha z}} \tag{E.5}$$

As shown in Abbink et al. (2010), $X = \frac{z}{4}$ if $\lim_{\alpha \to 0}$, which is the risk-neutral equilibrium. Deriving with respect to α delivers the slope of the function:

$$\frac{\partial X}{\partial \alpha} = \frac{ze^{-\alpha z}\left(2\alpha + 2\alpha e^{-\alpha z}\right) - \left(1-e^{-\alpha z}\right)\left(2+2e^{-\alpha z} - 2\alpha z e^{-\alpha z}\right)}{4\alpha\left(1+e^{\alpha z}\right)^2},$$

which simplifies to:

$$\frac{\partial X}{\partial \alpha} = \frac{e^{-2\alpha z} + 2\alpha z e^{-\alpha z} - 1}{2\alpha\left(1+e^{\alpha z}\right)^2} \tag{E.6}$$

Abbink et al. (2010) show that the slope is negative for all $\alpha > 0$ and $z > 0$. This means that departing from the risk neutral equilibrium at $\alpha = 0$ towards a higher level of risk aversion, equilibrium group contribution decreases. To illustrate, Figure 11 depicts equilibrium group contributions for specific α-values and $z = 480$.

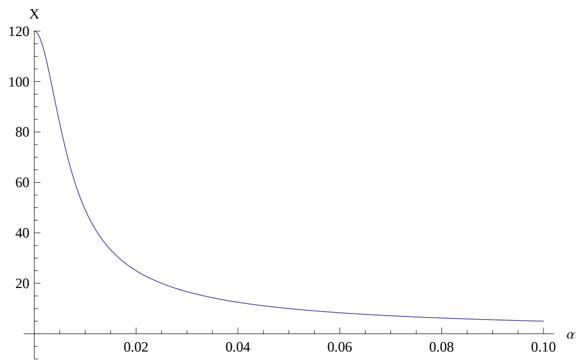

Figure 11: Equilibrium Contributions per contest group under CARA

CRRA We consider constant relative risk aversion, specified as $u(\pi_i) = \frac{\pi^{1-\rho}}{1-\rho}$, with ρ being the risk parameter. Set in to (E.3):

$$\frac{1}{1-\rho} \cdot \frac{(z+E-v_i)^{1-\rho} - (E-v_i)^{1-\rho}}{(z+E-v_i)^{-\rho} - (E-v_i)^{-\rho}} = 2X \tag{E.7}$$

Consider Figure 12 to see that contribution for the contest decreases with risk aversion, under the assumption of symmetric behaviour ($v_i = \frac{X}{4}$) and the parameters of the game ($z = 480, E = 120$). Treatments with three contributors behave fairly similar to groups of four contributors.

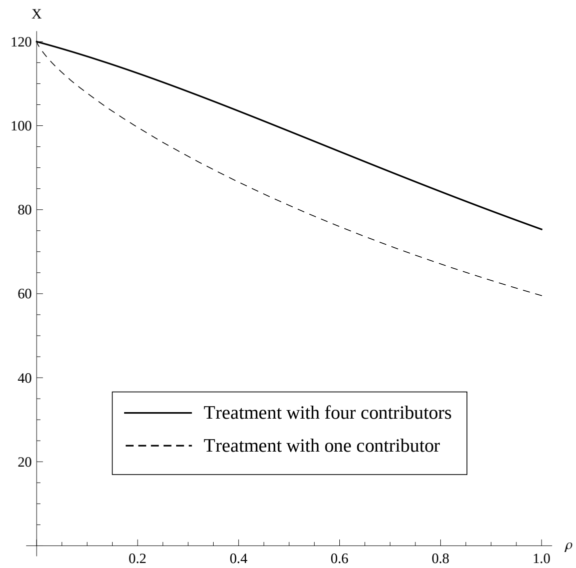

Figure 12: Equilibrium Contributions per contest group under CRRA

Appendix F Regression Table

Table 11: Analysis of Chat Contents using Interaction Terms – GLS random effects models. Standard errors clustered to allow for intra-pair correlation.

VARIABLES	(17) Follower Contribute
Low contribution	-14.009^{***} (5.18)
Low contribution x trans	-8.104 (6.86)
Medium contribution	3.521 (3.44)
Medium contribution x trans	0.931 (5.81)
High contribution	17.715^{***} (4.88)
High contribution x trans	-5.165 (6.40)
Alternate	-0.059 (7.72)
Alternate x trans	-11.435 (8.52)
Bonding	10.037^{***} (2.67)
Bonding x trans	-9.355^{***} (3.02)
Small talk	10.619^{***} (2.35)
Small talk x trans	-6.601^{*} (3.95)
Understanding	2.234 (10.13)
Understanding x trans	6.218 (11.25)
Efficiency	-0.522 (2.41)
Efficiency x trans	-3.123 (4.67)
Followers' behaviour	6.101^{**} (2.38)
Followers' behaviour x trans	-0.539 (3.57)
Give much to followers	12.773^{***} (4.13)
Give little to followers	-15.280^{***} (3.43)
Other	4.939 (6.25)
Other x trans	-3.942 (6.69)
Contribution previous period	0.279^{***} (0.08)
Contribution prev. period x trans	0.019 (0.13)
Group won previous period	-4.782 (4.96)
Group won previous period x trans	-18.372^{*} (10.14)
Transactional Leader	26.145 (16.74)
Constant	44.592^{***} (9.62)
Number of observations	476
Number of individuals	36
Within model R-squared	0.160
Between model R-squared	0.829
Overall R-squared	0.391

* p<0.10, ** p<0.05, *** p<0.01
Clustered standard errors in parentheses.

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