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JEL classification codes

C91, C72, D23, D74

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Property Rights and Loss Aversion in Contests *

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1. Introduction

Conflicts are ubiquitous. Examples of conflict range from war, terrorism, crime and political clashes, to rent-seeking, sports, computer security, legal battles and business turf wars. The analysis of conflicts – both theoretically and in the field – has subsequently attracted substantial attention in the social sciences. A distinct feature of any conflict is that involved parties expend costly resources to receive some gain or to avoid a loss. Irrespective of the outcome, the resources spent cannot be recovered. This enables one to use the tools of contest theory (see, e.g., Konrad, 2009) to analyze conflict situations.

Private property rights (Alchian and Demsetz, 1973) and related issues of loss aversion (Kahneman and Tversky, 1979) are arguably some of the most important elements that determine the intensity of conflict. Disputes over property rights have been the source of conflict since the start of the civilization. The Indian Epic Mahabharata (see Smith, 2009) written in about 900 BC, for example, centers on the specific issue of property rights and the resulting conflict among kingdoms. More recent examples include conflicts between the UK and Argentina over the Falkland Islands, between China, Philippines, Viet Nam and several other countries in the South China Sea and between Israel and Syria over Golan Heights. Such conflicts even exist in the animal kingdom, for example when a wasp captures a host and tries to lay eggs, often another wasp tries to invade the host. Stockermans and Hardy (2013) and Humphries et al. (2006) use complementary approaches to show that those wasps who value the host most will fight harder and win more often. The phenomenon of loss aversion is also observed in international conflicts where the observed long status quos are often attributed to loss aversion (Levy, 1996). Zamir and Ritov (2012) argue in the law literature that it is efficient for the burden of proof in civil litigation to be on the plaintiff due to the presence of loss aversion. Loss aversion can be observed in sports contests as well. Lee (2004), for example, finds that the professional players in the World Poker Tour are more sensitive to losses than gains. Finally, Petersen & Hardy (1996) show that in the owner-intruder contests among wasps, the owner was advantaged whereas Stokkebo and Hardy (2000) show that this is because egg load affects resource value perception (in other words, loss aversion).

Existing research has focused on how property rights and conflict affect growth (e.g., Skaperdas, 1992; Hafer, 2006). However, some important aspects have received little attention in the literature. First, the effects of property rights on conflict intensity has hitherto not been theorized. Second, a behavioral foundation for the effect of property rights is lacking. Third, since it is difficult to obtain data from the field, there is little empirical evidence.

In this study we analyze the effects of property rights on conflict intensity. We model conflicts as contests and theorize that property rights invoke loss aversion. We then provide testable predictions using both an expected utility model and a model with loss aversion (plus a further one with loss aversion and social preferences). We then run a laboratory experiment to test the hypotheses obtained from the theoretical model. In the experiment we change the frame in different treatments such that in one treatment the contest game is framed in a gain domain, in another treatment it is framed in a loss domain, and in the final treatment it is framed in the gain domain for one player whereas in the loss domain for another player. Our novel model with loss aversion provides specific ranking of bids or efforts by subjects whereas the standard theory predicts equal equilibrium bids in the different treatments. Experimental results support the prediction of loss aversion, whereby effort spent in a loss frame is significantly higher than the effort spent in a gain frame. Whereas other rankings are preserved qualitatively, they are not statistically significant. A behavioral model rationalizes these findings.

While the independent literatures on property rights, loss aversion and contests are huge, their intersection is quite thin. [1] Loss aversion is a human tendency to strongly prefer avoiding losses to acquiring gains. Hence, understandably, ownership of a valuable object also brings an aversion to losing that object. Property rights, thus, have a specific behavioral effect on the rights holder. The holder of the property rights might face loss aversion (Tversky and Kahneman, 1991), whereas the non-holder might not. A series of papers following Kahneman et al. (1991) explore the difference in willingness to pay and willingness to accept and attribute the difference to loss aversion or an endowment affect. Hoffman et al. (1996) show that dictators behave close to Nash equilibrium if they earn their endowment to be shared. This is also attributed to loss aversion or endowment effects. The application of the same notions in conflict or contests, however, is more recent.

Contest theory analyzes situations in which players expend costly effort in order to affect the probability of winning a prize. Given the real life implications of property rights and loss aversion in conflicts – which is often modeled through a contest – it is natural for contest researchers to be interested in this topic. Cornes and Hartley (2003, 2012) are the first to investigate this issue. They show theoretically that with loss aversion, less effort is expended in a contest. Kolmar (2008) uses a Tullock contest with an endogenously produced rent to investigate endogenously enforced property rights as incentives for efficient production. Gill

[1] Various dimensions and the effects of property rights is investigated in the law and economics and in the innovation literature. But since our aim is very different from the aims of such literature, we do not cover them here. Interested reader may consult Barzel (1997) or Colombatto (2004) for references.

and Stone (2008) include loss aversion in a tournament model with an endogenous reference point whereas Morgan and Sisak (2015) show that the fear of losing may elicit more effort in "winner takes all" investment games.

The first experiment in this area is by Kong (2008) who implements a standard contest experiment and elicits loss aversion with a survey. Supporting the result from Cornes and Hartley (2003), Kong (2008) shows that with higher loss aversion, less effort is expended. This is reiterated in Falk et al. (2008) who show that a larger prize spread might reduce effort expended in a tournament due to loss aversion. Eisenkopf and Teyssier (2013) use a tournament model and instead of winner-take-all probability, they implement a prize-sharing rule as a function of the effort expended. They show that this framing eliminates loss aversion. Dutcher et al. (2015) use the same explanatory variable as in Kong (2008) and find contradictory results. None of these studies, however, provide either a direct test of loss aversion in contests or the effect of property rights in contests.

Thus, in this study we make a three-fold contribution. We are the first to contribute to the intersection of the literature on property rights, loss aversion and contests. We also provide a first, direct, empirical test of loss aversion on conflict outcomes. Finally, we show the effects of framing in contest experiments, and provide a behavioral explanation of the results.

The rest of the paper proceeds as follows. In the next section we describe the treatments and provide theoretical predictions and related hypotheses. Section 3 describes the details of the experimental procedure. We report the results in Section 4. Section 5 describes a behavioral model that better explains some experimental results and Section 6 concludes.

2. Treatments, theory and hypotheses

In this section we first describe the different situations related to property rights and conflict and match them with the three treatments of this study. Next, we provide a theoretical background and the predictions generated by expected utility theory, standard theory with loss aversion, and a specific theory with loss aversion in which property rights are made salient. We then provide hypotheses arising from each of these theoretical predictions.

In standard contest experiments, subjects start with no prize and make costly and irreversible bids to affect the likelihood of winning a prize. This essentially portrays situations in which none of the players hold property rights and they engage in conflict to gain the property rights to the prize. Various contests such as sports, rent-seeking or innovation tournaments can be modeled in this way. We keep this *gain* frame as the baseline and introduce two further treatments. We first consider the polar opposite case in which both the players hold property rights to a prize, but may lose these due to the outcome of the conflict. Hence, in the *loss* frame we allow both the subjects to start with prizes and place bids. The winner gets to keep the prize but whoever loses the contest loses his prize. A number of contests such as the case of downsizing due to performance, elimination tournaments, or the fight between two gladiators in the amphitheater (the loser loses his right to life) exemplify this frame. In the final treatment we consider the case where one of the players holds property rights that he may lose, whereas the other player does not hold property rights, but may gain it as an outcome of the conflict. In this *mixed* frame, one of the subjects starts with a prize whereas the other starts with no prize. The prize stays with the subject-with-prize if he wins, and is transferred to the subject-without-prize otherwise. Examples given in the introduction, including that of the wasp and conflicts between countries are eminent field examples of this frame.

In the laboratory we implement the above three treatments of a two-player Tullock (1980) contest. Each player has initial resource E that can be spent in the contest. Let player i bid $b_i \in [0, E]$. Irrespective of the outcome of the contest, players forgo their bids. The probability that player i wins is represented by a lottery contest success function:

$$p_i(b_1, b_2) = \begin{cases} b_i/\,(b_1 + b_2) & \text{if } (b_1 + b_2) \neq 0 \\ \quad 1/2 & \text{otherwise} \end{cases} \quad \text{and } \textstyle\sum_i p_i\,(b_1, b_2) = 1 \tag{1}$$

Given the contest success function, we now formally introduce the treatments below.

Gain Treatment. None of the players holds initial property rights to a prize and hence both start with no prize. They compete to win a prize of common value $V > 0$ that is gained by the winner, but there is no prize for the loser. The payoff function of player i is:

$$\pi_i(b_1, b_2) = \begin{cases} V + (E - b_i) & \text{with prob } p_i(b_1, b_2) \\ 0\ + (E - b_i) & \text{with prob } 1 - p_i(b_1, b_2) \end{cases} \tag{2}$$

Loss Treatment. Both players hold initial property rights to the prize, and consequently each player starts with a prize of common value $V > 0$. Post contest, the winner gets to keep his prize but the loser must relinquish theirs. The payoff function of player i is:

$$\pi_i(b_i, b_{-i}) = \begin{cases} V + (E - b_i) - 0 & \text{with prob } p_i(b_1, b_2) \\ V + (E - b_i) - V & \text{with prob } 1 - p_i(b_1, b_2) \end{cases} \tag{3}$$

Mixed Treatment. Without loss of generality assume that player 1 holds the initial property rights for a prize but player 2 does not. Hence, player 1 starts with a prize of common value $V > 0$ and player 2 does not start with any prize. After the contest, if player 1 is the winner then he gets to keep his prize. But if player 2 is the winner then the prize is transferred to them. Hence, the payoff functions of the players are:

$$\pi_1(b_1, b_2) = \begin{cases} V + (E - b_1) - 0 & \text{with prob } p_1(b_1, b_2) \\ V + (E - b_1) - V & \text{with prob } 1 - p_1(b_1, b_2) \end{cases} \tag{4A}$$

$$\pi_2(b_1, b_2) = \begin{cases} V + (E - b_2) & \text{with prob } 1 - p_1(b_1, b_2) \\ 0 \ + (E - b_2) & \text{with prob } p_1(b_1, b_2) \end{cases} \tag{4B}$$

Note that once we set $V - V = 0$, the payoff functions in (2), (3), (4A) and (4B) are the same. Hence, under risk neutrality and no loss aversion, the expected payoff of player i, $E(\pi_i)$ for $i = 1,2$, in each of the cases becomes:

$$E(\pi_i) = p_i V + (E - b_i) \tag{5}$$

The existence and uniqueness of the equilibrium for this game are proved by Szidarovszky and Okuguchi (1997). Following standard procedures (e.g., Chowdhury and Sheremeta, 2011), the unique Nash equilibrium bid is $b^* = V/4$ and the equilibrium payoff is $\pi^* = E + V/4$. Note that the equilibrium bid, when one does not consider loss aversion, does not depend on the initial endowment or on the specific treatment.

Cornes and Hartley (2012) introduce the standard version of a loss aversion model in a Tullock contest in which the players "value gains less than losses of similar magnitude". There may exist multiple equilibrium, but for the specific two-player symmetric lottery case we are concerned with, Cornes and Hartley (2012) show that the equilibrium is unique. Again, since the payoff functions are the same in (2), (3), (4A) and (4B), the equilibrium bids are also the same for the three treatments. However, Cornes and Hartley (2012) find that the equilibrium bid is lower in magnitude than the equilibrium bid under no loss aversion. For this two-player version see Sheremeta (2013) for an easier version of the proof.

Since we are interested in treatment effects, we can combine the predictions from the standard expected utility and Cornes and Hartley (2012) type loss aversion models together. Let us denote the bids in the Gain frame as b_G, bids in the Loss frame as b_L, bids by the holder of the property rights in the Mixed frame as b_{ML}, and the bids by the player with no property rights in the Mixed frame as b_{MG}. Then the predictions are:

$$b_G = b_L = b_{ML} = b_{MG} \tag{6}$$

As an alternative to this prediction, we propose a simple variation of the loss aversion model focusing on salience. Our experimental design relies solely on the salience of property rights through framing; which, in turn, induces loss aversion over the property rights of the prize. Hence, we consider a model in which a player who does not hold the property rights (and may gain it through the contest), values it at V. But a player who holds the property rights of the prize (and may lose it over the contest), values it at λV where $\lambda > 1$.

For the Gain treatment, the payoff function (Eq. 2) and expected payoff (Eq. 5) remains the same as 'no loss aversion'. Hence, the equilibrium bid also remains the same as: $b_G = V/4$.

However, the payoff functions under the Loss frame (Eq. 3) is now:

$$\pi_i(b_i, b_{-i}) = \begin{cases} V + (E - b_i) - 0 & \text{with prob } p_i(b_1, b_2) \\ V + (E - b_i) - \lambda V & \text{with prob } 1 - p_i(b_1, b_2) \end{cases} \tag{7}$$

And the corresponding expected payoff is:

$$E(\pi_i) = p_i \lambda V + \big((1 - \lambda)V + E - b_i\big) \tag{8}$$

Applying standard procedures, the unique Nash equilibrium bid is: $b_L = \lambda V/4$.

The case for the Mixed treatment is a bit different. In this case the expected payoff for the property rights holder is depicted by Equation (8), while the expected payoff for the player with no property rights is depicted by Equation (2). Solving for equilibrium provides the following equilibrium bids: $b_{MG} = \lambda V/(1 + \lambda)^2$ and $b_{ML} = \lambda^2 V/(1 + \lambda)^2$.

This also means that the average equilibrium bid in the Mixed treatment is $\overline{b_M} = [b_{MG} + b_{ML}]/2 = [\lambda V/(1 + \lambda)^2 + \lambda^2 V/(1 + \lambda)^2]/2 = \lambda V/2(1 + \lambda)$. Given $\lambda > 1$, it is thus easy to observe that $\lambda V/4 > \lambda V/2(1 + \lambda) > V/4$. This gives us the first hypothesis that there is a clear ranking among average bids across different treatments. More specifically, the average bid in the Mixed treatment lies in between the average (or individual) bids in the Loss and the Gain treatments.

Hypothesis 1: $b_L > \overline{b_M} > b_G$.

It is also easy to observe that, given $\lambda > 1$, the bids by players with property rights are higher than the bids by the players without property rights within the Mixed treatment. This gives the next Hypothesis.

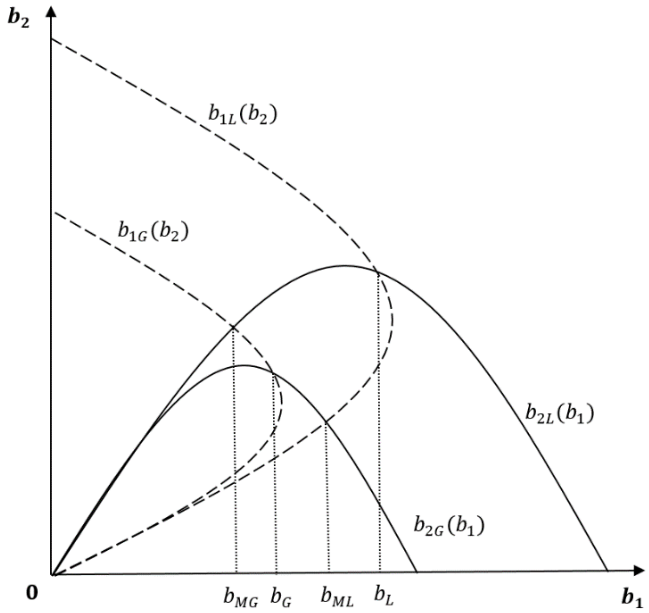
Hypothesis 2: $b_{ML} > b_{MG}$.

Lastly, it can be observed after some manipulation that there is a ranking among the bids of the four different types of players: $\lambda V/4 > \lambda^2 V/(1 + \lambda)^2 > V/4 > \lambda V/(1 + \lambda)^2$. This provides our next hypothesis that players with (without) property rights in the Loss (Gain) treatment bid more than their counterpart in the Mixed treatment:

Hypothesis 3: $b_L > b_{ML}$ and $b_G > b_{MG}$.

A diagrammatic description of the hypotheses is given by Figure 1 where the X-axis (Y-axis) depicts the bids of Player 1 (Player 2). Consider 4 cases: Player 1 holds or does not hold property rights vs. Player 2 holds or does not hold property rights. The parabolas are best response functions of the players: e.g., the large dotted parabola $b_{1L}(b_2)$ is the best response of Player 1 when he holds property rights. An equilibrium is achieved at the intersection of the best response functions of the two players. Observe that the bid by Player 1 when both he and the rival hold property rights, b_L, is greater than the bid b_{ML}, when he holds property rights but his rival does not. This, in turn is greater than the bid b_G, when none hold property rights. The bid b_{MG}, when Player 1 does not hold property rights but his rival does, is the smallest.

Figure 1. Equilibrium bid with property rights and loss aversion



The intuition behind this ranking is simple. In the Loss frame both the players perceive loss with high weight. However, in Mixed, only the property rights holder does so. Due to the asymmetry, the response of the property rights holder to other player's bid is not as high as the case when both face loss aversion. Similarly, the ranking in Hypothesis 3 appears due to asymmetry in player type in the Mixed treatment. Put another way, when a player with no property rights faces one with property rights, he reduces his bid.

3. Experimental procedures

The experiment was computerized using z-Tree (Fischbacher, 2007) and was run in a laboratory of the Centre for Behavioural and Experimental Social Science (CBESS) at the University of East Anglia. The subjects were students at the University and were recruited through the online recruiting system ORSEE (Greiner, 2015). We employed a fixed matching protocol meaning that in each session two subjects were randomly matched into one group of contestants and the matching did not change in a session. This was made clear in the instructions, a copy of which is included in Appendix II. A total of 44 subjects participated in each of the Loss and the Gain treatments (22 independent observations each) and 88 subjects in the Mixed treatment (44 independent observations). This is because in the latter treatment we have 44 subjects who hold property rights and the remaining 44 subjects do not.

In all treatments, two players compete for a prize of 180 tokens, meaning that V = 180. Hence, the expected utility equilibrium bid (b^*) per period is 45 tokens in all treatments and this remains the same in finite repetitions of the one-shot game. Players can enter bids up to one decimal place. While players compete in each of 25 periods, they are paid the average earning of five of these periods which were chosen randomly. All subjects in a session are paid for the same five rounds. Table 1 summarizes the treatment details.

Table 1. Treatment specification

Treatment	Budget / period ($\boldsymbol{E}$)	Players / group ($\boldsymbol{N}$)	Prize value ($\boldsymbol{V}$)	Expected Utility Eqbm bid ($\boldsymbol{b}^*$)	Total no. of subjects
Gains	180	2	180	45	44
Loss	180	2	180	45	44
Mixed	180	2	180	45	88

Each subject participated in only one of the sessions and no participant had participated in any contest or loss aversion experiment previously. Before the contest part, a risk elicitation task *a la* Eckel and Grossman (2008) was run, but the outcome of this task was not revealed until the end of the experiment. Instructions were read aloud by an experimenter, after which subjects answered a quiz before they could proceed to the experiment. Before the payment was made, subject demographic information were collected through an anonymous survey. Each session took around 45 minutes. At the end of each session the token earnings were converted to GBP at the rate of 1 token to 3 Pence. Subjects on average earned about £8.40.

4. Results

We first report the results aggregated at the treatment level, and test Hypothesis 1. We then move on to analyze bids at the individual level and test Hypotheses 2 and 3. In each case, we report descriptive statistics before running non-parametric tests or panel regressions.

4.1 Aggregate results

Table 2 presents descriptive statistics of bids in the three treatments. We run z-tests (Wilcoxon ranksum tests) that confirm the common phenomenon in Tullock experiments (see Dechenaux et al., 2015) that average bids in each treatment are higher than the equilibrium bid of 45 (p-values <0.05 in each test). Moreover, a Kruskal Wallis test also confirms that the bids are different across treatments (chi-squared = 8.379 with 2 d.f.; p = 0.0152), rejecting the prediction from the expected utility model (Eq. 6).

Table 2. Descriptive statistics of bids across subject-pairs per treatment

	Obs	**Mean**	**St Dev**
Gain	22	53.747	19.426
Loss	22	71.901	17.858
Mixed	44	62.662	22.112

It is easy to observe that there is a clear ranking of average bids across treatments. The mean bid in Gain treatment is 53.7; this increases to 62.7 in the Mixed treatment and to 71.9 in the Loss treatment. To understand if this is a common phenomenon over the time period, we plot the trends in individual bids over the 25 periods in Figure 1.

Figure 1. Average individual bids over time

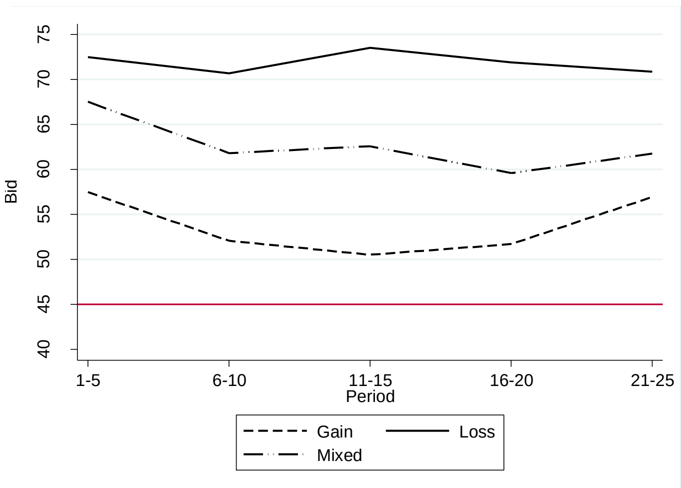


Figure 1 shows that this ranking remains stable over the 25 periods (the horizontal line is the equilibrium bid at 45). Hence, the data, at least qualitatively, support Hypothesis 1. To test this formally we run pairwise Wilcoxon tests (reported in Table 3).

Table 3. Pairwise comparison of treatments: Two-sided Wilcoxon tests

	Loss Domain	Mixed
Gain Domain	-2.887**	-1.551
	[0.0039]	[0.1210]
Loss Domain	-	1.768*
		[0.0770]

Figures in brackets are p-values; ** and * indicate significance at the 5% and 10% levels.

The tests confirm significant differences between Loss and Gain, and between Loss and Mixed; but the difference between the Gain and Mixed is marginally insignificant at the conventional level (p-value = 0.12). This gives our first result.

Result 1: *Average bids in the Loss treatment are significantly higher than average bids in the Gain and the Mixed treatment. However, differences in average bids between the Gain and the Mixed treatment are not significant at the conventional level.*

This result broadly supports Hypothesis 1, and confirms the effects of loss aversion through property rights. Note that our model with loss aversion does not include the social preferences of the subjects. However, social preferences – especially spite – might explain the no-difference result between Gain and Mixed. In Section 5 we provide a behavioral model with social preferences that explains this finding.

4.2 Individual level results: with and without property rights

We next investigate if there are differences between the behavior of those with property rights to the prize and the behavior of those without rights within the Mixed treatment. Moreover, we investigate whether property rights holders (or non-holders) behave in the same way in a ‘pure’ treatment and in the Mixed treatment. Similar to Figure 1, Figure 2 presents the time trend of mean individual bids. The left (right) panel of Figure 2 presents bids of those with (without) property rights in the Mixed treatment and those in the Loss (Gain) treatment. Similarly, Table 4 now splits the descriptive statistics of the Mixed treatments into the holder and non-holder of property rights.

Figure 2. Average bid over time

(a) Holders of property rights (b) Non-holders of property rights

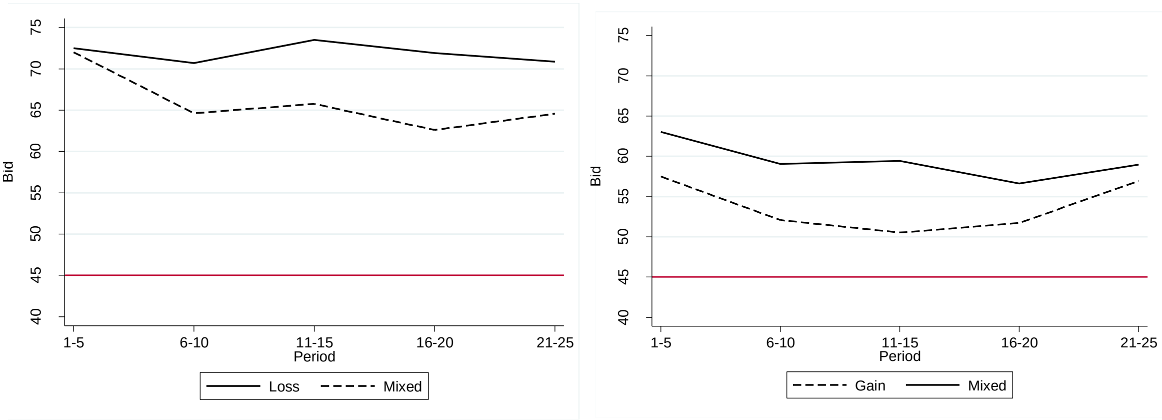


Table 4. Descriptive statistics of bids

	Obs.	Mean	St Dev
Loss	22	71.901	17.858
Mixed (holder)	44	65.914	26.34
Mixed (non-holder)	44	59.409	23.680
Gain	22	53.747	19.426

Both Figure 2 and Table 4 illustrate that there is a ranking of bids as follows: Loss > Mixed (property rights holder) > Mixed (property rights non-holder) > Gain. This would support Hypothesis 2, that the property rights holders bid more than the non-holders within the Mixed treatment. Furthermore, it seems to partially support Hypotheses 3: that the bids in the Loss treatment are greater than the bids by the property rights holder in the Mixed treatment. But bids in the Gain treatment are not greater than the bids of the property rights non-holders in the Mixed treatment.

However, a two-sided Wilcoxon test shows no difference in bids between those who have property rights in Mixed versus those in Loss: $z = 1.360$; $p = 0.1738$. This would constitute a rejection of Hypothesis 3. Similarly, a two-sided Wilcoxon tests shows no difference between who don't have property rights in Mixed vs. those in Gain: $z = -0.680$; $p = 0.4964$. This is characterized by Result 2.

Result 2: *There is no significant difference between the bids of the holder of property rights in the Loss and in the Mixed treatment, as well as between the bids of the non-holder of property rights in the Gain and in the Mixed treatment.*

Finally, to distinguish between the bids of the holder and non-holder of property rights within the Mixed treatments (note that these observations are not independent) we implement a t-test that confirms difference in bids (t = 1.8345, p = 0.0735) supporting Hypothesis 2.

Note, however, the tests employed so far are very conservative, given that they cannot incorporate the individual specific or demographic effects, nor can they account for temporal effects. Most importantly, they cannot incorporate the cardinal information in the data. To incorporate all of these features, and to test robustness of the results above, we run a series of random effects panel regressions as reported in Table 5.

The dependent variable is the bid by an individual in a period. We cluster standard errors at the player-pair level, as well as at the session level and run the regressions (a) for the whole data; (b) for only Gain and Loss data, and (c) separately for the Mixed treatment. We are interested in the treatment effect and hence include two treatment dummies (keeping Gain as baseline). Furthermore, for the Mixed treatment we include a dummy for the holder of the property rights. A set of controls are also included. The demographic controls are a 'risky behavior' dummy (choosing more risky options 4-6 over less risky options 1-3 in the risk test), age, gender (female = 1), and experience in participating in economics experiments. The strategic controls are the lag of a player's own bid, lag of the rival's bid, a dummy for whether the player won in the last period, and a time trend. Our variables of interest are the treatment dummies and dummy for holder of property rights in the Mixed treatment.

Table 5. Random effects regression results

Dep. var: Bid	All	All	Gain-Loss	Gain-Loss	Mixed	Mixed
Lag bid	0.485*** (0.032)	0.474*** (0.0301)	0.453*** (0.0378)	0.444*** (0.038)	0.504*** (0.048)	0.480*** (0.044)
Lag win	-4.624*** (1.044)	-4.461*** (1.045)	-3.247*** (1.192)	-3.150*** (1.189)	-6.215*** (1.702)	-5.814*** (1.702)
Lag other bid	0.174*** (0.023)	0.170*** (0.023)	0.215*** (0.026)	0.211*** (0.027)	0.147*** (0.033)	0.143*** (0.031)
Loss treatment dummy	6.457*** (2.095)	7.079*** (2.075)	6.275*** (2.195)	6.526*** (2.184)		
Mixed treatment dummy	3.042 (1.919)	4.068** (1.855)				
Property rights holder					4.657* (2.409)	6.689** (2.625)

Period	-0.009 (0.075)	-0.013 (0.078)	0.010 (0.124)	0.008 (0.127)	-0.031 (0.084)	-0.040 (0.088)
Risk dummy		-5.363*** (1.535)		-3.299* (1.854)		-6.868*** (2.413)
Age ≥21		-2.796* (1.532)		-0.415 (1.917)		-5.448** (2.467)
Female		-0.721 (1.571)		0.976 (2.056)		-2.750 (2.586)
Experience in Experiment		0.178 (0.109)		0.196* (0.110)		-0.156 (0.474)
Constant	20.80*** (2.676)	24.61*** (2.963)	19.39*** (3.225)	20.10*** (3.696)	23.05*** (4.371)	31.79*** (4.879)
Observations	4224	4224	2112	2112	2112	2112

Numbers in parentheses are robust SEs; *, **, and ** implies significance in 10%, 5% and 1% levels.

The regressions provide several interesting results. First, these reiterate Result 1 and Result 2. Both in the combined regression as well as in the regression comparing only the Loss and the Gain treatments, the coefficient for the Loss treatment dummy is positive and significant at the 1% level. Furthermore, unlike with the non-parametric tests, with controls the dummy for the Mixed treatment is also positive and significant. Hence, these provide stronger support for Hypothesis 1.[2] Finally, the dummy for property rights holder in the Mixed treatment is positive and significant – indicating that the bids by the property rights holder is higher than the non-holders within the Mixed treatment. This (along with the t-test result described earlier) provide formal support for loss aversion and for Hypothesis 2 and leads to Result 3:

Result 3: *Bids by the property rights holders are greater than the bids by the non-holders of property rights within the Mixed treatment.*

5. A behavioral explanation of the results

In the previous section we show that both between the Loss and the Gain treatments, as well as within the Mixed treatment, a holder of property rights bid more than a non-holder. This is explained with a model of loss aversion. However, some other predictions are supported qualitatively but not quantitatively in the experiment. Here we argue that although the model

[2] The coefficients for the controls have the usual signs and significance levels (see, e.g., Dechenaux et al., 2015).

with loss aversion fulfills the main objective of predicting treatment effects, it does not include social preferences of the subjects. Social preferences (e.g. inequity aversion or spite) among contestants may explain the divergence between our hypotheses and empirical findings.

We introduce a linear model of inequality aversion of Fehr and Schmidt (1999) as applied by Herrman and Orzen (2008) to contests. The model postulates that a subject might dislike disadvantageous inequity in payoffs, i.e., dislikes being behind others. Further, he might dislike it when the rival is disadvantaged; or, like such inequality if he is spiteful. Let $\alpha \geq 0$ denote the disadvantageous and $\beta \leq 1$ (with $\beta < 0$: spite) denote the advantageous inequity aversion parameters. Then one can show the following.

Proposition 1. *Equilibrium effort with social preference in the Gain frame is* $b_G^* = \frac{V(1+\alpha-\beta)}{2(2+\alpha-\beta)}$ *and in the Loss frame is* $b_L^* = \frac{\lambda V(1+\alpha-\beta)}{2(2+\alpha-\beta)}$.

Proof: See Appendix I-A.

Proposition 2. *If player i is the holder of property rights and player j is not, then the equilibrium effort with social preference in the Mixed frame is then obtained by solving:*

$$V\frac{b_j}{(b_i+b_j)^2} - (1-\lambda)V\frac{b_j}{(b_i+b_j)^2} - 1 + \alpha\lambda V\frac{b_j}{(b_i+b_j)^2} - \alpha\frac{b_j^2}{(b_i+b_j)^2} - \alpha\frac{b_j^2}{(b_i+b_j)^2} - \beta V\frac{b_j}{(b_i+b_j)^2} - \beta\frac{b_j^2}{(b_i+b_j)^2} + \beta\frac{2b_ib_j+b_i^2}{(b_i+b_j)^2} = 0$$

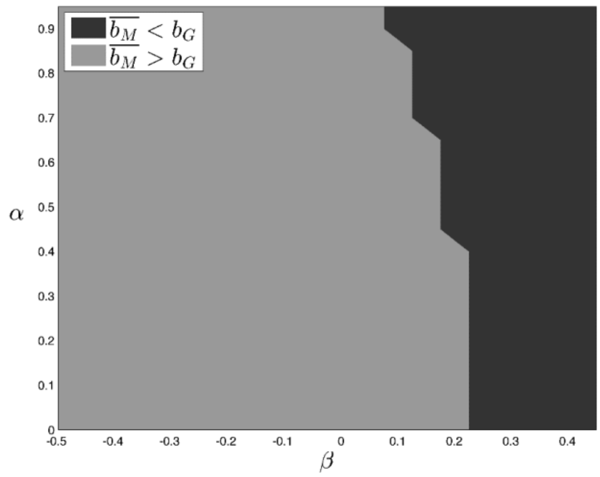
$$V\frac{b_i}{(b_i+b_j)^2} - 1 + \alpha V\frac{b_i}{(b_i+b_j)^2} - \alpha\frac{b_i^2}{(b_i+b_j)^2} - \alpha\frac{b_i^2}{(b_i+b_j)^2} - \beta\lambda V\frac{b_i}{(b_i+b_j)^2} - \beta\frac{b_i^2}{(b_i+b_j)^2} + \beta\frac{2b_ib_j+b_j^2}{(b_i+b_j)^2} = 0.$$

Proof: See Appendix I-B.

Again, several interesting implications can be observed. First, and most importantly, Proposition 1 shows that players bid higher in the Loss treatment than in the Gain treatment – even after accounting for social preferences. But it is now hard to find a closed form solution for the Mixed treatment, and no specific hypotheses relating to the Mixed treatment can be formed. This is since the ranking may change depending on the values attached to the inequity aversion parameters. To test this, we run simulations of average individual bids on a couple of situations for which we could not find support for our model with loss aversion for hypotheses that were not supported by the data. The simulations, however, shows that bids by the property rights holder in the Mixed treatment is higher than non-holder (supporting Hypothesis 2).

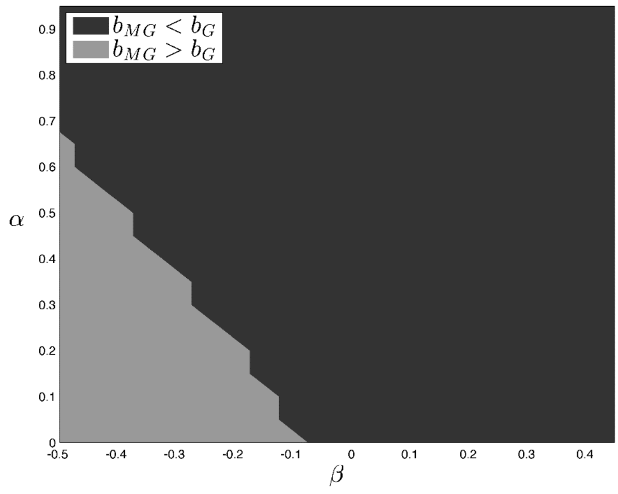
Hypothesis 1 predicts higher average bids in the Mixed treatment compared than in the Gain treatment. While this result is supported qualitatively, the difference is not statistically significant. We simulate the bids in the two treatments for $V = 180, \lambda = 2, \alpha \in [0,1]$, and $\beta \in [-0.5,0.5]$. The result is shown in Figure 3 and the details of the simulation procedures are reported in Appendix I-C. The bid in the Mixed treatment is greater (lower) than the bid in the Gain treatment in the light (dark) grey area. Hence, depending on the social preference of the subject it is possible to observe both outcomes and the overall empirical result may become mixed; explaining why one might not find a significant difference between the bid levels.

Figure 3. Simulated bids in the Mixed treatment versus in the Gain treatment



We further run simulations with the same parametric restrictions for the non-holders of property rights in the Mixed treatment. Again observe from Figure 4 that when there is spite ($\beta < 0$) the theoretical prediction $b_{MG} < b_G$ (Hypothesis 3) may be reversed. Hence, overall the empirical result may not be significant due to heterogeneous social preferences.

Figure 4. Simulated bids by non-holders in the Mixed treatment vs. in the Gain treatment



6. Discussion

We analyze theoretically and experimentally the effects of property rights and resulting loss aversion on behavior in contests. We implement a novel experimental design that changes the property rights only through framing and salience. The standard theoretical models of expected utility (Tullock, 1980) or loss aversion (Cornes and Hartely, 2012) predict no difference in bids among treatments, whereas a loss aversion model with salient property rights – that we introduce – provides clear ranking in equilibrium bids across treatments. In the experiment subjects in the Loss frame bid significantly more than the subjects in the Gain frame both in the 'pure' as well as in the Mixed treatments – confirming the predictions from the loss aversion model. Some further results, while qualitatively supported form the laboratory data, are not always statistically significant. We show that this can be explained with a behavioral model which accounts for differences in social preferences.

Although there have been studies that include the concept of loss aversion in contests and have used control for loss aversion in data analysis, this is the very first experiment that provides a direct test of loss aversion in contests. We find several interesting implications. First, the effect of property rights and loss aversion is very robust. Both the theoretical (with or without social preferences) and empirical results support higher effort when property rights are made salient. This matches with and provides a micro theoretical foundation of the field observations from biology, litigation, and conflict literatures to name a few. Second, this is the first experiment, to our knowledge, that employs framing in understanding behavior in a contest setting. There is a recent strand of literature that investigates the effects of experimental design (see Chowdhury et al. (2014b) for an example and literature) on contest outcome. The current study, hence, contributes to this area. Third, and relating to the second point above, these results provide new insights for both contest design and policy. For example, since it is possible to manipulate effort in contests by simply changing the frame, it may be useful to introduce such framing effects in organizations and tournaments.

This research can be extended in various ways. Although framing and property rights are known to have gender effects in the decision theory literature (see, e.g., Chowdhury et al., 2014a), it is not observed in this strategic situation. It will be interesting to investigate further in this area. The structure can be applied to the all-pay auction or tournament settings. In addition to loss aversion, the impact of regret on behavior in contests can be examined. A field experiment will complement the current results and provide more support (or not) for policy. We leave these as various avenues of future research.

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Appendix I: Proofs of the Propositions and Simulation Details

A. Proof of Proposition 1

For the Gain treatment, utility under social preference is –

$u_i(b_i, b_j) = \frac{b_i}{b_i+b_j} V + (E - b_i) - \alpha \frac{b_j}{b_i+b_j} [V + b_i - b_j] - \beta \frac{b_i}{b_i+b_j} [V + b_j - b_i]$

Calculations for obtaining the equilibrium effort for the Gain treatment can be obtained directly from Herrmann and Orzen (2008, pp. 37-39). This leads to:

$$b_G^* = \frac{V(1 + \alpha - \beta)}{2(2 + \alpha - \beta)}$$

For the Loss treatment, utility under social preference is –

$u_i(b_i, b_j) = \frac{b_i}{b_i+b_j} V + \frac{b_j}{b_i+b_j} (1 - \lambda)V + (E - b_i) - \alpha \frac{b_j}{b_i+b_j} [\lambda V + b_i - b_j] - \beta \frac{b_i}{b_i+b_j} [\lambda V + b_j - b_i]$

$$\frac{\partial u_i(b_i, b_j)}{\partial b_i} = V \frac{b_j}{(b_i + b_j)^2} - (1 - \lambda)V \frac{b_j}{(b_i + b_j)^2} - 1 + \alpha\lambda V \frac{b_j}{(b_i + b_j)^2} - \alpha \frac{b_j^2}{(b_i + b_j)^2} - \alpha \frac{b_j^2}{(b_i + b_j)^2} - \beta\lambda V \frac{b_j}{(b_i + b_j)^2} - \beta \frac{b_j^2}{(b_i + b_j)^2} + \beta \frac{2b_i b_j + b_i^2}{(b_i + b_j)^2}$$

Symmetry implies $b_i = b_j = b^*$ imposing this in $\frac{\partial u_i(b_i,b_j)}{\partial b_i} = 0$ returns –

$$V \frac{1}{4b^*} - (1 - \lambda)V \frac{1}{4b^*} - 1 + \alpha\lambda V \frac{1}{4b^*} - \alpha \frac{1}{4} - \alpha \frac{1}{4} - \beta\lambda V \frac{1}{4b^*} - \beta \frac{1}{4} + \beta \frac{3}{4} = 0$$

$$\frac{V}{2b^*} - \frac{(1 - \lambda)V}{2b^*} + \frac{\alpha\lambda V}{2b^*} - \frac{\beta\lambda V}{2b^*} = (2 + \alpha - \beta)$$

$b_L^* = \frac{\lambda V(1+\alpha-\beta)}{2(2+\alpha-\beta)}$. ■

B. Proof of Proposition 2

For Mixed treatment, let player i has property rights and player j doesn't, then –

$u_i(b_i, b_j) = \frac{b_i}{b_i+b_j} V + \frac{b_j}{b_i+b_j} (1 - \lambda)V + (E - b_i) - \alpha \frac{b_j}{b_i+b_j} [\lambda V + b_i - b_j] - \beta \frac{b_i}{b_i+b_j} [V + b_j - b_i]$

FOC: $\frac{\partial u_i(b_i,b_j)}{\partial b_i} = 0$ implies

$$V\frac{b_j}{\left(b_i+b_j\right)^2}-(1-\lambda)V\frac{b_j}{\left(b_i+b_j\right)^2}-1+\alpha\lambda V\frac{b_j}{\left(b_i+b_j\right)^2}-\alpha\frac{b_j^2}{\left(b_i+b_j\right)^2}-\alpha\frac{b_j^2}{\left(b_i+b_j\right)^2}-\beta V\frac{b_j}{\left(b_i+b_j\right)^2}-\beta\frac{b_j^2}{\left(b_i+b_j\right)^2}+\beta\frac{2b_ib_j+b_i^2}{\left(b_i+b_j\right)^2}=0$$

And

$$u_j\left(b_i,b_j\right)=\frac{b_j}{b_i+b_j}V+\left(E-b_j\right)-\alpha\frac{b_i}{b_i+b_j}\left[V+b_j-b_i\right]-\beta\frac{b_j}{b_i+b_j}\left[\lambda V+b_i-b_j\right]$$

FOC: $\frac{\partial u_j(b_i,b_j)}{\partial b_j}=0$ implies

$$V\frac{b_i}{\left(b_i+b_j\right)^2}-1+\alpha V\frac{b_i}{\left(b_i+b_j\right)^2}-\alpha\frac{b_i^2}{\left(b_i+b_j\right)^2}-\alpha\frac{b_i^2}{\left(b_i+b_j\right)^2}-\beta\lambda V\frac{b_i}{\left(b_i+b_j\right)^2}-\beta\frac{b_i^2}{\left(b_i+b_j\right)^2}+\beta\frac{2b_ib_j+b_j^2}{\left(b_i+b_j\right)^2}=0$$

■

C. Details of the simulation

The simulations are run using Matlab. The details of the procedures are described below.

The FOCs are defined as FOC: $\mathbb{R}_2 \mapsto \mathbb{R}_2$, more specifically

$$FOC\left(b_i,b_j\right)=\begin{bmatrix}\frac{\partial u_i(b_i,b_j)}{\partial b_i}\\ \frac{\partial u_j(b_i,b_j)}{\partial b_j}\end{bmatrix}$$

Thus, strictly speaking, this function only returns the derivative of both utility functions at a certain combination of effort levels.

We iterate on this function using a multivariate version of the Newton-Raphson algorithm with convergence criteria $\varepsilon=\delta=10^{-6}$ and a maximum of 100 iterations.[3] The initial vector of efforts comes from two random draws from $uniform[0,1]$.

Since the results seem to vary marginally with the draw of the initial vector, for each parameter constellation we drew 50 initial vectors, solved and only took the average of all those solutions into account if the sum of squares of these 50 draws was less than 0.01.

[3] Where ε is the maximal distance between two iteration steps on effort levels we allow and δ is the maximum value the derivatives can have at a solution. See e.g. Miranda and Fackler (2004) for a detailed description.

This script was used in the following algorithm:[4]

1. Set $\alpha = -0.05, \beta = -0.55, \lambda = 2, V = 180$.
2. Increase α by 0.05.
3. Increase β by 0.05.
4. Compute equilibrium bids (for all 4 frames) and store together with α and β.
5. If $\beta < 0.5$, then go to Step 3, otherwise set $\beta = -0.55$ and go to the next step.
6. If $\alpha < 1$, then go to Step 2, otherwise stop.

The matrix that contains all saved data from step 4 is cleaned from all non-convergent cases and infinite solutions. It is the resulting matrix with which we created the graphs.

The Matlab codes are available from the corresponding author by request.

[4] One can estimate λ from the Gain and the Loss treatments and the estimated value is $\lambda = {\sim}1.35$. Although we have implemented $\lambda = 2$ for easier visual representation in our simulation, qualitative results from the simulation remains the same even when we make $\lambda = 1.35$.

Appendix II: Instructions

GENERAL INSTRUCTIONS

This is an experiment in the economics of decision making. This experiment consists of two unrelated parts. Instructions for the first part are given next and the instructions for the second part will be provided after the first part of the experiment is finished.

The instructions are simple. If you follow them closely and make appropriate decisions, you can earn an appreciable amount of money.

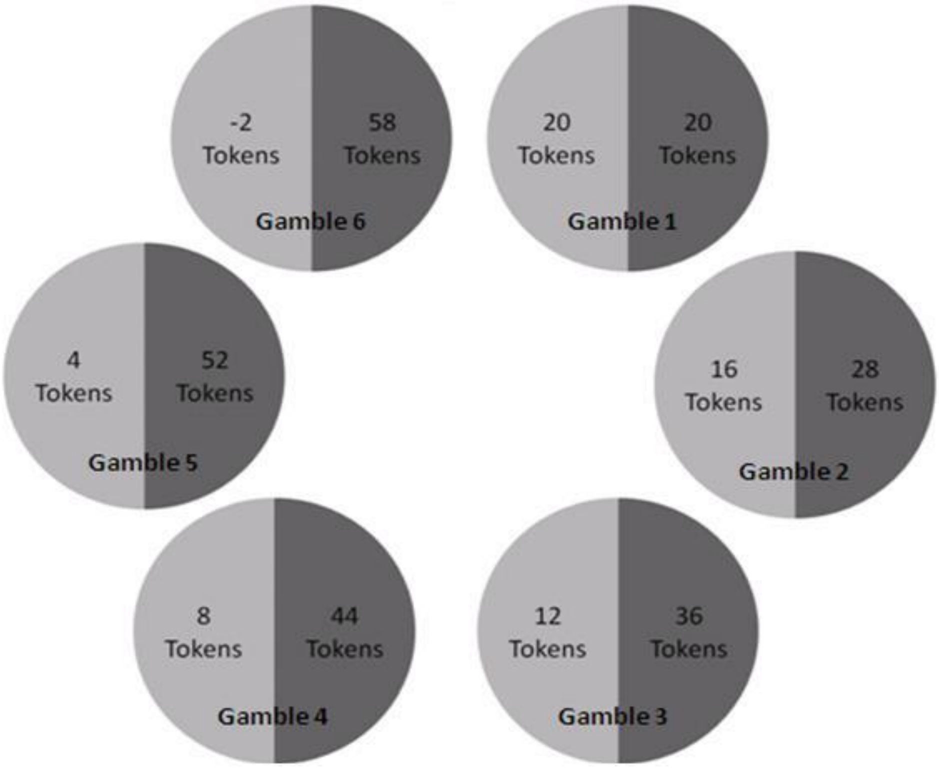
It is very important that you remain silent and do not look at other people's work. If you have any questions, or need assistance of any kind, please raise your hand and an experimenter will come to you. If you talk, laugh, exclaim out loud, etc., you will be asked to leave and you will not be paid. We expect and appreciate your cooperation.

Experimental Currency is used in the experiment and your decisions and earnings will be recorded in tokens. At the end of today's experiment, you will be paid in private and in cash. Tokens earned from both parts of the experiment will be converted to Pound Sterling at a rate of:

_1_ token to **_3_** Pence (£0.03).

INSTRUCTIONS – PART 1

In this task, you will be asked to **choose from six different gambles** (as shown below). Each circle represents a different gamble from which you must **choose the one that you prefer**. Each circle is divided in half, with the number of tokens that the gamble will give you in each circle.



Your payment for this task will be determined at the end of today's experiment. A volunteer will come to the front of the room and toss a coin. If the outcome is heads, you will receive the number of tokens in the light grey area of the circle you have chosen. Alternatively, if the outcome is tails, you will receive the number of tokens shown in the dark grey area of the circle you have chosen. Note that no matter which gamble you pick, each outcome has a 50% chance of occurring.

Please select the gamble of your choice by clicking one of the "Check here" buttons that will appear on each circle in the picture Once you have made your choice, please click the "Confirm" button at the bottom of the screen.

For your record, also tick the gamble you have chosen in the above picture.

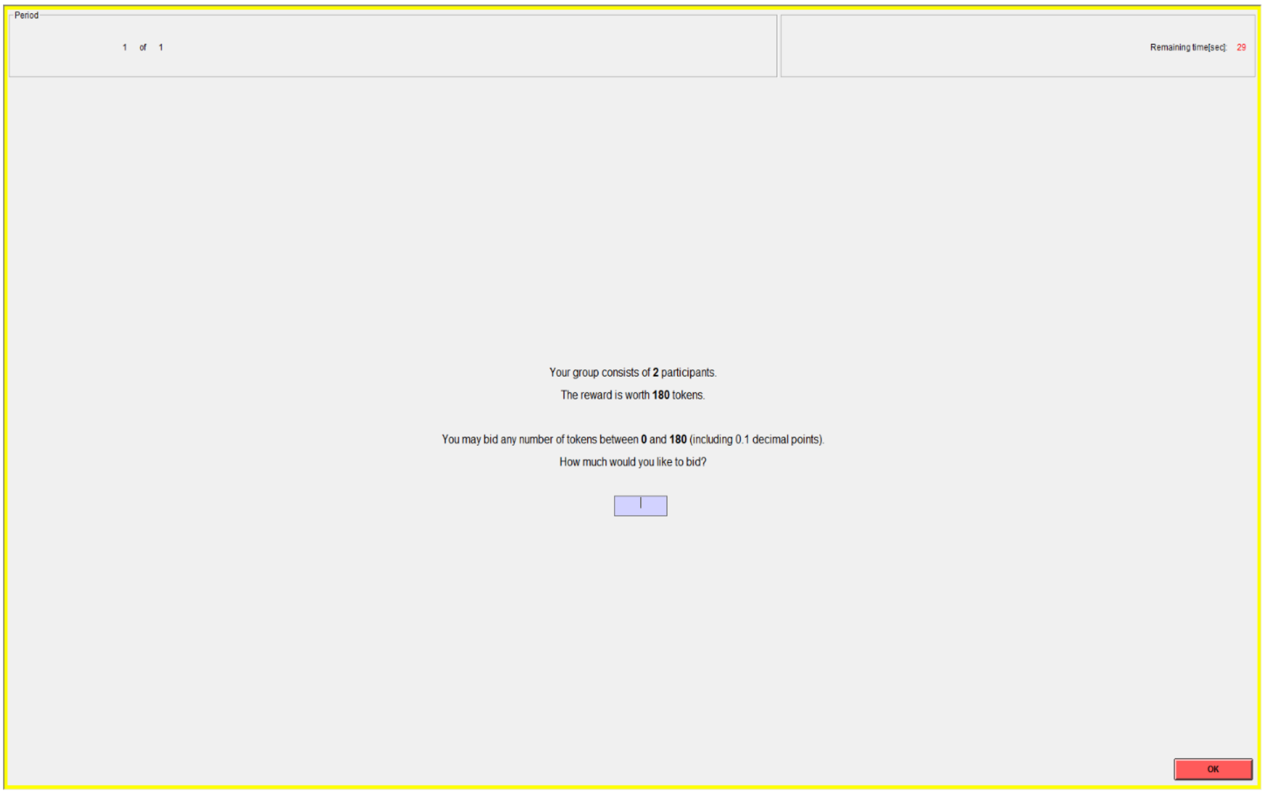
Once everyone has made their decision, this task will end and we will move on to Part 2 of the experiment. Your payment for this task will be decided at the end of today's experiment.

INSTRUCTIONS – GAIN DOMAIN

YOUR DECISION

This part of the experiment consists of **25** decision-making periods. At the beginning, you will be randomly and anonymously placed into a group of **2 participants**. The composition of your group will remain the same for all 25 periods. You will **not** know who your group member is at any time.

Each period you will receive an initial endowment of **180** tokens. Each period, you may bid for a reward of **180 tokens**. You may bid any number between **0** and **180** (including 0.1 decimal points). An example of your decision screen is shown below.



YOUR EARNINGS

For each **bid** there is an associated **cost** equal to the bid itself. The cost of your bid is:

Cost of your bid = Your bid

The more you bid, the more likely you are to receive the reward. The more the other participant in your group bid, the less likely you are to receive the reward. Specifically, your chance of receiving the reward is given by your bid divided by the sum of all 2 bids in your group:

$$\text{Chance of receiving the reward} = \frac{\text{Your bid}}{\text{Sum of all 2 bids in your group}}$$

You can consider the amounts of the bids to be equivalent to numbers of lottery tickets. The computer will draw one ticket from those entered by you and the other participant, and assign the reward to one of the participants through a random draw. If you receive the reward, your earnings for the period are equal to your endowment of 180 tokens *plus* the reward of 180 tokens *minus* the cost of your bid. If you do not receive the reward, your earnings for the period are equal to your endowment of 180 tokens *minus* the cost of your bid. In other words, your earnings are:

If you receive the reward: Earnings = Endowment + Reward – Cost of your bid = 180 + 180 – your bid

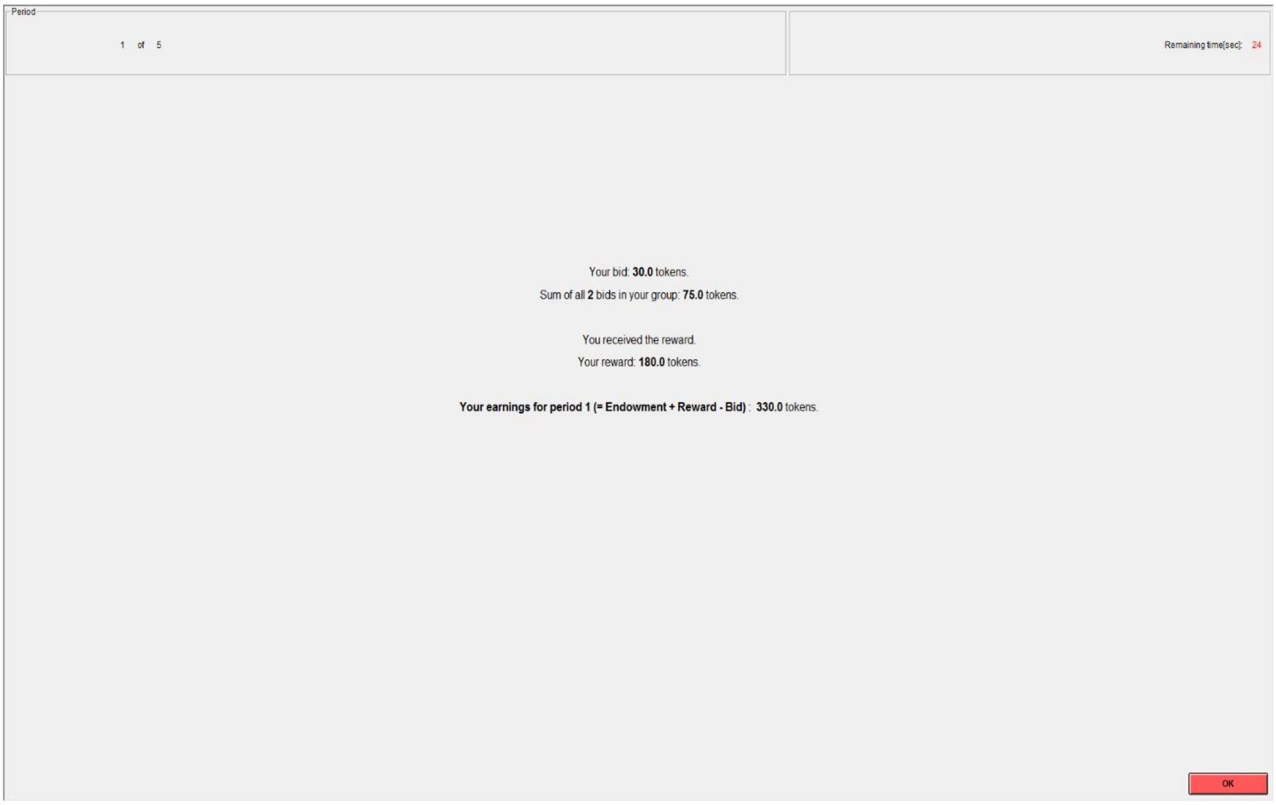
If you do not receive the reward: Earnings = Endowment **-** Cost of your bid = 180 – your bid

An Example (for illustrative purposes only)

Let's say participant 1 bids 30 tokens and participant 2 bids 45 tokens. Therefore, the computer assigns 30 lottery tickets to participant 1 and 45 lottery tickets to participant 2. Then the computer randomly draws **one lottery ticket out of 75** (30 + 45). As you can see, participant 2 has the **highest chance** of receiving the reward: **0.60 = 45/75** and participant 1 has **0.40 = 30/75** chance of receiving the reward.

Assume that the computer assigns the reward to participant 1, then the earnings of participant 1 for the period are 330 = 180 + 180 – 30, since the reward is 180 tokens and the cost of the bid is 30. Similarly, the earnings of participant 2 are 135 = 180 – 45.

At the end of each period, your bid, the sum of all 2 bids in your group, your reward, and your earnings for the period are reported on the outcome screen as shown below. Once the outcome screen is displayed you should record your results for the period on your **Personal Record Sheet** (page 4) under the appropriate heading.



IMPORTANT NOTES

At the beginning of this part of the experiment you will be randomly grouped with another participant to form a 2-person group. You will not be told which of the participants in this room are assigned to which group.

At the end of the experiment the computer will randomly choose **5 of the 25** periods for actual payment for this part of experiment. You will be paid the average of your earnings in these 5 periods. These earnings in tokens will be converted to cash at the exchange rate of **_1_** token to **_3_** Pence (£0.03) and will be paid at the end of the experiment.

Are there any questions?

Personal Record Sheet

(5 periods from here will be randomly chosen for final payments)

Period	Your bid	Sum of all 2 bids in your group	Your reward	Your earnings for this period
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				

Total Earnings

Period Chosen	Earnings for this period
Total	

Total earnings from table above: ____________ **(1)**

Average of above earnings: (1) ÷ 5 ____________ **(2)**

Earnings from Part 1: ____________ (3)

Total earnings (2) + (3) ____________ (4)

Multiply by exchange rate: **(4) × __0.03___**

Total payment for the experiment: **£____________**

QUIZ

1. Does group composition change across periods in the experiment?

Ans. Yes No

2. What is the value of 1 token in Pence?

Ans. 3 Pence 6 Pence 9 Pence

Questions 3 to 6 apply to the following information.

In a given period, suppose the bids by participants in your group are as follows.

Bid of participant 1: 55 tokens

Bid of participant 2: 70 tokens

3. What is the chance that participant 1 will receive the reward?

Ans. _______ out of ________

4. What is the chance that participant 2 will receive the reward?

Ans. _______ out of ________

5. If you are Participant 1 and you **did not receive** the reward what are your earnings this period?

Ans. ___________ tokens

6. If you are Participant 2 and you **received** the reward what are your earnings this period?

Ans. ___________ tokens

EXPLANATIONS FOR QUIZ ANSWERS

1. Does group composition change across periods in the experiment?

Ans. No

2. What is the value of 1 token in Pence?

Ans. 3 Pence

3. What is the chance that participant 1 will receive the reward?

Ans. 55 out of 125.

4. What is the chance that participant 2 will receive the reward?

Ans. 70 out of 125.

5. If you are Participant 1 and you **did not receive** the reward what are your earnings this period?

Ans. 125 tokens (= Endowment – bid = 180 – 55)

6. If you are Participant 2 and you **received** the reward what are your earnings this period?

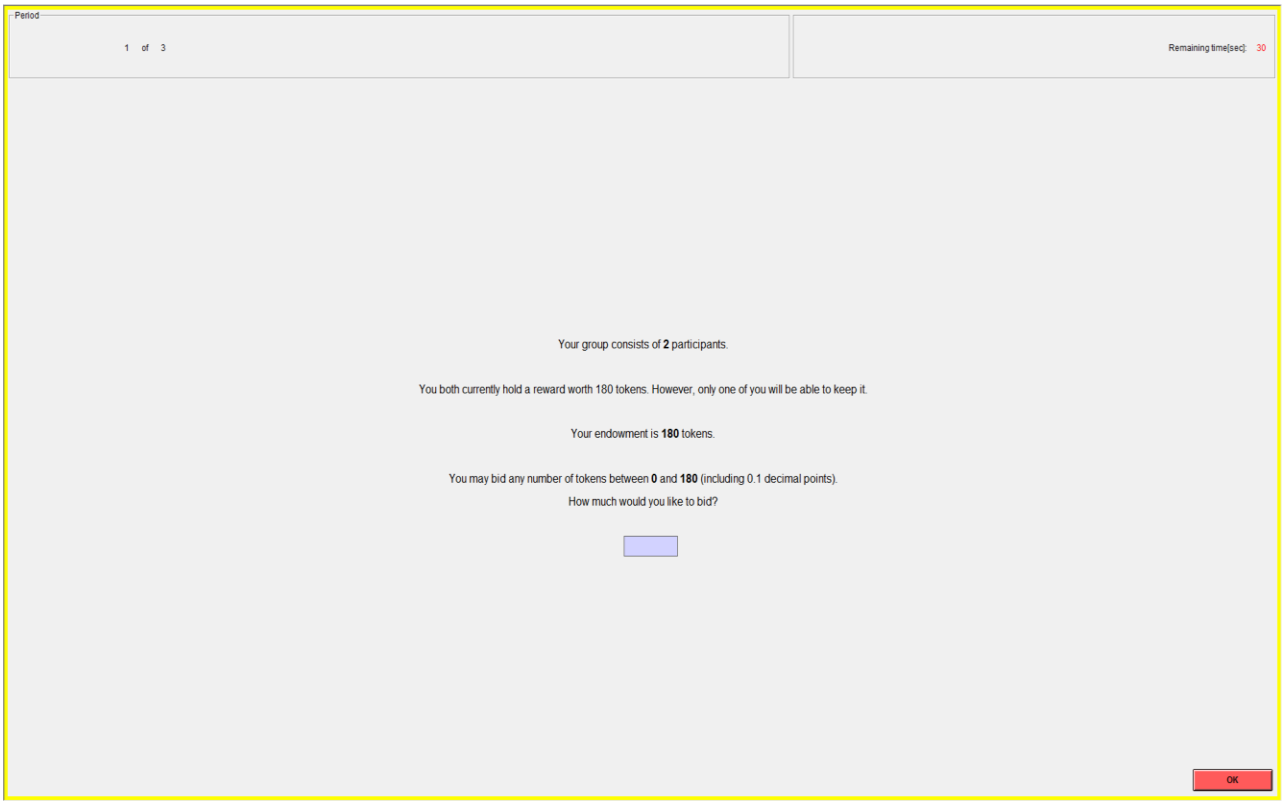
Ans. 290 tokens (= Endowment + Reward – Bid = 180 + 180 – 70)

INSTRUCTIONS – LOSS DOMAIN

YOUR DECISION

This part of the experiment consists of **25** decision-making periods. At the beginning, you will be randomly and anonymously placed into a group of **2 participants**. The composition of your group will remain the same for all 25 periods. You will **not** know who your group member is at any time.

Each period both of you will receive an initial **endowment of 180** tokens as well as a **reward of 180** tokens. Each period, both of you may bid to keep your reward, but only one of you will be able to keep your reward. You may bid any number between **0** and **180** (including 0.1 decimal points). An example of your decision screen is shown below.



YOUR EARNINGS

For each **bid** there is an associated **cost** equal to the bid itself. The cost of your bid is:

Cost of your bid = Your bid

The more you bid, the more likely you are to keep the reward. The more the other participant in your group bids, the less likely you are to keep the reward. Specifically, your chance of keeping the reward is given by your bid divided by the sum of all 2 bids in your group:

$$\text{Chance of keeping the reward} = \frac{\text{Your bid}}{\text{Sum of all 2 bids in your group}}$$

You can consider the amounts of the bids to be equivalent to numbers of lottery tickets. The computer will draw one ticket from those entered by you and the other participant, and decide which one of the participants will keep the reward through a random draw. If you get to keep your reward, your earnings for the period are equal to your endowment of 180 tokens *plus* the reward of 180 tokens *minus* the cost of your bid. If you do not get to keep your reward, your earnings for the period are equal to your endowment of 180 tokens *minus* the cost of your bid. In other words, your earnings are:

If you keep the reward: Earnings = (Endowment + Reward) – Cost of your bid – 0
= 180 + 180 – your bid – 0

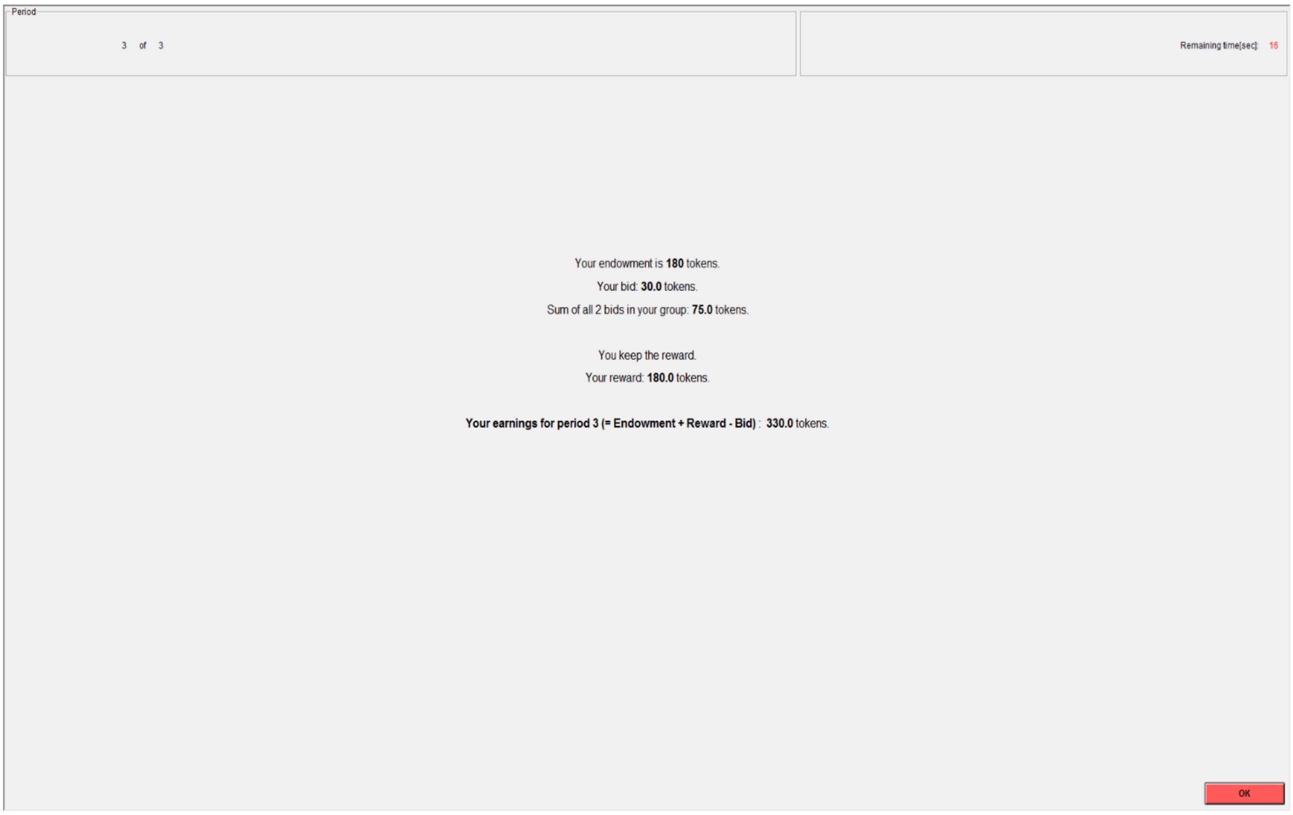
If you do not keep the reward: Earnings = (Endowment + Reward) – Cost of your bid – Reward
= 180 + 180 – your bid – 180 = 180 – your bid

<u>An Example (for illustrative purposes only)</u>

Let's say participant 1 bids 30 tokens and participant 2 bids 45 tokens. Therefore, the computer assigns 30 lottery tickets to participant 1 and 45 lottery tickets to participant 2. Then the computer randomly draws **one lottery ticket out of 75** (30 + 45). As you can see, participant 2 has the **highest chance** of keeping the reward: **0.60 = 45/75** and participant 1 has **0.40 = 30/75** chance of keeping the reward.

Assume that the computer decides that participant 1 will keep the reward, then the earnings of participant 1 for the period are 330 = (180 + 180) – 30 – 0, since the reward is 180 tokens and the cost of the bid is 30. Similarly, the earnings of participant 2 are 135 = (180 + 180) – 45 – 180.

At the end of each period, your bid, the sum of all 2 bids in your group, if you could keep your reward, and your earnings for the period are reported on the outcome screen as shown below. Once the outcome screen is displayed you should record your results for the period on your **Personal Record Sheet** (page 4) under the appropriate heading.



IMPORTANT NOTES

At the beginning of this part of the experiment you will be randomly grouped with another participant to form a 2-person group. You will not be told which of the participants in this room are assigned to which group.

At the end of the experiment the computer will randomly choose **5 of the 25** periods for actual payment for this part of experiment. You will be paid the average of your earnings in these 5 periods. These earnings in tokens will be converted to cash at the exchange rate of **_1_** token to **_3_** Pence (£0.03) and will be paid at the end of the experiment.

Are there any questions?

Personal Record Sheet

(5 periods from here will be randomly chosen for final payments)

Period	Your bid	Sum of all 2 bids in your group	Your reward	Your earnings for this period
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
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20				
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22				
23				
24				
25				

Total Earnings

Period Chosen	Earnings for this period
Total	

Total earnings from table above: ____________ **(1)**

Average of above earnings: (1) ÷ 5 ____________ **(2)**

Earnings from Part 1: ____________ (3)

Total earnings (2) + (3) ____________ (4)

Multiply by exchange rate: **(4) × 0.03**

Total payment for the experiment: **£ ____________**

QUIZ

1. Does group composition change across periods in the experiment?

Ans. Yes No

2. What is the value of 1 token in Pence?

Ans. 3 Pence 6 Pence 9 Pence

Questions 3 to 6 apply to the following information.

In a given period, suppose the bids by participants in your group are as follows.

Bid of participant 1: 55 tokens

Bid of participant 2: 70 tokens

3. What is the chance that participant 1 will keep the reward?

Ans. _______ out of ________

4. What is the chance that participant 2 will keep the reward?

Ans. _______ out of ________

5. If you are Participant 1 and you **did not keep** the reward what are your earnings this period?

Ans. ___________ tokens

6. If you are Participant 2 and you **kept** the reward what are your earnings this period?

Ans. ___________ tokens

EXPLANATIONS FOR QUIZ ANSWERS

1. Does group composition change across periods in the experiment?

Ans. No

2. What is the value of 1 token in Pence?

Ans. 3 Pence

3. What is the chance that participant 1 will keep the reward?

Ans. 55 out of 125.

4. What is the chance that participant 2 will keep the reward?

Ans. 70 out of 125.

5. If you are Participant 1 and you **did not keep** the reward what are your earnings this period?

Ans. 125 tokens (= Endowment – bid = 180 – 55)

6. If you are Participant 2 and you **kept** the reward what are your earnings this period?

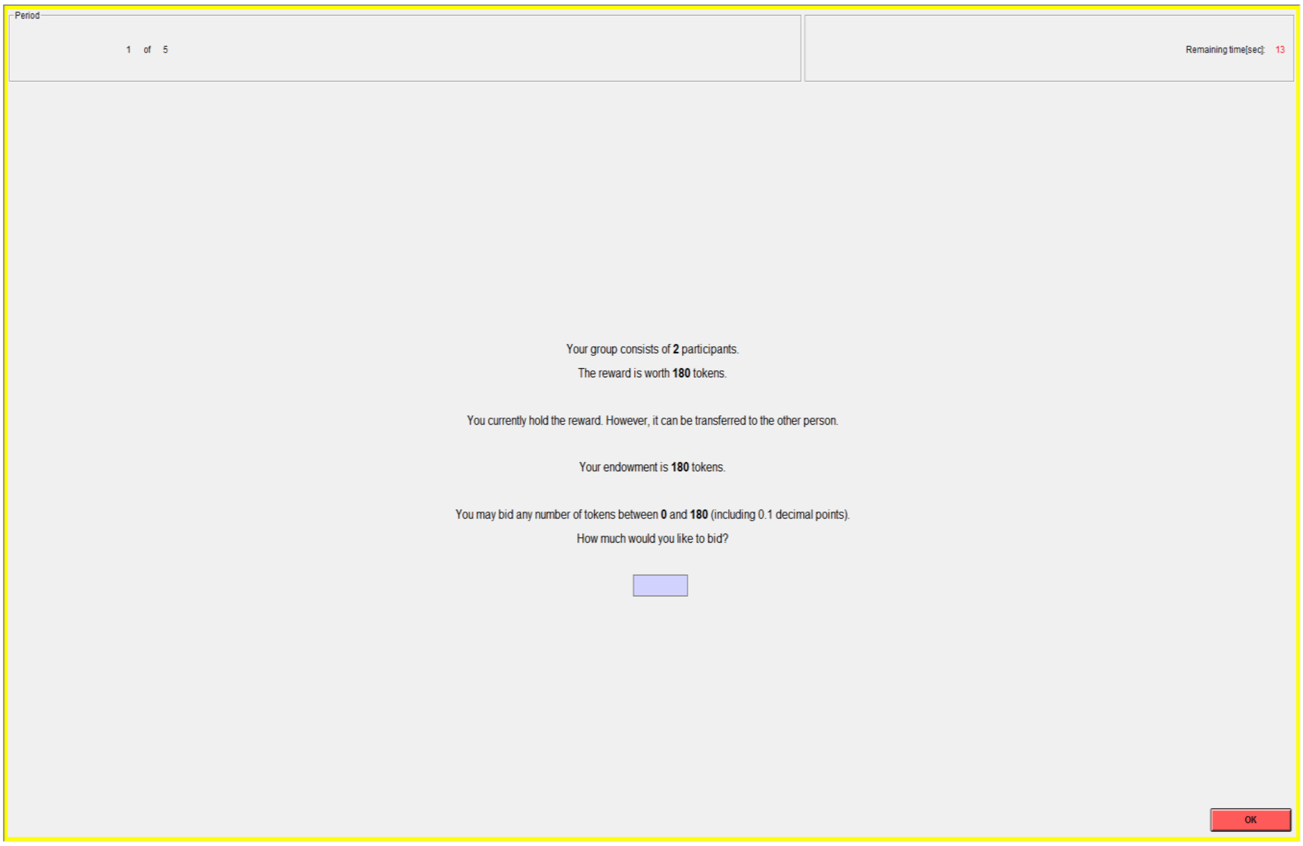
Ans. 290 tokens (= Endowment + Reward – Bid = 180 + 180 – 70)

INSTRUCTIONS – MIXED

YOUR DECISION

This part of the experiment consists of **25** decision-making periods. At the beginning, you will be randomly and anonymously placed into a group of **2 participants**. The composition of your group will remain the <u>same</u> for all 25 periods. You will **not** know who your group member is at any time.

Each period you will receive an initial endowment of **180** tokens. One of you will also start each period with **a reward of 180 tokens** and the other will start with **no reward**. These roles will be the <u>same</u> throughout the experiment. Both of you may bid to either keep the reward (if you already have it), or to transfer the reward to you from the other participant (if you do not already have it). You may bid any number between **0** and **180** (including 0.1 decimal points). An example of your decision screen is shown below.



YOUR EARNINGS

For each **bid** there is an associated **cost** equal to the bid itself. The cost of your bid is:

Cost of your bid = Your bid

If you start with the reward, then the more you bid, the more likely you are to keep the reward. The more the other participant in your group bids, the less likely you are to keep the reward. Specifically, your chance of keeping the reward is given by your bid divided by the sum of all 2 bids in your group:

$$\text{Chance of keeping the reward (if you start with the reward)} = \frac{\text{Your bid}}{\text{Sum of all 2 bids in your group}}$$

If you start with no reward, then the more you bid, the more likely you are to transfer the reward to yourself. The more the other participant in your group bids, the less likely you are to transfer the reward to yourself. Specifically, your chance of transferring the reward to yourself is given by your bid divided by the sum of all 2 bids in your group:

$$\text{Chance of transferring the reward to yourself (if you do not start with the reward)} = \frac{\text{Your bid}}{\text{Sum of all 2 bids in your group}}$$

You can consider the amounts of the bids to be equivalent to numbers of lottery tickets. The computer will draw one ticket from those entered by you and the other participant and either let the reward to stay with the participant who starts with it, or transfer it to the other participant through a random draw.

If you started with the reward and get to keep your reward, your earnings for the period are equal to your endowment of 180 tokens *plus* the reward of 180 tokens *minus* the cost of your bid. If you do not get to keep your reward, your earnings for the period are equal to your endowment of 180 tokens *minus* the cost of your bid. In other words, your earnings are:

If you keep the reward: Earnings = (Endowment + Reward) – Cost of your bid – 0

= (180 + 180) – your bid – 0

If you do not keep the reward: Earnings = (Endowment + Reward) – Cost of your bid – Reward

= (180 + 180) – your bid – 180 = 180 – your bid

If you started with no reward but the reward is transferred to you, your earnings for the period are equal to your endowment of 180 tokens *plus* the reward of 180 tokens *minus* the cost of your bid. If the reward is not transferred to you, your earnings for the period are equal to your endowment of 180 tokens *minus* the cost of your bid. In other words, your earnings are:

If the reward is transferred to you: Earnings = Endowment + Reward – Cost of your bid
= 180 + 180 – your bid

If the reward is not transferred to you: Earnings = Endowment – Cost of your bid
= 180 – your bid

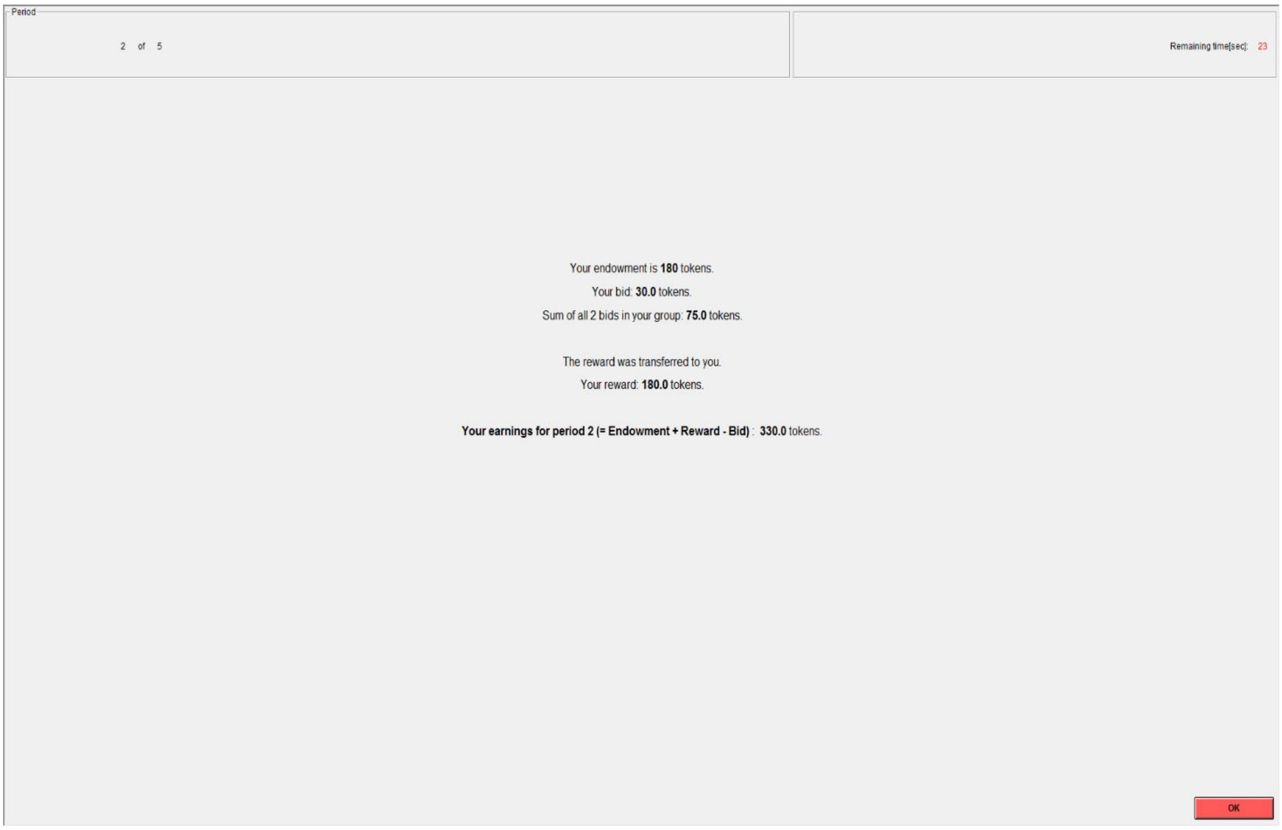
<u>An Example (for illustrative purposes only)</u>

Let's say participant 1 starts with the reward of 180 tokens and participant 2 starts with no reward. Then participant 1 bids 30 tokens and participant 2 bids 45 tokens. Therefore, the computer assigns 30 lottery tickets to participant 1 and 45 lottery tickets to participant 2. Then the computer randomly draws **one lottery ticket out of 75** (30 + 45). As you can see, participant 2 has the **highest chance** that their ticket is drawn: **0.60 = 45/75** and participant 1 has **0.40 = 30/75** chance that their ticket is drawn.

Assume that the computer draws a ticket of participant 1, then the reward stays with participant 1 and the earnings of participant 1 for the period are 330 = (180 + 180) – 30 - 0, since the reward is 180 tokens and the cost of the bid is 30. Since the reward is not transferred to participant 2, the earnings of participant 2 are 135 = 180 – 45.

If the computer draws a ticket of participant 2, then the reward is transferred to participant 2 and the earnings of participant 1 for the period are 150 = (180 + 180) – 30 – 180, since the reward is now transferred to participant 2 and the cost of the bid is 30. Similarly, due to the transfer, the earnings of participant 2 are 315 = 180 – 45 + 180.

At the end of each period, your bid, the sum of all 2 bids in your group, your reward, and your earnings for the period are reported on the outcome screen as shown below. Once the outcome screen is displayed you should record your results for the period on your **Personal Record Sheet** (page 5) under the appropriate heading.



IMPORTANT NOTES

At the beginning of this part of the experiment you will be randomly grouped with another participant to form a 2-person group. You will not be told which of the participants in this room are assigned to which group.

At the end of the experiment the computer will randomly choose **5 of the 25** periods for actual payment for this part of experiment. You will be paid the average of your earnings in these 5 periods. These earnings in tokens will be converted to cash at the exchange rate of **_1_** token to **_3_** Pence (£0.03) and will be paid at the end of the experiment.

Are there any questions?

Personal Record Sheet

(5 periods from here will be randomly chosen for final payments)

Period	Your bid	Sum of all 2 bids in your group	Your reward	Your earnings for this period
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25				

Total Earnings

Period Chosen	Earnings for this period
Total	

Total earnings from table above: _____________ **(1)**

Average of above earnings: (1) ÷ 5 _____________ **(2)**

Earnings from Part 1: _____________ (3)

Total earnings (2) + (3) _____________ (4)

Multiply by exchange rate: **(4) × 0.03**

Total payment for the experiment: **£** _____________

QUIZ

1. Does group composition change across periods in the experiment?

Ans. Yes No

2. Does role of the player, who starts with a reward of 180 tokens or who starts with no rewards, change across periods in the experiment?

Ans. Yes No

3. What is the value of 1 token in Pence?

Ans. 3 Pence 6 Pence 9 Pence

Questions 4 to 7 apply to the following information.

In a given period, suppose the roes and the bids by participants in your group are as follows.

Participant 1 starts with a reward of 180 tokens, and participant 2 starts with no reward.

Bid of participant 1: 55 tokens

Bid of participant 2: 70 tokens

4. What is the chance that participant 1 will get to keep the reward?

Ans. _______ out of ________

5. What is the chance that the reward will be transferred to participant 2?

Ans. _______ out of ________

6. If you are Participant 1 and you **did not get to keep** the reward what are your earnings this period?

Ans. ___________ tokens

7. If you are Participant 2 and the reward **is transferred to you**, what are your earnings this period?

Ans. ___________ tokens

EXPLANATIONS FOR QUIZ ANSWERS

1. Does group composition change across periods in the experiment?

Ans. <u>No</u>

2. Does role of the player, who starts with a reward of 180 tokens or who starts with no rewards, change across periods in the experiment?

Ans. Yes No

3. What is the value of 1 token in Pence?

Ans. <u>3 Pence</u>

4. What is the chance that participant 1 will get to keep the reward?

Ans. <u>55</u> out of <u>125</u>.

5. What is the chance that the reward will be transferred to participant 2?

Ans. <u>70</u> out of <u>125</u>.

6. If you are Participant 1 and you **did not get to keep** the reward what are your earnings this period?

Ans. <u>125</u> tokens (= Endowment + Reward – bid – Reward = 180 + 180 – 55 – 180)

7. If you are Participant 2 and the reward **is transferred to you**, what are your earnings this period?

Ans. <u>290</u> tokens (= Endowment + Reward – Bid = 180 + 180 – 70)