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Fight Alone or Together? The Need to Belong

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Fight Alone or Together? The Need to Belong*

Changxia Ke†

March 12, 2013

Abstract

Alliances often face both free-riding and hold-up problems, which undermine the effectiveness of alliances in mobilizing joint fighting effort. Despite of these disadvantages, alliances are still ubiquitous in all types of contests. This paper asks if there are non-monetary incentives to form alliances, e.g., intimidating/discouraging the single player(s) who is/are left alone. For this purpose, I compare symmetric (2 vs. 2) and asymmetric (2 vs. 1) contests to their equivalent 4-player and 3-player individual contests, respectively. We find that alliance players in symmetric (2 vs. 2) contests behave the same as those in equivalent 4-player individual contests. However, in asymmetric (2 vs. 1) contests, stand-alone players were strongly discouraged to exert effort (especially the females), compared to the 3-player individual contests. Alliance players may have anticipated this effect and also reduced their effort, if alliances share the prize according to the merit rule. Behavioural factors such as the need to belong can help reconcile the "paradox of alliance formation".

Keywords: Alliance Formation, Contest and Conflict, Experiment.

JEL Codes: D72; D74; C91

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1 Introduction

The distribution of resources in the world more or less resembles the nature of "contest" in economic theory. Namely, a group of players, whether individuals, enterprises, interest groups, or countries, expend costly effort to compete for some common prize(s). Examples of their competitive interactions range from individual beauty or sport contests to wars and military contests among countries. Tullock (1967) was the first to formalize contests in a rent-seeking environment, and subsequent theories in this field have developed along different dimensions and been applied in various contexts.[1] Furthermore, when there are more than two players in a contest, alliances which allow members to pool their resources in the fight against common adversaries, are often observed in wars, political elections, rent-seeking activities, patent races, etc.

Despite of the pervasiveness of alliances in practice, doubts have persisted about its success and effectiveness. For example, Olson (1965) and Olson and Zeckhauser (1966) point out that the typical collective action problem gives alliance members strong incentives to free-ride on other members' effort, and free-riding problems become more severe as the number of alliance players increases. Therefore, Olson (1965) suggests that small groups are actually more effective and more likely to win the contests (i.e., the so-called "paradox of group size"). This paradox has been proven in some specific contexts (e.g., Tullock 1980; Katz and Tokatlidu 1996; Baik and Lee 1997), but not necessarily in others (Chamberlin 1974; Mac Guire 1974; Sandler 1993; Esteban and Ray 1999; 2001).

More recent studies focus on endogenous alliance formation rather than exogenously changing the size of contest groups. In a three-player model, Skaperdas (1998) and Esteban and SÃąkovics (2003) show that individual players have no incentive to form a two-player alliance, not only because of the free-riding problem, but also because they perceive the possibility of future internal conflict among alliance players who must share the prize after defeating their adversaries. The sharing process might *ex ante* attempt to be peaceful, but no guarantee ensures it would be. In that case, a subsequent contest may take place to determine the final winner among the victorious alliance, a process that involves further costly effort

[1] See Konrad (2009) for a review.

and reduces the expected payoff for alliance players. Therefore, anticipation of future conflict further reduces the alliance members' incentive to expend effort in the inter-alliance contest and, consequently, its winning probability and expected payoff. The widely observed practice of alliance formation, even in the face of these two major disadvantages, constitute the "paradox of alliance formation" (Konrad 2009). However, in more complex settings in which players are asymmetric and budget constrained or possess complementary resources that increase the alliance's capability (Konrad and Kovenock 2009; Skaperdas 1998), stable alliance formation might emerge endogenously in equilibrium (for a review, see Bloch 2009).

Instead of looking for the missing factors that might resolve the alliance formation paradox in theory, I aim to understand the paradox in the original setup using experimental methods. In particular, I study whether simply being in an alliance has an impact on the behavior of alliance members and/or stand-alone players, especially when alliance formation makes the competing parties asymmetric (in terms of the number of players in each party). There has being long-standing discussions in psychology about human's need to belong, especially when others are in groups.[2] The formation of the alliance could benefit the alliance players by intimidating the more lonesome individual players, if there is indeed the need to belong.[3] Recent experiments in economics also show that people behave differently when they are in groups versus alone in both strategic and non-strategic situations (Charness et al. 2007; Sutter 2009).[4] Whether and how potential behavioral or psychological factors influence the contest behavior of players both within and outside the alliance, could have strong impacts on the attractiveness of alliance formation. The experiment reported herein aims to better understand these hypotheses.

In order to study the pure framing effects of alliances, the sharing rule between

[2] See Baumeister and Leary (1995) for more literature.

[3] There are also other similar arguments. For example, McCallum et al. (1985) propose that people care more about winning and behave more aggressively when they compete in groups. Campbell (1965) argues that people are more willing to contribute to group causes, even if this requires risk to their own lives (i.e., "group spirits"). The reasons that people behave differently in groups versus individually likely are multifaceted though.

[4] Expansive literature deals with group identiy and group or team decisions versus individual decision making in psychology and economics. Recent articles (e.g., Charness et al. 2007; Chen and Li 2009; Sutter 2009; Ambrus et al. 2009) offer more detailed reviews.

the allaince members has to chosen such that there is no monetary incentive/disincentive of being in an alliance. Egalitarian (or equal) sharing rule and merit (or proportional-sharing) rule are the most commonly used versions in prior literature. Under the egalitarian/equal sharing rule, members of the alliance receive equal shares of the prize, irrespective of how much they have contributed in the inter-alliance contest, so a free-riding problem arises. In the merit rule, members share the prize according to their relative contributions to the inter-alliance contest, and the free-riding problem is fully eliminated.[5] Players should be equally incentivized, irrespective of being in an alliance or not, and thus be indifferent between competing individually or forming an alliance.[6] Therefore, comparing contest behavior with alliances to its equavilent individual contests provides a natural way to study whether there is a pure framing effect of being in an alliance.

The experiment consists of three treatments. In the base treatment, three individual players each decide independently the effort they will expend in a contest, and a lottery wheel draws the winner afterwards, according to a standard Tullock lottery contest success function (i.e., the winning probability of each player is determined by the ratio of their effort to the total effort of all three players). In two experimental (alliance) treatments, two players enter an alliance to contest the third player. The winning probability for the third player stays the same, but the alliance's winning probability is equal to the ratio of alliance players' joint effort over the total effort of all three players. I call this scenario an inter-alliance contest, hereafter though the third player is only in an alliance with him- or herself.

[5] Alliance players can always break up and engage in a sub-contest after victory, so these peaceful sharing solutions may not be enforceable, which demands consideration of the sub-contest sharing rule. In a previous paper, Ke et al. (2010) compare the equal sharing and sub-contest sharing rules to identify the size of the hold-up problem in an inter-alliance contest, induced by the further dissipative intra-alliance contest. In this study I deliberately choose the proportional sharing rule to eliminate both the free-riding problem and the hold-up problem (induced by the threat of potential internal conflict).

[6] Another rule broadly discussed in theory uses convex combinations of both equal sharing and proportional sharing. Taking the combined ratio as an exogenous choice, Nitzan (1991a, 1991b), Davis and Reilly (1999), and Ueda (2002) study how equilibrium effort changes with this ratio. Lee (1995), Baik and Shogren (1995), Baik and Lee (1997), and Noh (1999, 2002) further endogenize the sharing rule and find that alliances of symmetric group size choose the proportional sharing rule, even though they would be better off if everyone chose equal sharing rule. In reality, both equal and proportional sharing rules have disadvantages. Although the proportional rule eliminates free-riding, it can be very costly or even infeasible to enforce when effort can not be monitored easily.

The difference between the two alliance-treatments pertains to the sharing rule implementation stage. In the first alliance treatment, after defeating the stand-alone player, one alliance player is randomly drawn as the final and sole winner of the prize. The winning probability of an alliance player (conditional on a joint victory) is equal to the proportion of the effort he or she contributes to the total effort by the alliance.[7] Compared with that in the base treatment, the winning probability for each individual alliance player in this treatment is essentially the same (for given effort choices). In addition, the winner always gets the full prize in both treatments. Therefore, alliance formation does not change the problem facing each individual player, and the equilibrium predictions should be identical to those in the base treatment. The equivalence holds even if I abstract away from the risk-neutrality assumption, as is often used in contest theories. Therefore, this design provides the minimum alliance framing possible to identify the psychological impact of alliance formation. However, in this treatment alliances are somewhat "temporary", because they eventually break up following inter-alliance contests when the spoils of the alliances's victory are not shared. The prospect that only one of the two alliances players receives the full prize might significantly weaken the tie between alliance members. The perception of tie strenghth between the alliance players thus might influence effort choices by the players.

Instead of drawing one winner from the victorious alliance, in the second alliance-treatment, the prize is shared between the two alliance players. Sharing the fruit of a joint victory should strengthen their tie and make the alliance manipulation more salient. However, it is still comparable to the other two treatments, because the alliance player still receives a share of the prize that is in proportion to the effort he or she contributed to the total effort of the alliance. For a risk-neutral, expected-payoff maximizer, the equilibrium predictions are the same as in the other two treatments. Therefore, deviations in this treatment should indicate how the improved saliency of the alliance feature affects effort choices in

[7] Although this sharing rule differs slightly from the usual term of the proportional sharing rule, I count it as a proportional sharing rule. In a sense, it represents a special form of proportional sharing rule because alliance players share the probability of receiving the sole property rights of a full prize rather than a share of that prize.

inter-alliance contests. Furthermore, it is possible to identify (or eliminate) other potential behavioral factors (e.g., changing risk preference, the need to belong, joy of winning, group spirit) that could affect the attractiveness of alliance formation through treatment comparison.

This study thereby offers two major findings. First, alliance formation has a significant impact on stand-alone players' effort choice even if the alliance is only temporary. When the contest is asymmetric (2 versus 1), the stand-alone player are more likely to drop out or greatly reduce effort, which confirms that the need to belong creats psychological disadvantages for lonesome players in the contest when others are in a group. Second, risk attitudes seem stable, and players do not play more aggressively in groups. On the contrary, they expend similar effort in temporary alliances but significantly less effort in permanent alliances, compared with individual contests. This result is consistent with the predictions derived from a simple model that takes the non-monetary utility of winning into consideration. In summary, if alliance members can agree on a sharing rule, such that the free-riding problem can be eliminated and peaceful sharing is ensured, alliance formation can benefit members both inside and outside the alliance (especially alliance players) via reduced over-dissipation.

This study also relates to a wide range of experimental studies related to contests. First, experimental tests of contest theories often focus on one-stage contests (Millner and Pratt 1989; 1991; Shogren and Baik 1991; Davis and Reilly 1998; Potters et al. 1998; Anderson and Stafford 2003) or multi-stage contests (Schmitt et al. 2004; Parco et al. 2005; Sheremeta 2010) and reveal that people expend much more effort than what would be predicted in equilibrium.[8] Similar to these studies, I find over-dissipation is the rule in this experiment. Second, in literature that investigates group contests, Ahn et al. (2011) compare individual-individual contests, group-group contests, and individual-group contests, finding over-dissipation in all of them such that they reject "the paradox of group size" proposed by Olson (1965). Sheremeta and Zhang (2010) compare effort choices in individual contests to those in group contests (with intra-group communica-

[8] The proposed explanations of over-dissipation include the non-monetary utility of winning (Parco et al. 2005; Sheremeta 2010), misperception of the winning probabilities (Baharad and Nitzan 2008), quantal response equilibrium, and heterogeneous risk preferences (Goeree et al. 2002, Sheremeta 2011).

tion and joint decision-making) and find that group-chosen efforts are much lower than individual effort, which they explain by asserting that groups are more risk-averse than individuals. Sutter and Strassmair (2009) study how intra and/or inter-group communication affect effort levels in group contests (with individually chosen effort); intra-group communication increases contest effort, whereas inter-group communication facilitates collusion and reduces contest effort. Abbink et al. (2010) further study the effect of intra-group punishment on inter-group contests and find that allowing punishment greatly increases the dissipation rate. In all these studies, the prize is either non-rivalous among group members or shared equally. The only experimental studies, to the best of my knowledge, that involve the proportional sharing rule are Gunnthorsdottir and Rapoport (2006) and Kugler et al. (2010). However, instead of comparing contest behavior in groups than in individuals, they study the public goods problem embedded in group contests and focus on comparisons of the impact of two different sharing rules (equal vs. proportional).

To establish the findings and extended of this study, I begin in Section 2 by explaining the experimental design and implementation. In Section 3, I report the experimental results, followed by a conclusion in Section 4.

2 Experiment

The experiment is based a standard Tullock (1980) lottery contest. Imagine that there are three players, A, B and C, who must expend costly effort to win a fixed prize value ($V = 450$).[9] In a baseline treatment (T1), each player simultaneously and independently chooses an effort level from $\{0, 1, 2, ..., 250\}$ and compete against one another. A lottery wheel then draws one winner (i) out of the three players, according to the winning probability $p_i = x_i/X$, where x_i is the effort choice of player i, and X is the total effort of all three players. The winner gets the full prize and pays for his or her effort; and the losers get nothing (yet still need to pay for their own effort). Therefore, the expected payoff of each individual player is given by $E(\pi_i) = p_i V - x_i$. For a risk-neutral, expected-payoff maximizer, the optimal

[9] The values of all the parameters are given in units of experimental currency.

effort choice should be $x_i^* = \frac{2}{9}V = 100$. In equilibrium, each player has a *one-third* probability to win the prize, and the expected profit is 50 for every player. In total, *two-thirds* of the prize value are dissipated in the contest (in equilibrium).

In two other treatments, all the parameter values remain constant, but players A and B are forced into an alliance. Alliance formation binds the winning probability of the alliance players, such that they either jointly win or jointly lose the contest against player C. Each alliance member still decides the effort he or she expends independently though. Following the same logic, the probability that player C wins the prize stays the same as in T1 ($p_C = x_C/X$), and the probability that the alliance players win the contest is $p_{AB} = X_{AB}/X$ (where $X_{AB} = x_A + x_B$, is the total effort expended by A and B). Therefore, the probability that an alliance player wins the prize depends not only on his or her own effort but also on the effort of the alliance player. Effort is perfectly substitutable between alliance players. If the alliance loses against player C, player C gets the whole prize (450), as in the *Base* treatment. However, if the alliance players win against player C, the sharing rule between the alliance players differs in two experimental treatments.

In the second treatment, conditional on the alliance winning against player C, another lottery wheel randomly draws one final winner between A and B, according to their previous effort choices relative to the total effort expended by A and B together. Specifically, the probability that player i (A or B) is the final winner, conditional on the victory of the alliance, is given by $q_{AB}^i = x_i/X_{AB}$. I name this treatment "*Arandom*" where *A* referring to the *alliance* and *random* means that the final winner in the alliance is randomly decided according to q_{AB}^i. Therefore, for each alliance player, the expected payoff is calculated as $E(\pi_i) = (p_{AB} * q_{AB}^i) * V - x_i$. The alliance formation according to this *random*-proportional rule does not change the nature of the problem compared with the *Base* treatment, because the joint probability that the alliance wins and (at the same time) that this player is drawn as the final winner (i.e., $p_{AB} * q_{AB}^i = \frac{X_{AB}}{X} * \frac{x_i}{X_{AB}} = \frac{x_i}{X}$) is identical to p_i in the *Base* treatment. As Table 1 shows, the equilibrium efforts, expected profits, and total rate of dissipation remain unchanged. This equivalence holds even if players are not risk-neutral.[10] The comparison between *Arandom* and *Base* allows us to test

[10]However, if risk preference is not stable (e.g., players might become more or less risk averse when they are in groups), the prediction might change. The next section details why this is not

the pure framing effect of alliance formation, such as when people become more or less competitive as the institutional organization of the competition changes.

Similar to the *Arandom* treatment, A and B again are forced into an alliance in the third treatment. However, in case of a victory, alliance players A and B share the prize in proportion to what they have contributed in the contest against player C. I name this treatment "*Aproportion*". Let s^i_{AB} be the share of the prize that i gets, so the alliance players' expected payoff is determined by $E(\pi_i) = p_{AB} * (s^i_{AB} * V) - x_i$, where $s^i_{AB} = x_i/X_{AB}$. Although both q^i_{AB} and s^i_{AB} are equal to x_i/X_{AB}, the former indicates a conditional winning probability, the latter represents the proportion of the prize. For given effort choices, alliance players in *Arandom* treatments face a lower winning probability for a higher prize, whereas those in *Aproportion* have a higher winning probability for a lower prize. However, because the expected values of the two lotteries are the same, the expected-payoff maximizing equilibrium effort should be identical in all three treatments (see Table 1). The *ex post* outcome is very different in *Aproportion* and *Arandom* treatment though. The tiny change from *Arandom* to *Aproportion* strengthens the tie between the alliance players and makes the alliance manipulation more salient. This manipulation enables me to test if increasing the saliency of alliance features (without changing the expected payoff) further influences the contest behavior of both alliance players and individual players.[11]

The experiment was run in the MELESSA laboratory at the University of Munich. The participants were recruited and included students from all fields.[12] Each of the 216 total participants undewent 24 rounds of the same treatment and kept their individual role as player A, B, or C throughout all rounds. Anonymity between subjects was preserved throughout the experiment, and the payment procedure ensured that the laboratory staff could not link individual behavior

the case in this experiment.

[11] Heterogeneous risk preference, misperception of winning probabilities, and joy of winning might explain over-dissipation in contests, which could also drive different behavior in *Aproportion* and *Arandom* treatments. Other psychological motivations or certain social preferences might play roles as well. Identifying the impact of each of these factors is interesting but beyond the scope of this paper. As a first step, this study is mainly explorative. Narrowing down the potential candidate set based on the experimental results is possible, as I detail in the next section.

[12] The participants were recruited using ORSEE software (Greiner 2004). The experiment was programmed using Z-Tree (Fischbacher 2007).

Treatment	Base	Arandom	Aproportion
Prize	450	450	450
Players	A,B,C	AB$\Leftrightarrow$C	AB$\Leftrightarrow$C
Winner	A, or B, or C	A, or B, or C	AB or C
(x_A^*, x_B^*, x_C^*)	(100,100,100)	(100,100,100)	(100,100,100)
Total dissipation rate	$\frac{2}{3}$	$\frac{2}{3}$	$\frac{2}{3}$
(P_A^*, P_B^*, P_C^*)	$(\frac{1}{3}, \frac{1}{3}, \frac{1}{3})$	$(\frac{1}{3}, \frac{1}{3}, \frac{1}{3})$	$(\frac{2}{3}, \frac{2}{3}, \frac{1}{3})$
$(\pi_A^*, \pi_B^*, \pi_C^*)$	(50, 50, 50)	(50, 50, 50)	(50, 50, 50)

Table 1: Treatment specifications and theoretical predictions with risk-neutrality.

to the individual students. During the experiments, students were divided six-person groups and re-matched within these groups in each round to eliminate quasi-repeated games effects. The precise division of the subgroups was not explained to the participants during the experiment; rather, they knew only that they would be randomly rematched with other players in each round and could play with and/or against different people in different rounds.[13] The instructions were provided and also read to them by the laboratory staff, and an entry quiz guided them through the experiment to ensure proper understanding. In addition of a participation fee of EUR 4, they received a fixed payment of EUR 0.6, for each round played.[14] To reduce possible effects of good or bad luck in earlier rounds, subjects were paid according to their decisions and outcomes in 6 random rounds out of 24, at the end of the experiment. The average earnings per subject were EUR 20 in total. Before finishing the session, participants answered an exit questionnaire. The time for sessions in all treatments was very similar and took roughly 1.5 hours.

[13] This design offers a good compromise between the problem of repeated game efffects and the quest for sufficient independent observations.

[14] In previous contest experiments, participants have been given per-round endowments in experimental currency, and then they decide how much they should invest. Price and Sheremeta (2011) find that over-dissipation relates positively to the amount of endowment participants receive though. The fixed payment in this experiment is another form of endowment (given in real currency) on which participants cannot easily base their effort choices.

3 Results

Contrary to standard theoretical predictions, alliance players expend less effort (compared with a contest without alliances in the *Base* treatment) when the prize is shared between the two alliance players. However, when there is only one final winner in the alliance, alliance players behave the same as if there were no alliance. Alliance formation intimidates stand-alone players (especially women), such that more single players expend very little effort or no effort when they confront one united “stronger” opponent rather than two single and symmetric opponents. In this section, I establish these results by first presenting the summary statistics and then examining individual behavior.

3.1 Treatment effects

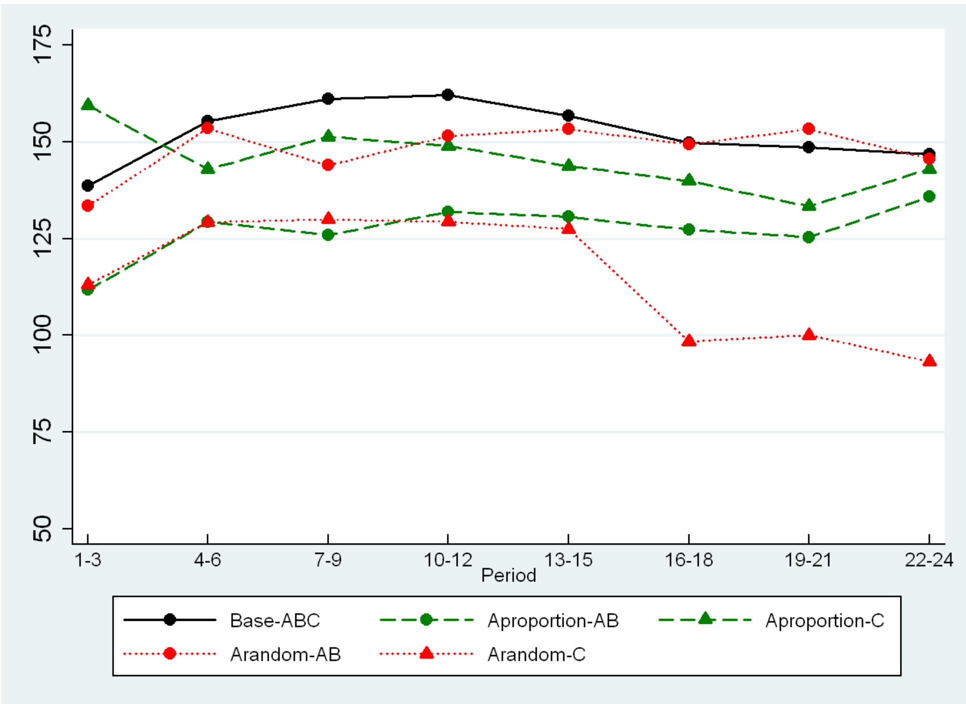

Figure 1: Average effort by treatment, period and player.

In Figure 1, I depict the average effort for every three periods in each treatment.

The solid line with circles illustrates the average effort for all three players in the *Base* treatment. Players expend around 150 units on average in the *Base* treatment, which is 50% higher than the equilibrium prediction. This result is in line with the results in previous experimental contests. To examine the impact of alliance formation, I plot the average effort for alliance players and single players separately in the *Arandom* and *Aproportion* treatments. Compared with the *Base* treatment, alliance players in *Arandom* expend similar effort – 148 units on average (see the dotted line with circles). However, the average effort expended by player C in *Arandom* is much lower (116), as also shown in Figure 1 by the dotted line with triangles for player C, which is much lower than the solid line, especially in later periods. When the prize is shared proportionally between the alliance players, the deviation from the *Base* treatment reverses. The alliance players in the *Aproportion* treatment invest significantly less effort than players in the *Base* treatment, or 127 units on average (dashed line with circles), whereas the average effort expended by player C (145 units on average) is not much different from that in the *Base* treatment (dashed lines with triangles for single players and with circles for alliance players in Figure 1).

	Alliances Compared with Base			Player C Compared withBase		
Data set (Period)	1-24	1-12	13-24	1-24	1-12	13-24
Constant	162.3***	164.3***	161.3***	165.1***	167.0***	164.0***
	(7.95)	(7.78)	(9.41)	(9.47)	(9.25)	(11.85)
Arandom	1.93	-6.44	9.95	-45.35**	-33.49*	-60.70**
	(12.60)	(12.31)	(14.97)	(18.96)	(18.49)	(23.85)
Aproportion	-32.13**	-36.99***	-28.57*	-12.09	-4.89	-27.02
	(12.56)	(12.27)	(14.85)	(18.98)	(18.52)	(23.83)
Log-likelihood	-19056	-9742	-9248	-13071	-6669	-6319
Wald χ^2	8.18**	9.65***	6.13**	5.73*	3.32	6.75**
Left-censored obs.	55	28	27	160	54	106
Uncensored obs.	3215	1644	1571	2099	1073	1026
Right-censored obs.	714	344	370	597	313	284

Note: In all regressions, data in the Base treatment are the benchmark.
*** p-value<.01. ** p-value<.05. * p-value<.10.

Table 2: Random-effect Tobit regressions on effort choices

Using random-effect Tobit regressions, I can confirm that the differences in

Figure 1 are statistically significant.[15] The regression results are provided in Table 2. In two sets of regressions, I compare the alliance players (A and B) and single players (C) separately with the players in the *Base* treatment. The dependent variable is the effort choice of each individual player. The potential independent variables are the treatment dummies (*Arandom* and *Aproportion*). I report regressions for the full data set and for either the first or the second half of the experiment to investigate if there are the dynamic changes in behavior. Alliance players in the *Aproportion* treatment overall expend around 32 points less than the players in the *Base* treatment. This difference is slightly bigger in the first half of the experiment than in the second half (36.99 vs. 28.57).[16] However, alliance players in the *Arandom* treatment expend similar effort as in the *Base* treatment. Single players expend much less effort (45 points) in *Arandom* treatment than in the *Base* treatment, and the differences increase and become more significant in periods 13 to 24 (61 points, p-value<.05) compared with periods1 to 12 (33 points, p-value<.1). Although the single players in *Aproportion* also expend less effort, especially in later periods (-27.02), the coefficients are not significant.

To further examine treatment differences at the individual level of the data, I plot histograms of effort choices by player A/B or player C in different treatments in Figure 2. First, the effort choices are widely distributed between 0 and 250. Second, the lower panel of the graph, which lists the histograms of alliance players' individual effort, indicates that the two distributions for the *Base* and the *Arandom* treatment look almost identical. Efforts are distributed fairly evenly between 0 to 200, with a spike (of around 40% of the observations) in the range of 200 to 250 in both treatments. However, the spike at the right end disappears in the *Aproportion* treatment, and more choices shift to the center of the feasible set. Third, single players shift their effort choice, either to left or to right end of the distribution, leaving fewer intermediate efforts in the two alliance treatments than in the *Base* treatment (see the upper panel of Figure 2).

In summary, alliance formation seems to affect the effort choices of both alliance players and individual players. The finding about the alliance players rules

[15] The effort choice is restricted between 0 and 250. Thus Tobit models become the natural selection.

[16] This can be seen in Figure 1, especially in the last three periods.

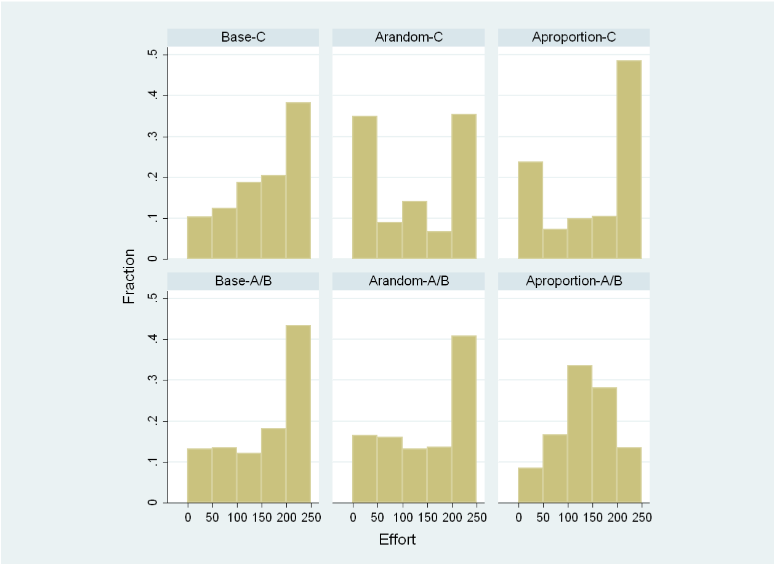

Figure 2: Histograms of effort choice by treatment and player.

out the "group spirits" hypothesis, because these players expend equal or less (rather than more) effort than individual players. Players' risk preference also seem stable, irrespective of whether they play in an alliance or individually, because behavioral shifts from the *Base* treatment to the *Arandom* treatment are not observed.[17] Finally, I propose that the reduced effort contribution in the *Aproportion* treatment can be explained by the joy of winning. Assuming players earn extra non-monetary utility from winning is similar to allowing for an extra prize to the final winner(s). This extra non-monetary utility has a public-good nature in the *Aproportion* treatment but not in the *Base* or *Arandom* treatments, because these latter treatments feature one final winner. Therefore, alliance formation in *Aproportion* induces free-riding incentives for the alliance players to gain this extra prize, leading to reduced effort. Although the prediction might be different depending on whether people gain the same amount of non-monetary utility when they win alone or together with others, or whether the utility varies with the size

[17] Sheremeta and Zhang (2010) indicate that groups make less risky decisions than individuals. The major difference between their finding and my finding is that there is no communication in my experiment, and decisions are made independently rather than jointly. In other words, simply being in a group does not change players' risk preference, but the interactions between group members might.

of the prize, one can at least show that alliance players should reduce their effort and single players should increase their effort in the *Aproportion* treatment, compared with the *Base* and *Arandom* treatments, if the extra utility from winning is the same irrespective of whether the prize is shared, using the simple joy-of-winning model proposed by Sheremeta (2010). The detailed solutions are in the Appendix.[18]

Single players (fighting against an alliance) might feel lonesome or have less confidence than they actually should have about winning the contest such that they greatly reduce their effort. Being in a "weaker" position, single players also might perceive winning as a great challenge and thus derive more joy of winning from it, in which case they would fight very hard. The former type of players should exhibit greater need to belong and lower joy of winning than the latter type. The shifts observed in Figure 2 for player C suggest that both types of players appear in the subject pool. Therefore, an analysis that combines the individual characteristics and effort choices should reveal types of players.

3.2 Gender differences among stand-alone players

Figure 2 shows that individual effort choice is rather heterogeneous. To determin who deviates and in what direction in the alliance treatments, I summarize the effort choice for different groups of players, according to their individual characteristics (e.g., age, gender, discipline in university study). Neither alliance players' effort choices nor effort choices in the *Base* treatment depend heavily on these individual traits.[19] However, when alliance formation leads to group asymmetry (2 versus 1), male and female single players behave differently. To elaborate this point, I present both summary statistics (see Table 3) and histograms of single players' efforts (in alliance treatments) by gender (see Figure 3). I again split the data into the first and second 12 periods to detect dynamic changes.

[18] In Figure 1, the average effort choices of both alliance players and single players in the initial periods (1-3) in *Aproportion* exactly follow the direction of this prediction. Later deviation from this equilibrium by single players is the result of learning and reactions to previous success/failure.

[19] Summary statistics according to these characteristics for alliance players and players in the *Base* treatment are therefore ommited.

	Arandom		Aproportion	
Period	1-12	12-24	1-12	12-24
Male:	176	124	157	174
	(87)	(107)	(102)	(100)
Female:	104	99	148	126
	(91)	(97)	(89)	(94)

Note: Standard deviations in brackets.

Table 3: Average effort of single players (C) by gender.

In *Arandom*, female players' average effort is 104 units in period 1 to 12 and then falls to 99 in periods 13 to 24; in contrast, however, male players start with very high average effort (176) in the first 12 periods and then reduce it to 124 units in the second half of the experiments (see the second and third columns in Table 3). This trend corresponds to the individual choices presented in four histograms on the left side of Figure 3. Almost 60% of choices made by male players are above 200 in periods 1 to 12, but this number drops to around 40% in periods 13 to 24, accompanied by an increase in the choices below 50 from around 10% in periods 1-12 to 35% in periods 13-24. For female players in *Arandom*, more than 35% of their choices are below 50, and around 30% of the choices are above 200; this distribution does not change significantly in the second half. This difference between male and female single players also indicates that the sharp decline in the average effort time series for player C in the *Arandom* treatment (Figure 1) was caused mainly by the dramatic shifts men made.

In *Aproportion*, the dynamics are slightly different. Both male and female players starts with similar effort (157 vs. 148), but then move in opposite directions. Male players' average effort increases to 174, while female players' effort reduces to 126. Looking at the full distributions on the right side of Figure 3, around 20% of the players (both male and female) expend less than 50, and 50-60% of the players expend more than 200 in the first half of the experiment. However, men respond with more extremely high effort (i.e., choices above 200 increase from 60% to 70%) in periods 13 to 24, and womens respond with less extremely high effort (i.e., choices above 200 decrease from 50% to around 35%) but more extremely low effort (i.e., choices below 50 increase from 20% to 30%).

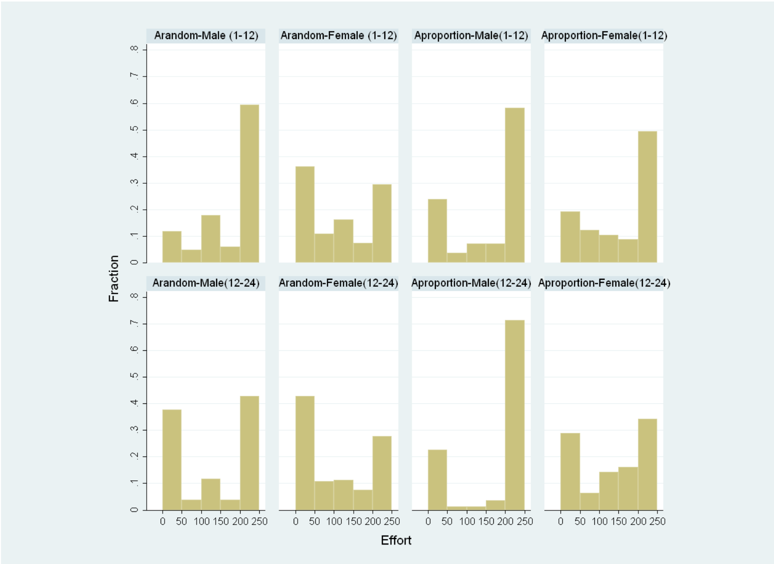

Figure 3: Histogram of single players' effort choice (by treatment and gender).

These observations suggest that men tend to fight harder initially when they contest a two-player alliance. However, they also quickly respond to their success or failure. In the *Arandom* treatment, the joint effort of alliance players is approximately twice that of the single players, so single players often lose the contest. Therefore, male single players soon greatly reduce their effort. In *Aproportion*, the lower joint effort by the alliance players allows single players to win more often than in the *Arandom* treatment. As a result, male single players pick the extremely high effort more often in the second half of the experiment. However, female single players are always more likely to drop out or expend less effort in the contest when they face a two-player alliance rather than two individual players.

These results are in line with recent studies on gender difference. Controlling for the ability of men and women, Niederle and Vesterlund (2007) find that men are twice as likely as women to join a tournament, mainly because of their greater interest in (preference for) for competition and their higher levels of over-confidence. Furthermore, Healy and Pate (2011) find that the gender gap declines by two-thirds if competition takes place in two-person teams, irrespective of the gender of one's partner. Potential candidates, such as risk or feedback aversion or confidence, have been ruled out as major reasons. Instead, women appear not to like competition if they must compete alone, whereas they feel much more comfortable when they have a partner. In summary, these results indicate that women tend to have more intrinsic need to belong to a group and enjoy the joy-of-winning less if they have to fight alone rather than in a group.[20]

3.3 Rent dissipation and social welfare

After examining the effort choice for different groups of players in different treatments, I turn to the impact of alliance formation on the total rate of dissipation and individual profits. Table 4 shows that players in *Base* treatment dissipate more than 100% of the prize (457.2), and this over-dissipation on average leads to negative profit (-2.4 points). Over-dissipation declines when there is alliance formation, such that total dissipation is 411.2 in *Arandom* and 399.9 in *Aproportion*, as a result of the lower effort expended by alliance players or single players. Consequently, the average profits of each individual player improve in the two experimental treatments, especially for alliance players. The average payoff is highest in the group of alliance players under proportional sharing rules (25 points). Not surprisingly, in a post-experiment questionaire, a majority of respondants indicated that they would have preferred to be in an alliance, had they been given the opportunity to choose. In particular, 65% of the alliance players and 83% of the single players in the *Aproportion* treatment, and 54% of the alliance players and 58% of the single players in the *Arandom* treatment, chose "yes" in response to this question. In conclusion, alliance formation can benefit both alliance players and single players by reducing wasteful resource dissipation in rent-seeking contests.

4 Conclusion

Alliance formation is often observed in rent-seeking contests, political elections, wars, and so on. However, there are two major disadvantages of alliances: the free-riding problem and the potential threat of internal conflict when it comes to dividing the prize after alliance victory. In this article, I study alliance form-

[20] Interested readers should refer to Croson and Gneezy (2009) for a review of gender differences in both individual competition and in risk and social preferences.

Treatment	Base	Arandom		Aproportion	
Players	A/B/C	A/B	C	A/B	C
Payoff (by role)	-2.4	13.3	12.1	25.1	-0.1
	(206)	(208.8)	(182.2)	(113.1)	(192.1)
Payoff (overall)	-2.4	12.9		16.7	
	(206)	(200)		(144.7)	
Total dissipation	457.2	411.2		399.9	
	(158.6)	(172.3)		(126.6)	

Notes: Standard deviations are in brackets.

Table 4: Summary of dissipation rate and average payoffs.

ation with share proportional rules to abstract away from these two potential disadvantages of alliance formation. By comparing effort choices in contests with exogenously formed alliances (with proportional rules) against effort choices in individual contests, I examine whether behavioral factors such as need to belong, group spirits, and joy of winning make the alliance more attractive, even when there is no actual expected monetary gain from alliance formation. People expend less effort if they are in an alliance and share the prize proportionally, compared with when they play in individual contests. However, this effect disappears if the alliance is temporary, such that only one player in the alliance is entitled to the full prize in the end. This finding is consistent with predictions derived from a simple model that incorporates the non-monetary utility of winning. Moreover, alliance formation has a significant impact on single players, even if the alliance is temporary. Female players are always more likely to be discouraged by the alliance and expend lower effort, whereas male single players initially expend higher effort and soon move in opposite directions depending on whether they win or not. The gender difference in contest behavior suggests that female players have higher need to belong and derive much less non-monetary utility from winning if they must compete individually against a group. Because over-dissipation is a wide-spread phenomenon in contest experiments, both alliance players and stand-alone players benefit from alliance formation due to reduced over-dissipation.

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A A simple joy-of-winning model

In this appendix, I provide a simple theoretical model that takes the non-monetary utility of winning into consideration. Suppose each player gain additional utility w if he or she wins the prize, irrespective of whether the prize is shared with another player or not. The expected-payoff functions and their corresponding equilibrium solutions for each treatment are given in the following.

In the *Base* treatment, the expected utility is given by

$$E(\pi_i) = p_i(x_i, x_{-i})(V + w) - x_i, \tag{1}$$

and the expected-payoff maximizing effort choice is given by:

$$x^* = \frac{2}{9}(V + w). \tag{2}$$

It is trivial to show that the prediction does not change for the *Arandom* treatment, because the alliance formation in *Arandom* does not alter the objective function for all players.[21] However, in the *Aproportion* treatment, both the winning probability and the actual monetary price received differs for the alliance players. Therefore, the new expected payoff function is given by:

$$E(\pi_i) = \begin{Bmatrix} p_{AB} * (s^i_{AB} * V + w) - x_i & \text{for player } A \text{ or } B \\ p_i(x_i, x_{-i})(V + w) - x_i & \text{for player } C \end{Bmatrix}. \tag{3}$$

Consequently, the equilibrium effort choices that solve that first-order condition are:

[21] An important assumption in this model is that the non-monetary utility of winning (w) is only accompanied by the award of the prize and does not change with the actual prize value received by the players. In particular, in the *Arandom* treatment, alliance players might win against the single player, but if he or she does not receive the prize after the random-draw within the alliance, he or she does not gain w. This assumption is slightly different from Sheremeta (2010)'s assumption that players gain non-monetary utility of winning from each stage, irrespective of whether it is the intermediate or the final stage. With properly specified values/functions for w, these two different assumptions can lead to qualitatively equivalent equilibrium outcomes.

$$x_i^* = \left\{ \begin{array}{ll} \frac{(2w+V)^2(w+V)}{2(3w+2V)^2} & \text{for player } A \text{ or } B \\ \frac{(2w+V)(w+V)^2}{(3w+2V)^2} & \text{for player } C \end{array} \right\}. \tag{4}$$

It is easy to prove that $x_A^* = x_B^*$[22] $< x^* < x_C^*$[23]. Therefore, if players substract extra non-monetary utility from winning the prize, alliance players should expend less effort, and single players should expend more effort in *Aproportion* than in the other two treatments.

B Experimental instructions (for online publication)

B.1 Base treatment

Welcome to this experiment! Please read these instructions carefully and completely. Properly understanding the instructions will help you make better decisions and hence earn more money.

Your earnings in this experiment will be measured in Talers. At the end of the experiment we will convert the Talers you have earned to cash and pay you in private. For each **45 Talers** you earn you will be paid **1 Euro** in cash. Therefore, the more Talers you earn, the more cash you will gain at the end of today's experiment. In addition to the Talers earned during the experiment, each participant will receive a show-up fee of 4 Euros.

Please keep in mind that you are not allowed to communicate with other participants during the experiment. If you do not obey this rule you will be asked to leave the laboratory without getting paid. Whenever you have a question, please raise your hand; an experimenter will come to you.

[22] $x_A^* - x^* = x_B^* - x^* = -\frac{1}{18}\frac{V}{(2V+3w)^2}\left(7V^2 + 19Vw + 12w^2\right) < 0.$

[23] $x_C^* - x^* = \frac{1}{9}\frac{V}{(2V+3w)^2}\left(V^2 + 4Vw + 3w^2\right) > 0.$

B.1.1 Your task

This experiment will consist of 24 rounds. Before the actual experiment starts, you will first have to answer a few questions related to the experiment. The questions will be presented to you through the computer screen. For the experiment, groups consisting of three people are formed. These groups are randomly composed in each round. Your task in each round is to make some decisions. The money you earn depends on your decision and the decisions of the two other players in your group.

Let the three players in one group be called A, B, and C. In each round, three players A, B, and C compete for a prize of 450 Talers. The competition works as follows:

1. In a first stage, all players will simultaneously choose "an effort level". Each player decides independently on his or her own effort level. A player's effort is chosen as an integer between 0 and 250, and it corresponds to the amount of Talers the player would like to expend in the competition to win the prize. You will have to pay this amount of Talers to the lab, whether or not you win the competition. In the following, player A's effort is denoted by X_A, player B's effort is denoted by X_B, and similarly player C's effort is denoted by X_C.

2. Then, you will be shown the amount of Talers that the other players in your group have expended. The total expense is equal to the sum of all players' efforts: $X_A + X_B + X_C$.

3. Now a fortune wheel will turn and decide whether player A, or player B, or player C wins the 450-Taler-prize. As you will see, the fortune wheel is divided into three colors - yellow, green, and blue. The yellow color represents the Talers spent by player A (i.e., X_A), the green color represents the Talers spent by player B (i.e., X_B), and the blue color represents the Talers spent by player C (i.e., X_C). The three colored areas on the wheel represent exactly each player's shares in the total expense (i.e., $X_A + X_B + X_C$).

4. At the centre of the fortune wheel there is an arrow initially pointing to the top. After some time the arrow starts to rotate and then stops randomly.

If the arrow stops in the yellow-colored area, player A wins the prize; if the arrow stops in the green-colored area, player B wins the prize; if the arrow stops in the blue-colored area, player C wins the prize. This means that the probability that player A or B or C wins the prize is equal to his or her corresponding share of the effort in the total expense, hence

$$\text{Probability that } i \text{ wins} = \frac{\text{effort } X_i}{\text{total expense } X_A + X_B + X_C},$$

where i denotes A or B or C. For your information, the winning probability of every player will be displayed to you.

Therefore, each player's probability of winning depends not only on his or her own expenditure in the competition but also on the expenditures of the other players in the group. Note that the more Talers a player spends, the more likely it is that he or she wins the competition. More effort expended, however, means that a player has to pay more Talers to the lab.

5. If none of the players expends any Taler, i.e., $X_A = X_B = X_C = 0$, then it is equally likely that A, or B,or C wins. If two players (e.g., A and B) both do not expend any Taler, but the third player (e.g., C) expends at least one Taler, the third player (i.e., C) wins the competition.

6. Every player has to pay effort (in Taler) to the lab, irrespective of the outcome of the fortune wheel. Therefore, your earnings per round will be calculated as your gain in the competition minus your effort: earnings=gain-effort. The winning player gets the prize of 450 Taler and the losing players get nothing. The winning player's earnings $= 450 - X_i$, while the losing players' earnings$=$ $-X_i$.

B.1.2 Procedure

The experiment will consist of 24 identical rounds. In each round, you will have the same role (player A, or B, or C). The other two players in your group will be randomly assigned to you in each round.

You will not know who the other players in your group are. All the decisions you make will remain anonymous, and any attempt to reveal your identity to anyone is prohibited. After the experiment, you will be asked to answer some questions, including some personal information (e.g., gender, age, major...). All the information you provide will be kept anonymous and strictly confidential.

At the end of today's experiment, we will **randomly choose** 6 **rounds out of** 24 to pay you. Your total earnings in those 6 rounds will be added up, converted to euros, and paid to you in cash. This means that the earnings of all other rounds will not be paid to you and that you do not have to pay the efforts of these rounds either. You will get to know which 6 out of the 24 rounds will be chosen only after finishing these 24 rounds.

In addition to your earnings from these 6 selected rounds, you will receive **0.60 euros** for each of the 24 rounds you have played.

Before the experiment starts, we will ask you some questions (which are related to the actions in the experiment) through the computer screen.

B.2 Arandom treatment

Welcome to this experiment! Please read these instructions carefully and completely. Properly understanding the instructions will help you to make better decisions and hence earn more money.

Your earnings in this experiment will be measured in Talers. At the end of the experiment we will convert the Talers you have earned to cash and pay you in private. For each **45 Talers** you earn, you will be paid **1 Euro** in cash. Therefore, the more Talers you earn, the more cash you will gain at the end of today's experiment. In addition to the Talers earned during the experiment, each participant will receive a show-up fee of 4 Euros.

Please keep in mind that you are not allowed to communicate with other participants during the experiment. If you do not obey this rule you will be asked to leave the laboratory without getting paid. Whenever you have a question, please raise your hand; an experimenter will come to you.

B.2.1 Your task

This experiment will consist of 24 rounds. Before the actual experiment starts, you will first have to answer a few questions related to the experiment. The questions will be presented to you through the computer screen. For the experiment, groups consisting of three people are formed. These groups are randomly composed in each round. Your task in each round is to make some decisions. The money you earn depends on your decision and the decisions of the two other players in your group.

Let the three players in one group be called A, B, and C. In each round, three players A, B, and C compete for a prize of 450 Talers. The competition works as follows:

1. Two players A and B form an "alliance". Player C is playing on his or her own.

2. Your role in the experiment will be that of player A, B, or C. This role will be randomly assigned to you. Each participant will keep his or her role throughout the entire experiment.

3. In a first stage, all players will simultaneously choose "an effort level". Each player decides independently on his or her own effort level. A player's effort is chosen as an integer between 0 and 250, and it corresponds to the amount of Talers the player would like to expend in the competition to win the prize. You will have to pay this amount of Talers to the lab, whether or not you win the competition. In the following, player A's effort is denoted by X_A, player B's effort is denoted by X_B, and similarly player C's effort is denoted by X_C.

4. Then, you will be shown the amount of Talers that the other players in your group have expended. The efforts of player A and B will be added up, and the sum of X_A and X_B corresponds to the effort that the alliance of players A and B spends on the competition. The total expense is equal to the sum of all players' efforts: $X_A + X_B + X_C$.

5. Now a fortune wheel will turn and decide whether the alliance consisting of A and B or whether player C wins the 450-Taler-prize. As you will see, the fortune wheel is divided into two colors - red and blue. The red color represents the total Talers spent by players A and B (i.e., $X_A + X_B$). The blue color represents the Talers spent by player C (i.e., X_C). The two colored areas on the wheel represent exactly their shares in the total expense (i.e., $X_A + X_B + X_C$).

6. At the centre of the fortune wheel there is an arrow initially pointing to the top. After some time the arrow starts to rotate and then stops randomly. If the arrow stops in the red-colored area, players A and B win the prize. If the arrow stops in the blue-colored area, player C wins the prize. This means that the probability that players A and B win the prize is equal to their share of their joint effort in the total expense, hence

$$\text{probability that } A \text{ and } B \text{ win} = \frac{\text{effort } X_A + \text{effort } X_B}{\text{total expense } X_A + X_B + X_C}.$$

   Equivalently, the probability that player C wins the prize is equal to the share of C's effort in the total expense:

$$\text{probability that } C \text{ wins} = \frac{\text{effort } X_C}{\text{total expense } X_A + X_B + X_C}.$$

   For your information, the probabilities that either the alliance of A and B or player C wins the competition will be displayed to you.

   Therefore, each player's probability of winning depends not only on his or her own expenditure in the competition but also on the expenditures of the other players in the group. Note that the more Talers a player spends, the more likely it is that he or she wins the competition. More effort expended, however, means that a player has to pay more Talers to the lab.

7. If none of the players expends any Taler, i.e., $X_A = X_B = X_C = 0$, then it is equally likely that either the alliance A and B or player C wins. If players A and B both do not expend any Taler, but player C expends at least one Taler, player C wins the competition. If player C does not expend

any Taler, but either player A or player B (or both) expends at least one Taler, the alliance A and B wins the competition.

8. Every player has to pay effort (in Taler) to the lab, irrespective of the outcome of the fortune wheel. Therefore, your earnings per round will be calculated as your gain in the competition minus your effort: earnings=gain-effort.

   - In case player C wins, the competition ends and he or she gets the 450-Taler-prize; players A and B will gain nothing. While players A and B do not have any gain, but have to pay their efforts, the earnings of player C are calculated as follows: C's earnings $= 450 - X_C$. The earnings of player A or B are equal to $-X_A$ or $-X_B$, respectively.
   - In case the alliance of A and B wins the competition, player C's earnings $= - X_C$. One player out of the alliance will then be randomly drawn by the computer as the final winner for the 450-Taler-prize, whereas the other player gets nothing. **The winning probability for this second random draw is again determined by the efforts contributed in the contest against player C.**

     $$\text{probability that } A \text{ wins} = \frac{\text{effort } X_A}{\text{total expense } X_A + X_B}.$$

     $$\text{probability that } B \text{ wins} = \frac{\text{effort } X_B}{\text{total expense } X_A + X_B}.$$

     Therefore, the earnings are $450 - X_A$ for player A and $-X_B$ for player B if A wins; $-X_A$ for player A and $450 - X_B$ for player B if B wins.

B.2.2 Procedure

The experiment will consist of 24 identical rounds. In each round, you will have the same role (player A, B, or C). The other two players in your group will be randomly assigned to you in each round.

You will not know who the other players in your group are. All the decisions you make will remain anonymous, and any attempt to reveal your identity to anyone is prohibited. After the experiment, you will be asked to answer some questions, including some personal information (e.g., gender, age, major...). All the information you provide will be kept anonymous and strictly confidential.

At the end of today's experiment, we will **randomly choose** 6 **rounds out of** 24 to pay you. Your total earnings in those 6 rounds will be added up, converted to euros, and paid to you in cash. This means that the earnings of all other rounds will not be paid to you and that you do not have to pay the efforts of these rounds either. You will get to know which 6 out of the 24 rounds will be chosen only after finishing these 24 rounds.

In addition to your earnings from these 6 selected rounds, you will receive **0.60 euros** for each of the 24 rounds you have played .

Before the experiment starts, we will ask you some questions (which are related to the actions in the experiment) through the computer screen.

B.3 Aproportion treatment

Welcome to this experiment! Please read these instructions carefully and completely. Properly understanding the instructions will help you to make better decisions and hence earn more money.

Your earnings in this experiment will be measured in Talers. At the end of the experiment we will convert the Talers you have earned to cash and pay you in private. For each **45 Talers** you earn you will be paid **1 Euro** in cash. Therefore, the more Talers you earn, the more cash you will gain at the end of today's experiment. In addition to the Talers earned during the experiment, each participant will receive a show-up fee of 4 Euros.

Please keep in mind that you are not allowed to communicate with other participants during the experiment. If you do not obey this rule you will be asked to leave the laboratory without getting paid. Whenever you have a question, please raise your hand; an experimenter will come to you.

B.3.1 Your task

This experiment will consist of 24 rounds. Before the actual experiment starts, you will first have to answer a few questions related to the experiment. The questions will be presented to you through the computer screen. For the experiment, groups consisting of three people are formed. These groups are randomly composed in each round. Your task in each round is to make some decisions. The money you earn depends on your decision and the decisions of the two other players in your group.

Let the three players in one group be called A, B, and C. In each round, three players A, B, and C compete for a prize of 450 Talers. The competition works as follows:

1. Two players A and B form an "alliance". Player C is playing on his or her own.

2. Your role in the experiment will be that of player A, B, or C. This role will be randomly assigned to you. Each participant will keep his or her role throughout the entire experiment.

3. In a first stage, all players will simultaneously choose "an effort level". Each player decides independently on his or her own effort level. A player's effort is chosen as an integer between 0 and 250, and it corresponds to the amount of Talers the player would like to expend in the competition to win the prize. You will have to pay this amount of Talers to the lab, whether or not you win the competition. In the following, player A's effort is denoted by X_A, player B's effort is denoted by X_B, and similarly player C's effort is denoted by X_C.

4. Then, you will be shown the amount of Talers that the other players in your group have expended. The efforts of player A and B will be added up, and the sum of X_A and X_B corresponds to the effort that the alliance of players A and B spends on the competition. The total expense is equal to the sum of all players' efforts: $X_A + X_B + X_C$.

5. Now a fortune wheel will turn and decide whether the alliance consisting of A and B or whether player C wins the 450-Taler-prize. As you will see, the fortune wheel is divided into two colors - red and blue. The red color represents the total Talers spent by player A and B (i.e., X_A+X_B). The blue color represents the Talers spent by player C (i.e., X_C). The two colored

areas on the wheel represent exactly their shares in the total expense (i.e., $X_A + X_B + X_C$).

6. At the centre of the fortune wheel there is an arrow initially pointing to the top. After some time the arrow starts to rotate and then stops randomly. If the arrow stops in the red-colored area, players A and B win the prize. If the arrow stops in the blue-colored area, player C wins the prize. This means that the probability that players A and B win the prize is equal to their share of their joint effort in the total expense, hence

$$\text{probability that } A \text{ and } B \text{ win} = \frac{\text{effort } X_A + \text{effort } X_B}{\text{total expense } X_A + X_B + X_C}.$$

   Equivalently, the probability that player C wins the prize is equal to the share of C's effort in the total expense:

$$\text{probability that } C \text{ wins} = \frac{\text{effort } X_C}{\text{total expense } X_A + X_B + X_C}.$$

   For your information, the probabilities that either the alliance of A and B or player C wins the competition will be displayed to you.

   Therefore, each player's probability of winning depends not only on his or her own expenditure in the competition but also on the expenditures of the other players in the group. Note that the more Talers a player spends, the more likely it is that he or she wins the competition. More effort expended, however, means that a player has to pay more Talers to the lab.

7. If none of the players expends any Taler, i.e., $X_A = X_B = X_C = 0$, then it is equally likely that either the alliance A and B or player C wins. If players A and B both do not expend any Taler, but player C expends at least one Taler, player C wins the competition. If player C does not expend any Taler, but either player A or player B (or both) expends at least one Taler, the alliance A and B wins the competition.

8. Every player has to pay effort (in Taler) to the lab, irrespective of the outcome of the fortune wheel. Therefore, your earnings per round will be calculated

as your gain in the competition minus your effort: earnings=gain-effort.

- In case player C wins, the competition ends and he or she gets the 450-Taler-prize; players A and B will gain nothing. While players A and B do not have any gain, but have to pay their efforts, the earnings of player C are calculated as follows: C's earnings = 450 – X_C. The earnings of player A or B are equal to $-X_A$ or $-X_B$, respectively.
- In case the alliance of A and B wins the competition, then players A and B share the prize according to how much each player has expended in the contest against player C. Let S_A and S_B denote the share of 450-Thaler-prize entitled to player A and B, respectively:

$$S_A = \frac{\text{effort } X_A}{\text{effort} X_A + \text{effort} X_B},$$

$$S_B = \frac{\text{effort } X_B}{\text{effort} X_A + \text{effort} X_B},$$

Therefore, player A's earnings equal

$$S_A \times 450 - \text{effort} X_A = \frac{\text{effort } X_A \times 450}{\text{effort} X_A + \text{effort} X_B} - \text{effort} X_A,$$

player B's earnings equal

$$S_B \times 450 - \text{effort} X_B = \frac{\text{effort } X_B \times 450}{\text{effort} X_A + \text{effort} X_B} - \text{effort} X_B,$$

and player C's earnings = – X_C.

B.3.2 Procedure

The experiment will consist of 24 identical rounds. In each round, you will have the same role (player A, B, or C). The other two players in your group will be randomly assigned to you in each round.

You will not know who the other players in your group are. All the decisions you make will remain anonymous, and any attempt to reveal your identity to anyone is prohibited. After the experiment, you will be asked to answer some questions, including some personal information (e.g., gender, age, major...). All the information you provide will be kept anonymous and strictly confidential.

At the end of today's experiment, we will **randomly choose** 6 **rounds out of** 24 to pay you. Your total earnings in those 6 rounds will be added up, converted to euros, and paid to you in cash. This means that the earnings of all other rounds will not be paid to you and that you do not have to pay the efforts of these rounds either. You will get to know which 6 out of the 24 rounds will be chosen only after finishing these 24 rounds.

In addition to your earnings from these 6 selected rounds, you will receive **0.60 euros** for each of the 24 rounds you have played .

Before the experiment starts, we will ask you some questions (which are related to the actions in the experiment) through the computer screen.