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Abstract

We experimentally investigate simultaneous decision-making in two contrasting environments: one that encourages competition (lottery contest) and one that encourages cooperation (public good game). We find that simultaneous participation in the public good game affects behavior in the contest, decreasing sub-optimal overbidding. Contributions to the public good are not affected by participation in the contest. The direction of behavioral spillover is explained by differences in strategic uncertainty and path-dependence across games. Our design allows us to compare preferences for cooperation and competition. We find that in early periods, there is a negative correlation between decisions in competitive and in cooperative environments.

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1. Introduction

Individuals, firms, and policy makers simultaneously interact in many different environments in practice. In the workplace, workers may engage in sub-optimal behavior such as exerting effort to undermine co-workers to get a promotion, while they may also put forth effort on cooperative team projects assigned by the manager. Farm owners may compete daily with each other in the market for their products and at the same time they may cooperate to build facilities that would be mutually beneficial to reduce waste management costs.

The contribution of the current study is that we experimentally investigate individual behavior when competitive and cooperative environments are present simultaneously. To induce a cooperative environment, we employ a voluntary contribution mechanism (a public good game) and for a competitive environment we employ a lottery contest. In the voluntary contribution mechanism (VCM), individuals make contributions in order to provide a public good. In the contest, individuals make bids in order to win a prize. The type of contest we consider here is one in which higher bids lead to more socially wasteful outcomes. The main difference between these two games is that bids in the contest exert a negative externality on others, while contributions in the VCM exert a positive externality. The findings from the literature when these games are played in isolation are clear. In contests, individuals overbid relative to Nash equilibrium (Millner and Pratt, 1989, 1991; Sheremeta, 2011; Morgan et al., 2012).[1] In VCMs, individuals contribute half-way between the equilibrium free riding and the Pareto optimal level, with contributions declining over time (Ledyard, 1995; Fischbacher et al.,

[1] Overbidding decreases when subjects gain experience (Davis and Reilly, 1998; Sheremeta, 2011), when groups make bids instead of individuals (Sheremeta and Zhang, 2010), and when individual bidding space is constrained (Sheremeta, 2011).

2001).[2] The contest is similar to a wide variety of situations in practice, such as patent races, political contests, competitions for promotions in the workplace, or advertising campaigns. The VCM is similar to another broad class of situations, including the decision to volunteer for various groups or associations and monetary contributions to public goods or charities. The design of the experiment permits us to analyze the correlation between each individual's bid in the contest and contribution in the VCM.

The standard assumption in game theory is game independence, suggesting that the institutional context in which a decision is made does not matter. However, a number of experiments find that context may matter greatly. Learning and knowledge transfer is found to occur in games played in sequence (Kagel, 1995; Van Huyck et al., 1991; Schotter, 1998; Knez and Camerer, 2000; Ahn et al., 2001; Devetag, 2005; Brandts and Cooper, 2006). A "behavioral spillover" is said to have occurred whenever observed behavior differs when a game is played together with other games, compared to behavior observed when the game is played in isolation (Cason et al., 2012). Recent experiments directly measure behavioral spillovers, and find that spillovers occur when games are played simultaneously, causing behaviors exhibited in one game to be carried over to the other game in a predictable way (Huck et al., 2011; Bednar et al., 2012; Cason et al., 2012; Falk et al., 2012). Bednar et al. (2012) report a laboratory experiment with different two-player games and find that simultaneous game-play differs from isolated controls. Huck et al. (2011) study two dissimilar two-player games played simultaneously and find that learning spillovers occur when feedback is not readily available for each game. Cason et al. (2012) report a laboratory experiment where the same group of five players participate in two different coordination games and find that cooperative behavior spills over from one game to the

[2] Contributions increase when subjects are allowed to punish, assign disapproval points, send signals, or communicate with other subjects prior to contributions in the VCM (Ledyard, 1995; Fehr and Gachter, 2000).

other when games are played sequentially. Finally, Falk et al. (2012) investigate groups of different individuals playing two identical coordination games or two identical public goods games, and find that behavior does not differ from a baseline where only one game is played at a time.[3] The main difference of our study is that we investigate behavior in both competitive and cooperative environments, while previous studies consider coordination and public good games (Cason et al., 2012; Falk et al., 2012) or bi-matrix games such as the prisoner's dilemma (Bednar et al., 2012).

We find that overbidding in the contest is significantly reduced when individuals simultaneously participate in the VCM. This is a favorable outcome because higher bids in this type of contest lead to sub-optimal results (i.e., lower payoffs). However, we do not find significant differences in VCM contributions between the simultaneous-play and baseline treatments. The direction of behavioral spillover can be explained by differences in strategic uncertainty and path-dependence across the two games. The design of our experiment also allows us to comment on the correlation in competitiveness and cooperativeness of individuals. In early periods of the experiment, we find a negative correlation between decisions made in the lottery contest and in the VCM, suggesting that individuals who are more competitive tend to be less cooperative and vice versa. As discussed in the conclusion, this research has implications for political and management institutional design, and for related research that attempts to solve problems of overbidding in contests and under-contribution in public goods.

[3] Other existing studies consider simultaneous interaction in several public goods environments, either breaking a single public good into multiple parts or presenting multiple public goods (Biele et al., 2008; Cherry and Dickinson, 2008; Fellner and Lunser, 2008; Bernasconi et al., 2009).

2. Experimental Environment, Design and Procedures

2.1. The Contest and the VCM

The experimental design employs two laboratory games, a lottery contest and a VCM. The lottery contest is based on the theoretical model of Tullock (1980). In this contest, n identical risk-neutral players with initial endowment levels e compete for a prize v by submitting bids. The probability that a player i wins the prize is equal to player i's own bid b_i divided by the sum of all players' bids. Given this, the expected payoff from the contest for player i can be written as:

$$\pi_i^C = e - b_i + vb_i/\textstyle\sum_j b_j. \qquad (1)$$

Differentiating (1) with respect to b_i and accounting for the symmetric Nash equilibrium leads to the classic solution of $b^* = v(n-1)/n^2$, while the Pareto optimal level of bids is $b^{PO} = 0$.

The VCM is based on a linear public goods game where n identical risk-neutral players choose a portion of their endowments e to contribute to a public good (Groves and Ledyard, 1977). Player i's contribution c_i to the public good is multiplied by m and given to each of n players in the group, where $0 < m < 1$ and $m \times n > 1$. Thus, the payoff from the VCM for player i can be written as:

$$\pi_i^{VCM} = e - c_i + m\textstyle\sum_j c_j. \qquad (2)$$

The Nash equilibrium in the VCM is to free ride by contributing nothing, i.e. $c^* = 0$, while the Pareto optimal solution is to contribute one's full endowment to the public good, i.e. $c^{PO} = e$.

In the VCM (2), over-contribution relative to the Nash equilibrium leads to outcomes that are closer to the Pareto optimal result. On the other hand, in the contest (1), bidding is socially wasteful and the most socially desirable outcome is for all participants to bid 0. While playing the games in ensemble does not change the standard Nash equilibrium prediction in either game, Section 3 provides conjectures about the direction of probable spillover when games are played in ensemble.

2.2. Experimental Procedures

The experiment was conducted at the Vernon Smith Experimental Economics Laboratory. Subjects were recruited from a pool of undergraduate students at Purdue University. A total of 120 subjects participated in 6 sessions, with 20 subjects participating in each session. All subjects participated in only one session of this study. Some students had participated in other economics experiments that were unrelated to this research.

The computerized experimental sessions used z-Tree (Fischbacher, 2007) to record subject decisions and also (in the Simultaneous treatment) to record the order of decisions. We conducted three treatments as summarized in Table 1: a Baseline Contest treatment, a Baseline VCM treatment, and a Simultaneous treatment in which these two games were played simultaneously.[4] Subjects were given the instructions (available in the on-line appendix) at the beginning of the session and the experimenter read the instructions aloud. In each session, 20 subjects were randomly assigned to groups of n = 4 players and stayed in the same group throughout the entire experiment, playing each game for a total of 20 periods.

At the beginning of each period, each subject received an endowment of 80 francs in the contest (or VCM) and was asked to enter his or her bid (or contribution in the VCM). In the

[4] Note that treatments with two simultaneous contests or two simultaneous public goods are also possible as baselines. We believe that our Baseline Contest and Baseline VCM treatments are more appropriate for several reasons. First, this design allows us to see if behavior in ensemble games is different from behavior in isolated games. Second, if two simultaneous contests or two simultaneous public goods were played as the baseline, subjects would learn the game more quickly in the baselines than in the Simultaneous treatment, and we would not be able to make a direct comparison between treatments. Finally, although subjects did earn double the amount in Simultaneous as in VCM and Contest baselines, we do not expect to see an endowment effect since only two periods were randomly selected at the end for payment.

lottery contest, subjects competed with each other for the prize value of v = 80 francs. In the VCM, each subject chose a portion of the 80-franc endowment to contribute to the public good, and kept the other portion for him/herself. Each player's contribution to the public good was multiplied by m = 0.4 and the total of all contributions given to each of the 4 players in the group. We selected parameters that result in theoretically expected payoffs that are close in both games (85 and 80). Subjects did not know others' decisions before making their own decisions. After all subjects made their decisions, the sum of all bids (or contributions in the VCM) in each group was displayed on the output screen together with the outcome, and earnings were determined.

During the Simultaneous treatment, the contest and VCM games were displayed side by side on the same screen.[5] Each subject received a separate endowment of 80 francs in the contest and a separate endowment of 80 francs in the VCM at the beginning of each period. These endowments could not be transferred between games. Subjects were required to input their choices for each of the two games before moving on to the next period. To account for any order effect within each period, in one of the two Simultaneous sessions, the contest game was displayed on the left (the VCM game was on the right), and in the other Simultaneous session, the contest game was displayed on the right (the VCM game was on the left).[6]

At the end of the experiment, two periods from the game were selected for payment using a random draw from a bingo cage. In the Simultaneous treatment, two periods from each game (contest and VCM) were selected using the same method. Experimental francs were used

[5] We used categorical (and not ordinal) nomenclature to label each game, the colors blue and green (instead of, for example, 1 and 2 or A and B).

[6] When the contest game was displayed on the left, subjects made a decision in the contest game first 92% of the time. When the VCM was displayed on the left, subjects made a decision in the VCM game first 93% of the time. This is unsurprising, given that over 95% of subjects in the experiment self-reported that they read and write from left to right horizontally in their native language, and that all instructions were in English, which reads from left to right. Despite differences in order of decision-making within each period, we do not find any difference between individual behavior in the two Simultaneous sessions; therefore, we pool the sessions.

throughout the experiment, with a conversion rate of 25 francs = $1. Subjects earned $18 on average, and sessions (including instruction time) lasted on average 75 minutes.

3. Hypothesis Development

3.1. Behavioral Spillover

Although standard theoretical models do not predict that behavior during simultaneous interaction in two games should differ from behavior when each game is played in isolation, related work has found that behavioral spillovers do occur (Huck et al, 2011; Bednar et al., 2012; Cason et al., 2012).[7] Our study is intended to contribute additional evidence to inform the discussion of what behavioral effects may impact individual decisions when two disparate environments are experienced simultaneously. We provide two conjectures that predict the direction of behavioral spillovers in this context based on strategic uncertainty and path-dependence.

3.2. Strategic Uncertainty

Related work suggests that we can predict which game will, and which game will not, be affected by simultaneous play in another game by observing the characteristics of the games and behavior when each game is played in isolation (Bednar et al., 2012; Cason et al., 2012). One dimension on which two games may be compared is strategic uncertainty. Games with higher strategic uncertainty are more demanding on subjects' belief formation and therefore may produce greater cognitive load relative to games with lower strategic uncertainty. When playing

[7] Although we consider the impact of simultaneous game-play, spillovers of behavior or expectations are also present in settings with sequential game-play, as in as in Knez and Camerer (2000), Ahn et al. (2001), Cherry et al. (2003), Devetag (2005), Cherry and Shogren (2007), Herrmann and Orzen (2008), Dickinson and Oxoby (2011) and Cason et al. (2012).

ensembles of games, subjects may apply common analogies to disparate situations if the cognitive cost of developing a separate strategy for each game is too high (Samuelson, 2001). Related work has conjectured that games with lower strategic uncertainty have a stronger behavioral spillover effect onto games with higher strategic uncertainty (Bednar et al., 2012; Cason et al., 2012). One reason cited for this effect is that learning a strategy requires less effort or cognitive load in a game with lower strategic uncertainty relative to a game with higher strategic uncertainty (Cason et al., 2012).

Relevant measures for assessment of strategic uncertainty are the *ex ante* measure of complexity of the game and the *ex post* measure of volatility of behavior in the game. Using the measure of complexity, we posit that strategic uncertainty is greater in the contest than in the VCM. In the VCM, each subject forms beliefs about other's contributions and determines her probable outcome. In the contest, on the other hand, each subject must first form beliefs about other's bids and then form a belief about the probability that she will win, where this probability depends on her bid but also depends on other group members' bids.[8] While the equilibrium of the VCM is in dominant strategies, the equilibrium of the contest is not. Moreover, the payoff function is flatter (and concave) in the contest as compared to the VCM.

Bednar et al. (2012) and Cason et al. (2012) also use a measurement of volatility of choices called 'entropy' to describe the degree of strategic uncertainty. Similarly, we will be able to confirm the difference in strategic uncertainty between games *ex post,* measuring the degree of volatility in individual decision-making. Based on previous research, and the fact that the contest is a more complex game than the VCM, we expect subjects to apply strategies from the VCM to choices in the contest, causing behavioral spillover onto the contest.

[8] Understanding probability can be difficult for subjects due to bounded rationality (Camerer, 2003).

Conjecture 1: Behavioral spillover caused by differences in strategic uncertainty will prompt subjects to apply strategies from the VCM to choices in the contest.

3.3. Path-Dependence

Path-dependence is the extent to which the outcomes of previous periods matter for the current period (Page, 2006). For the purpose of this analysis, we define path dependence as a within-game phenomenon where only past behavior and experience in the same game affect future behavior. Van Huyck et al. (1990) use path-dependence to explain how decisions in future periods are influenced by subjects' shared experience within the same coordination game. Many games are path-dependent in the sense that current choices depend to some extent on previous choices of group members, but some games may be more path-dependent than others. Path dependence is generally determined after data on behavior is obtained, yet the structure of the game can also inform the level of path dependence *ex ante.*

We argue that the VCM is more path-dependent than the contest for several reasons. First, feedback in the VCM is less noisy (there is no probability involved), and individuals can react optimally to previous group members' choices without repeated exogenous shocks (e.g., winning the prize or not, as in the contest). Second, because the VCM does not involve a risk component (except strategic risk), individuals can more easily calculate their subjective best responses. While the VCM has a dominant strategy and conditioning one's behavior on the behavior of others is not required, the literature does document the existence of *conditional cooperators,* whose behavior depends heavily on behavior of group members (Fischbacher et al., 2001).

In addition to evaluating the structure of the game, evidence of path-dependent behavior can be obtained *ex post* through comparing individual behavior in period t with group behavior in period t-1 (Falk et al., 2012). More path-dependent games should be less susceptible to influence from other games, because individuals rely heavily on actions of others in previous rounds of the same game while making decisions. On the other hand, less path-dependent games should be more susceptible to influence from other games, because individuals are less influenced by actions of others in the same game.

Conjecture 2: The contest, which is less path-dependent, is more likely to be susceptible to behavioral spillover as compared to the VCM, which is more path-dependent.

4. Results and Discussion

4.1. Overview

Table 2 reports the average contribution in the VCM and the average bid in the contest across all treatments. In contrast to the theoretical prediction of $b^* = 15$, we find significant overbidding of about 120% in the Baseline Contest treatment (Wilcoxon signed-rank test, p-value < 0.05, n=10).[9] This finding is consistent with previous experimental literature on contests, which document that on average subjects overbid relative to the theoretical predictions in the range from 20% to 200% (Sheremeta, 2011; Morgan et al., 2012).[10] As a result of overbidding, subjects' payoffs are significantly lower than predicted.

The unique equilibrium prediction for contributions in the VCM is $c^* = 0$. Relative to theoretical predictions, we find significant over-contribution in the VCM in the Baseline VCM

[9] Unless otherwise stated, all non-parametric tests employ four subjects in a group across all periods as one independent observation.
[10] Sheremeta (2010a; 2010b; 2011) and Sheremeta and Zheng (2010) cite noise and errors, probability judgment biases, and a non-monetary utility of winning as explanations for overbidding.

treatment, which leads to more socially favorable outcomes (Wilcoxon signed-rank test, p-value < 0.05, n=10). This finding is also consistent with previous experimental studies, which report that over-contribution is common in public goods environments due to altruism or social norms (Ledyard, 1995). For example, Fehr and Gachter (2000) report contribution levels at 40-60% of the endowment during the experiment, with contributions falling to 27% in the final period.

Result 1. There is significant overbidding in the contest and significant over-contribution in the VCM relative to theoretical predictions.

Due to learning and interaction between group members, behavior may change during the course of the 20 periods. Throughout this section, we examine decisions in all periods of the experiment as well as average bids and contributions in "early" and "later" periods. We use the average bid (contribution) in the first 5 and last 5 periods of the contest (VCM) when making comparisons between early and later periods; nevertheless choosing different subsets of early and later periods gives us very similar results.

Figure 1 displays the distribution of bids in the contest over the first and the last 5 periods of the experiment. Contrary to the unique pure strategy Nash equilibrium of 15, individual bids are distributed on the entire strategy space in all treatments. This variance in bids persists throughout all periods of the experiment. The high variance in individual bids is consistent with previous experimental findings on contests (e.g., Davis and Reilly, 1998; Potters et al., 1998; Sheremeta, 2011).

Figure 2 displays the distribution of contributions in the VCM over the first and the last 5 periods of the experiment. In the first 5 periods of the experiment, individual contributions in the VCM are also distributed on the entire strategy space. However, in the last 5 periods of the experiment, individual contributions in the VCM are concentrated around the Nash equilibrium of 0. These observations are also consistent with previous experimental findings on VCMs (e.g., Fehr and Gachter, 2000; Fischbacher et al., 2001).

4.2. Comparison between Simultaneous and Baseline Treatments

Figure 3 displays the time series of the average contribution and the average bid for the Baseline and Simultaneous treatments. In the Baseline VCM treatment, the average contribution in the VCM starts at 36.7 in the first 5 periods and decreases significantly to 12.6 in the last 5 periods (Wilcoxon signed-rank test, p-value < 0.05, n=10).[11] Similarly, in the Simultaneous treatment, the average contribution starts at 35.6 in the first 5 periods and decreases significantly to 11.5 in the last 5 periods (Wilcoxon signed-rank test, p-value < 0.05, n=10). The difference between the average contribution to the VCM in the Baseline and the Simultaneous treatment is not significant (Wilcoxon rank-sum test, p-value = 0.54, n=m=10). This difference is also not significant for either the first 5 (Wilcoxon rank-sum test, p-value = 0.65, n=m=10) or last 5 periods of the experiment (Wilcoxon rank-sum test, p-value = 0.76, n=m=10).

Result 2: Simultaneous participation in both the VCM and the contest does not have a significant effect on contributions in the VCM.

Falk et al. (2012) use a design in which subjects play two public goods games simultaneously. They find that individuals are influenced in each game by the contributions of their own group members, but not by the contributions of the other group members. We find that even when playing two different games and with the same subjects, bids in the contest do not

[11] The rank-sum test uses as one independent observation the difference between the average contribution by four subjects in a group in the first 5 periods and the last 5 periods.

influence contributions to the public good.[12] Note that due in part to power limitations, we cannot say with certainty that the behavioral spillover from the contest to the VCM does not exist.[13] However, as we show next, even with the same power, we do find a significant spillover from the VCM to the contest, indicating that spillover effects exist.

In the Baseline Contest treatment, the average bid starts at 36.5 in the first 5 periods and decreases significantly to 33.7 in the last 5 periods (Wilcoxon signed-rank test, p-value = 0.06, n=10). In the Simultaneous treatment, the average bid in the contest starts at 31.5 in the first 5 periods and decreases significantly to 24.4 in the last 5 periods (Wilcoxon signed-rank test, p-value < 0.05, n=10). Overall, the declining bid trend in both treatments is consistent with previous research, documenting that overbidding decreases over time (Davis and Reilly, 1998; Sheremeta, 2011).

Figure 4 displays, by group, the average dissipation rate in the contest, defined as the sum of all bids divided by the value of the prize. Groups in the Baseline Contest treatment have greater dissipation rates than groups in the Simultaneous treatment. The difference between treatments appears mainly after subjects obtain some experience in playing the game(s). In the first 5 periods, the average bid in the Baseline treatment is higher, but it is not significantly different from the average bid in the Simultaneous treatment (Wilcoxon rank-sum test, p-value = 0.20, n=m=10). However, the average bid in Baseline is significantly higher than the average bid in the Simultaneous treatment in the last 5 periods (Wilcoxon rank-sum test, p-value < 0.05, n=m=10). This finding suggests that simultaneous participation in both the VCM and the contest

[12] Note that in the Falk et al. (2012) and in our study, endowments are not shared between the two games; rather, subjects receive a set endowment for each game. This result may be most applicable in this setting, but whether this result holds when endowments are shared across simultaneous games could be considered in future work.

[13] Using an average of contributions across 20 rounds, we must assume that each group is one independent observation and therefore there are only 10 independent observations per treatment. With only 10 independent observations, we have power of 80% to detect an effect size of 1.19 standard deviations using the Wilcoxon Mann-Whitney test.

reduces overbidding in the contest, although this behavioral spillover becomes more pronounced in later periods of the experiment. When averaging bids across all periods, we still find that bids are significantly higher in the Baseline treatment as compared to the Simultaneous treatment (Wilcoxon rank-sum test, p-value = 0.06, n=m=10).

Result 3: Simultaneous participation in both the VCM and the contest reduces overbidding in the contest.

We can conclude from Results 2 and 3 that bid choices in the contest are influenced by contribution choices in the VCM, but that contribution choices in the VCM are not as affected by bid choices in the contest. These findings provide initial support for *ex ante* Conjectures 1 and 2, suggesting that strategic uncertainty and path-dependence are two of the driving forces of behavioral spillovers.

4.3. Behavioral Effects

As discussed in Section 3, strategic uncertainty and path-dependence are two aspects of games that predict direction of behavioral spillover *ex ante*. The design of our experiment also allows us to provide an *ex post* analysis of strategic uncertainty and path-dependence in both the VCM and contest. Conjecture 1 predicts that behavioral spillover caused by differences in strategic uncertainty will prompt subjects to apply strategies from the VCM onto choices in the contest. Previous studies use a measure of entropy to evaluate the degree of volatility in individual decision-making and to determine the *ex post* amount of strategic uncertainty present in the game (Bednar et al., 2012; Cason et al., 2012). However, in both studies of Bednar et al. (2012) and Cason et al. (2012), the strategy space is very restricted (from 2 to 7 choices), and thus it is straightforward to measure the degree to which subjects arrive at a stable state (i.e., entropy state). In contrast, in our experiment, each of the four subjects in a group can choose any integer number between 0 and 80. Therefore, we use two alternative measures of the degree of volatility in individual decision-making. First, we compute the absolute difference between the decisions made in period *t* and period *t*-1. Second, we calculate the number of stable states for each subject. We define a *stable state* as whenever a subject makes the same bid or contribution choice in period *t* as in period *t*-1. We calculate both measures of volatility using the first 5 periods of game-play, since we want to observe the level of volatility before subjects become experienced. Based on both measures, we find that in the first 5 periods of the Simultaneous treatment, the average volatility of bids in the contest is significantly higher than the average volatility of contributions in the VCM.[14] These results suggest that in the Simultaneous treatment, the VCM game should have a stronger behavioral spillover effect onto the contest, which is predicted by Conjecture 1 and is in line with Results 2 and 3.

The prediction of Conjecture 2 is that the contest is less path-dependent than the VCM, and thus it is more likely to be susceptible to behavioral spillover from the VCM. To examine path-dependence, in Table 3 we report estimates of panel regressions conducted separately for each treatment. In these regressions, the dependent variable is either subject's *bid* in the contest (regressions 1 and 3) or *contribution* in the VCM (regressions 2 and 4). The independent variables are *bid-lag*, *group-bid-lag* (lagged average bid of other group members), *contribution-lag*, and *group-contribution-lag* (lagged average contribution of other group members). All regressions use a random effects error structure for the individual subjects to account for

[14] The average absolute difference of bids is 17.4 and the absolute difference of contributions is 13.6. The estimated number of stable states for each subjects indicate that 29.4% of contributions to the VCM and only 18.1% of bids in the contest are qualified as stable (i.e., state of entropy). This difference is significant (Wilcoxon rank-sum test, p-value < 0.05, n=m=10). Note also that the volatility of bids is also higher than the volatility of contributions in the last 5 periods of the experiment, although the difference is not significant. The average absolute difference of bids is 14.5 and the absolute difference of contributions is 9.1. Furthermore, 42.0% of contributions to the VCM and only 36.5% of bids in the contest are qualified as stable, although again this difference is not significant.

repeated measures, and a period trend to account for learning. Standard errors are clustered at the group level.

According to the estimation results in regression (1), the main determinant of *bid* in the Baseline Contest treatment is *bid-lag*, indicating that the individual subject's own previous bid influences her behavior in the contest. On the other hand, regression (2) shows that *contribution* in the Baseline VCM treatment is influenced by *contribution-lag* and *group-contribution-lag*, indicating that both individual subject's own previous bid, as well as group members' decisions, influence behavior in the VCM. These results provide additional support for our prediction that the VCM is more path-dependent (i.e., dependent on own and group previous behavior) than the contest.

Most importantly, by estimating regressions (3) and (4), we find that in the Simultaneous treatment, *bid* is not correlated with *group-bid-lag*, while *contribution* is significantly correlated with *group-contribution-lag*. Therefore, our *ex post* estimation results indicate that the VCM is more path-dependent than the contest. In line with Conjecture 2, the stronger path-dependence in the VCM causes the behavioral spillover from the VCM onto the contest.

Estimation results in Table 3 also indicate that *contribution-lag* negatively affects *bid* in the contest (regression 3) and *bid-lag* negatively affects *contribution* in the VCM (regression 4), although the latter finding is not statistically significant.[15] These results suggest that bids and contributions are negatively correlated. We further explore this correlation in the following sub-section.

[15] Both coefficients are significant when using the data only from the first 5 periods of the experiment.

4.4 Correlation of Bids and Contributions

Because of the within-subjects design of the Simultaneous treatment, we can directly compare bids in the contest with contributions in the VCM for the same individual. Figure 5 displays individual contributions and bids for the Simultaneous treatment, averaged over periods 1-5 and periods 16-20. We use average choices in periods 1-5 of the game in this analysis for several reasons. First, we want to observe behavior while subjects are not yet heavily influenced by interaction with group members. Second, we also want to allow for some learning of the payoff structure of the game. An average of choices in periods 1-5 provides a compromise between these two considerations. We also compare our results for earlier periods 1-5 to later periods 16-20, when subjects have been maximally influenced by behavior of their group members in both games.

A Spearman's rank correlation test shows that individuals who contribute more to the VCM also bid less in the contest in the first 5 periods of the game, and this correlation is significant at the 10% level when bids are aggregated at the individual level across the 5 rounds (correlation -0.27, p-value < 0.10). The negative correlation between individual contributions and bids disappears over time. When analyzing the last 5 periods of the experiment, we do not find a significant correlation (correlation 0.13, p-value = 0.43). This result is not surprising, given that by the end of the experiment, subjects' decisions have already been heavily influenced by the decisions of others and therefore social preferences play a less important role in the later periods.

Result 4. Bids in the contest are negatively correlated with contributions to the VCM in early periods, suggesting that inherently more competitive subjects are less cooperative and vice versa.

To explain the negative correlation between bids and contributions, we consider two competing theories that are often employed to explain individual behavior in the public goods and contest experiments. Two common explanations for non-zero contributions to public goods are based on bounded rationality or mistakes (Andreoni, 1995; Anderson et al., 1998) and social preferences (Fehr and Schmidt, 1999; Fischbacher et al., 2001; Falk et al., 2005). The same arguments are also often applied to explain behavior in contests (Herrmann and Orzen, 2008; Sheremeta, 2011; Mago et al., 2012). The design of our Simultaneous treatment enables us to distinguish between these two competing theories, because they generate opposing predictions for the direction of correlation between bids and contributions.

Bounded rationality and mistakes are often cited as reasons why behavior is not in line with theory in many settings. Using a quantal response equilibrium (QRE) model, which accounts for errors made by individual subjects, Anderson et al. (1998) show that depending on the magnitude of the decision error, mean contributions to the VCM lie between the Nash prediction ($c^* = 0$) and half the endowment ($c = 40$), and higher decision errors correspond to higher contributions. Sheremeta (2011) shows that according to QRE, mean bids in the contest lie between the Nash equilibrium ($b^* = 15$) and half the endowment ($b = 40$), and higher decision errors correspond to higher bids. Therefore, bounded rationality implies that subjects who make mistakes both contribute and bid more, which should result in a positive, rather than a negative, correlation between bids and contributions.

Social preferences are among other commonly cited reasons why subjects' behavior deviates from theoretical benchmarks. Intuitively, pro-social behavior implies higher contributions (Andreoni, 1995; Fischbacher et al., 2001), while spite implies lower contributions to the VCM (Falk et al., 2005). On the other hand, pro-sociality implies lower bids and spite implies higher bids in the contest (Hehenkamp et al., 2004; Mago et al., 2012). The main reason why social preferences work in the opposite direction in the VCM and the contest is that in the VCM individual contributions exert a positive externality on others, while in the contest individual bids exert a negative externality.[16]

We conclude, therefore, that the negative correlation between bids and contributions can be explained by social preferences but not by bounded rationality. This finding is also in line with related work on social preferences and sorting into competitive environments (Dohmen and Falk, 2011; Bartling et al., 2009; Teyssier, 2009). In contrast to previous studies, however, we did not explicitly elicit social preferences, but instead we measured cooperative individual behavior in the VCM and compared it to competitive individual behavior in the contest.

5. Conclusion

We study simultaneous decision-making in two contrasting environments: an environment that encourages competition (a lottery contest) and an environment that encourages cooperation (a public good game). We find that simultaneous participation in the public good game affects behavior in the contest, decreasing sub-optimal overbidding in the contest. However, contributions to the public good are not affected by simultaneous participation in the

[16] Similar to pro-sociality and spite, one can make an argument that inequity aversion can explain the negative correlation between contributions in the VCM and bids in the contest. Fehr and Schmidt (1999), for example, show that subjects who dislike disadvantageous inequity (i.e., the case when subjects dislike having the lowest relative payoff) should make lower contributions in the VCM in order to avoid the circumstance where they are the highest contributors with the lowest payoffs. Similarly, Grund and Sliwka (2005) and Herrmann and Orzen (2008) show that disadvantageous inequity aversion should cause subjects to bid more in the lottery contest in order to avoid a circumstance where they do not win a prize and thus receive the lowest payoff. Conversely to disadvantageous inequity aversion, advantageous inequality aversion (i.e., the case when subjects dislike having the highest relative payoff) should increase VCM contributions and decrease contest bids. Therefore, both disadvantageous and advantageous inequity aversion imply negative correlation between bids and contributions. It is important to emphasize that although inequality aversion is a potential explanation of our findings, in a recent study, Blanco et al. (2011) showed that there is a low correlation of subjects' inequality aversion between different games.

contest. The direction of behavioral spillover can be explained by differences in strategic uncertainty and path-dependence across the two games. Our design also allows us to simultaneously compare individual preferences for cooperation and competition. We find that in early periods of the experiment, there is a significant negative correlation between decisions made in competitive and cooperative environments, which can be justified by social preferences such as altruism or spite but not by bounded rationality theory.

Our findings provide clear evidence that the institutional context matters for some decision-making environments. Given that many activities in practice involve simultaneous decision-making in environments similar to contests and public goods, it is important to continue to study these competitive and cooperative environments in ensemble. Studies of other alternative environments in which there is competition (such as first and second price auctions, oligopolistic competition, and rank-order tournaments) and cooperation (such as trust games, weakest-link public goods, and common pool resources) are of great interest. Investigating behavioral spillover in different environments will allow for the development of a unifying theory of behavioral spillover. Finally, it is important to investigate how behavioral spillovers can be used to design more efficient economic systems. We leave these extensions for future research.

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Tables and Figures

Table 1: Summary of Treatments

Treatment	Game Played	Number of Sessions	Number of Subjects	Number of Independent Observations
Baseline Contest	Contest	2	40	10
Baseline VCM	VCM	2	40	10
Simultaneous	Contest & VCM	2	40	10

Table 2: Average Statistics

Game Played	Variable	Equilibrium Prediction	Simultaneous Treatment	Baseline Treatments
Contest	bid	15	26.8 (0.8)	33.5 (0.8)
	payoff	85	73.2 (1.2)	66.5 (1.2)
VCM	contribution	0	22.4 (0.9)	23.9 (1.0)
	payoff	80	93.4 (0.7)	94.3 (0.8)

Standard error of the mean in parentheses.

Table 3: Regression Models of Individual Subject Choices

Treatment	Baseline		Simultaneous	
Regression	(1)	(2)	(3)	(4)
	Contest	VCM	Contest	VCM
Subject's Choice	*bid*	*contribution*	*bid*	*contribution*
bid-lag	0.535***		0.406***	-0.055
	(0.105)		(0.059)	(0.034)
group-bid-lag	-0.123		-0.054	-0.059
	(0.099)		(0.065)	(0.052)
contribution-lag		0.562***	-0.068*	0.456***
		(0.063)	(0.033)	(0.042)
group-contribution-lag		0.159*	-0.063	0.348***
		(0.068)	(0.063)	(0.029)
period	-0.097	-0.518**	-0.575***	-0.432***
	(0.051)	(0.187)	(0.128)	(0.126)
constant	20.869***	11.303**	26.577***	10.967**
	(5.747)	(4.154)	(3.981)	(3.565)
Observations	760	760	760	760
Number of subjects	40	40	40	40

*** p<0.01, ** p<0.05, * p<0.10. All regressions use a random effects error structure for the individual subjects to account for repeated measures, and a period trend to account for learning. Standard errors are clustered at the group level. *group bid-lag* and *group contribution-lag* only include the bids and contributions of all *other* group members, excluding the individual under study.

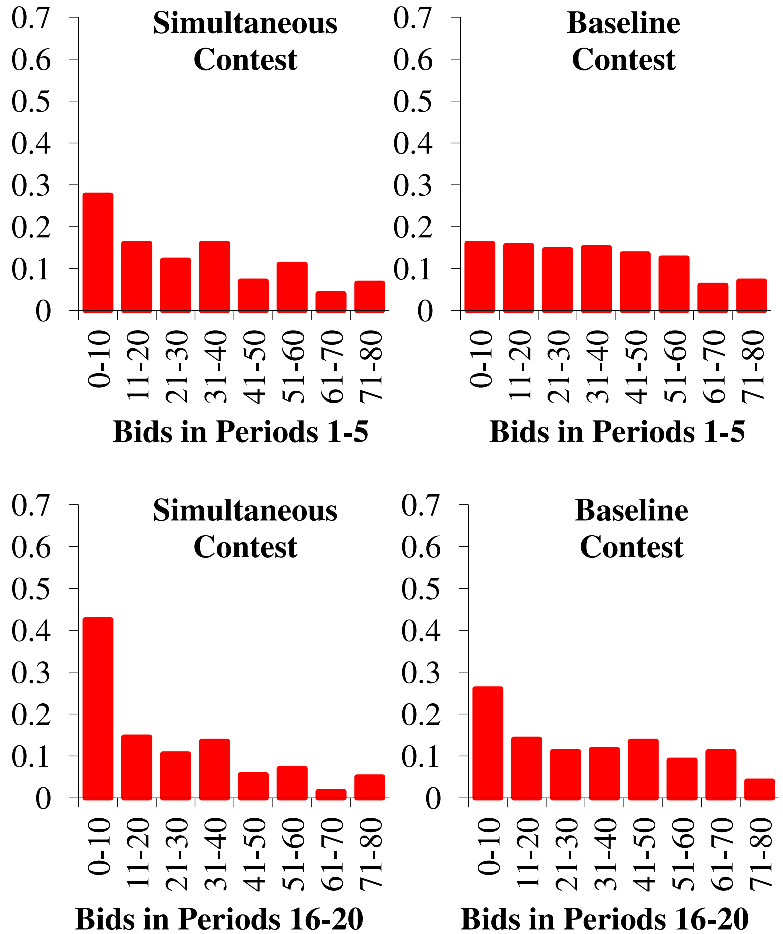

Figure 1: Distribution of Bids

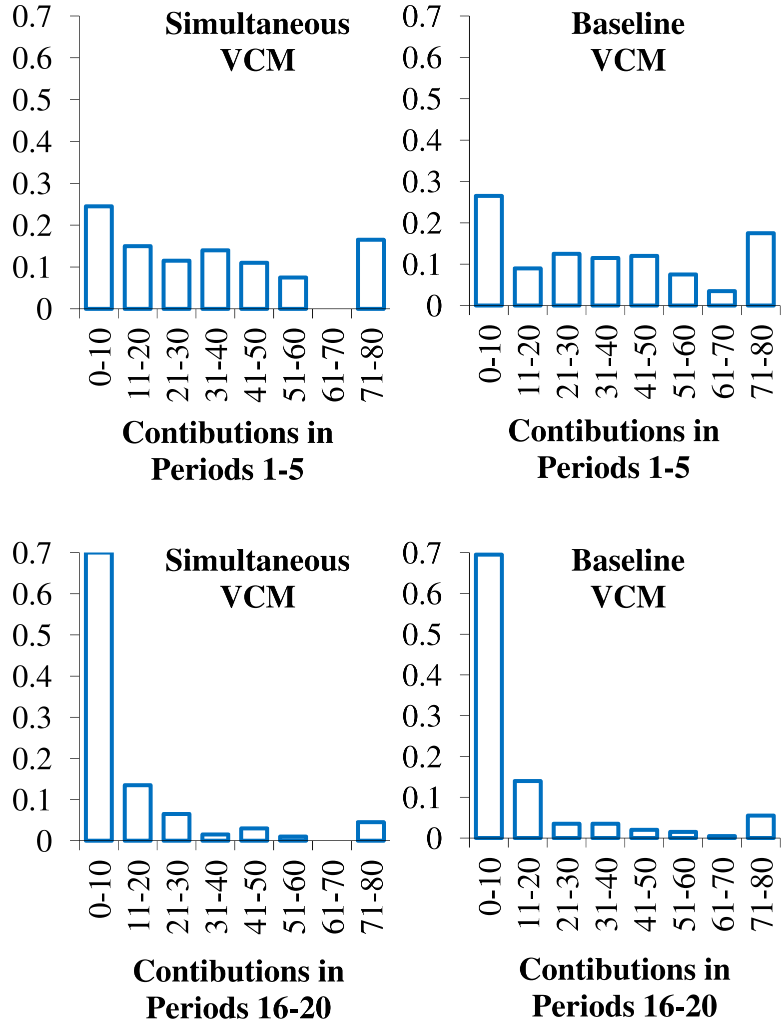

Figure 2: Distribution of Contributions

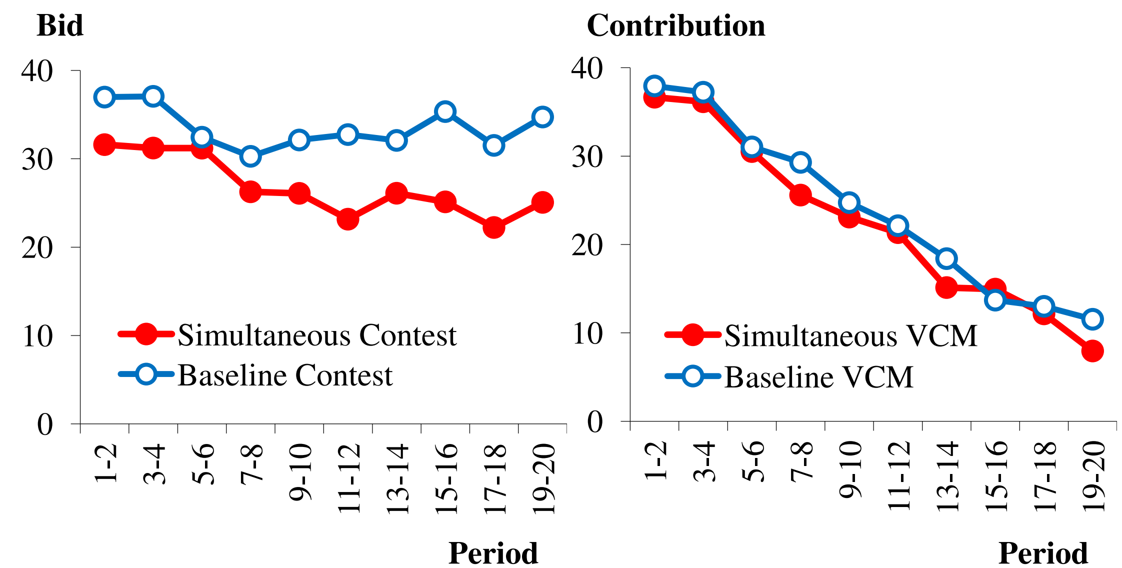

Figure 3: Average Bid and Contribution

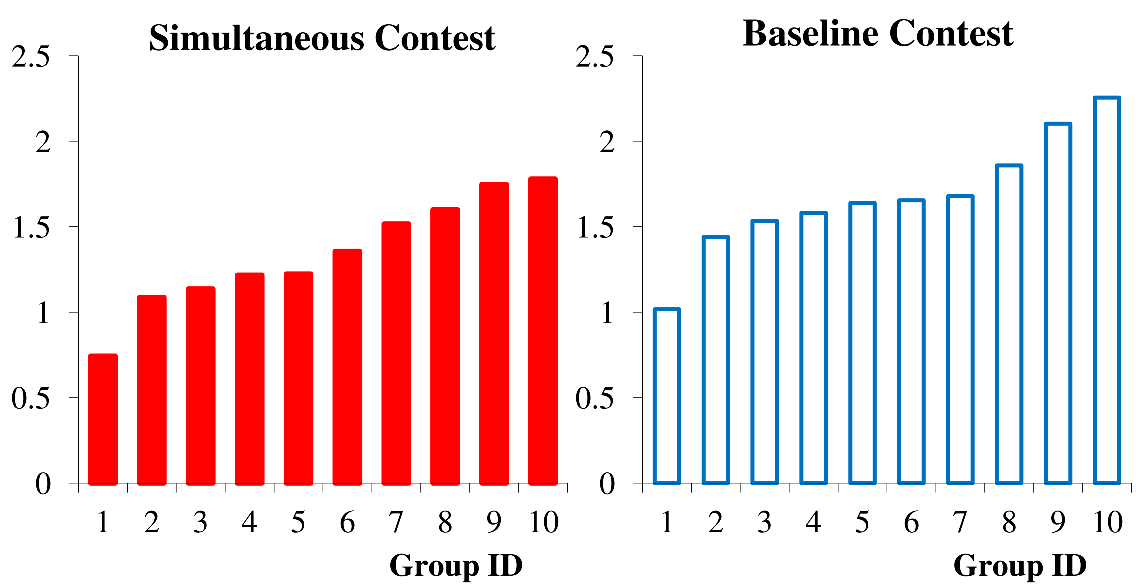

Figure 4: Dissipation Rate in the Contest by Groups

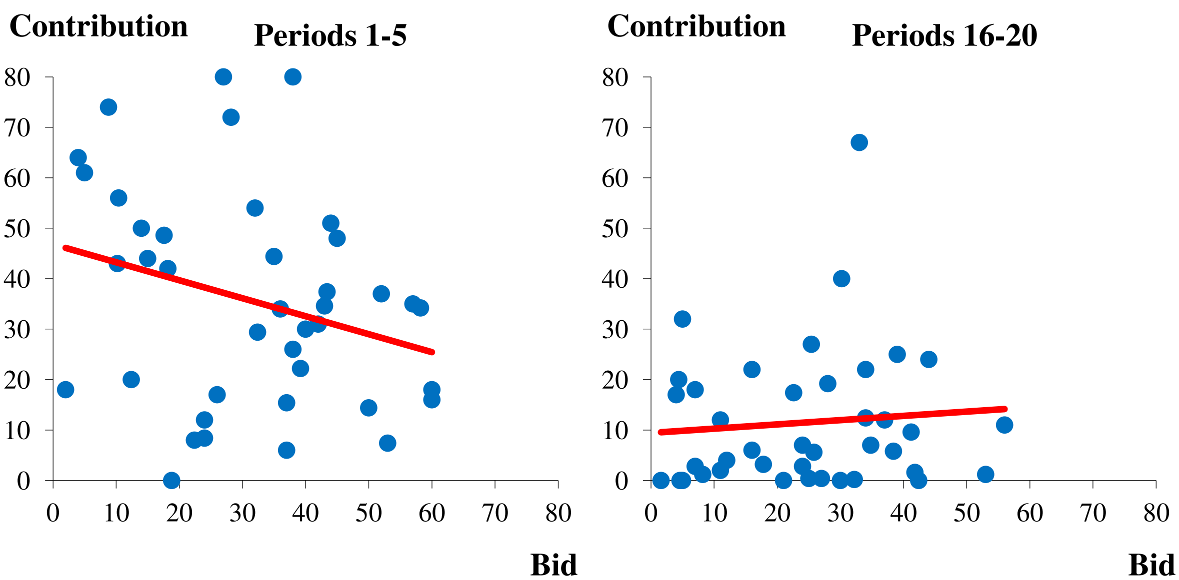

Figure 5: Correlation of Bids and Contributions (Periods 1-5 and 16-20 averaged)

[For On-Line Publication]
Appendix – Instructions for the Simultaneous Treatment

INSTRUCTIONS: In this experiment you will participate in a game with **three other** participants. You will not know the identity of the participants you are grouped with. The experiment will consist of **20 periods**. You will participate in both a **BLUE GAME** and a **GREEN GAME** at the same time and with the **same participants**. The **BLUE GAME** will appear on the left side of the screen and the **GREEN GAME** will appear on the right side of the screen at the same time in all 20 periods.

At the end of the experiment **2 out of 20** periods will be randomly selected for payment for the BLUE GAME and **2 out of 20** periods will be randomly selected for payment for the GREEN GAME. After you have completed all periods two tokens will be randomly drawn out of a bingo cage containing tokens numbered from **1 to 20**. The token numbers determine which two periods are going to be paid in the BLUE GAME. These tokens will be returned to the bingo cage, and two tokens will be randomly drawn again out of a bingo cage containing tokens numbered from **1 to 20**. The token numbers determine which two periods are going to be paid in the GREEN GAME.

Each period you will be given **80 francs** for the BLUE GAME and **80 francs** for the GREEN GAME. Francs will be converted to U.S. dollars at the end of the experiment at the rate of **25 francs = $1.** Each period, you will select a bid for the BLUE GAME and an allocation for the GREEN GAME. When you are ready to make your decision, click on the "input boxes" below "How much would you like to bid?" and "How much would you like to allocate to the Group Account?" and the program will allow you to enter in your number choices. When you are finished making your choices, click "Submit".

BLUE GAME: Each period, you and all other participants will be given an initial endowment of **80** francs and you will be asked to decide how much you want to bid for **a reward**. The reward is worth **80** francs to you and the other three participants in your group. You may bid any integer number of francs between **0** and **80**. After all participants have made their decisions, your earnings for the period are calculated. These earnings will be converted to cash and paid at the end of the experiment if the current period is the period that is randomly chosen for payment. If you receive the reward your period earnings are equal to your endowment plus the reward minus your bid. If you do not receive the reward your period earnings are equal to your endowment minus your bid.

If you receive the reward:	Earnings = Endowment + Reward – Your Bid = 80 + 80 – Your Bid
If you do not receive the reward:	Earnings = Endowment – Your Bid = 80 – Your Bid

The more you bid, the more likely you are to receive the reward. The more the other participants in your group bid, the less likely you are to receive the reward. Specifically, for each franc you bid you will receive one lottery ticket. At the end of each period the computer **draws randomly** one ticket among all the tickets purchased by **4 participants** in the group, including you. The owner of the drawn ticket receives the reward of 80 francs. Thus, your chance of receiving the reward is given by the number of francs you bid divided by the total number of francs all 4 participants in your group bid. You can never guarantee yourself the reward. However, by increasing your bid, you can increase your chance of receiving the reward. Regardless of who receives the reward, all participants will have to pay their bids.

$$\text{Chance of receiving the reward} = \frac{\text{Your Bid}}{\text{Sum of all 4 Bids in your group}}$$

In case all participants bid zero, the reward is randomly assigned to one of the four participants in the group.

Example: This is a hypothetical example used to illustrate how the computer is making a random draw. Let's say participant 1 bids 10 francs, participant 2 bids 15 francs, participant 3 bids 0 francs, and participant 4 bids 40 francs. Therefore, the computer assigns 10 lottery tickets to participant 1, 15 lottery tickets to participant 2, 0 lottery tickets to participant 3, and 40 lottery tickets for participant 4. Then the computer randomly draws **one lottery ticket out of 65** (10 + 15 + 0 + 40). As you can see, participant 4 has the **highest chance** of receiving the reward: **0.62 = 40/65.** Participant 2 has **0.23 = 15/65** chance, participant 1 has **0.15 = 10/65** chance, and participant 3 has **0 = 0/65** chance of receiving the reward.

After all participants make their bids, the computer will make a random draw which will decide who receives the reward. Then the computer will calculate your period earnings based on your bid and whether you received the reward or not.

GREEN GAME: Each period you will be given **80 francs** and you will be asked to decide how much of this amount you want to allocate to a **Group Account**. The remainder will be automatically allocated to your **Individual Account**. You may allocate any integer number of francs between **0** and **80**. After all participants have made their decisions, your earnings for the period are calculated. These earnings will be converted to cash and paid at the end of the experiment if the current period is the period that is randomly chosen for payment. Your earnings consist of two parts

1) Your earnings from the **Individual Account**
2) Your earnings from the **Group Account**

Your earnings from the Individual Account equal to the francs that you keep for yourself and do not depend on the decisions of others. Therefore, for **every franc** you keep for yourself in your Individual Account, you earn **1 franc**.

Your earnings from the Group Account depend on the total number of francs allocated to the Group Account by all 4 group members (including you). In particular, your earnings from the Group Account are **40 percent** of the **total allocation of all 4 group members** (including you) to the Group Account. Therefore, for every franc you allocate to the Group Account, you increase the total allocation to the Group Account by 1 franc. Therefore, your earnings from the Group Account rise by $0.4\times1=0.4$ francs. And the earnings of the other group members also rise by 0.4 francs each, so that the total earnings of the group from the Group Account rise by 1.6 francs.
In summary, your period earnings are determined as follows:

Your earnings = earnings from the Individual Account + earnings from the Group Account =

=80 - (your allocation to the Group Account) + 0.4×(allocation of 4 group members to the Group Account)

Example: Suppose that you allocated 40 francs to the Group Account and that the other three members of your group allocated a total of 120 francs. This makes a total of 160 francs in the Group Account. In this case each member of the group receives earnings from the Group Account of 0.4×160 = 64 francs. In addition, you also receive 40 francs from your Individual Account since you have kept 40 francs to your Individual Account.

OUTCOME SCREEN

BLUE GAME: At the end of each period, your bid, the sum of all bids in your group, whether you received the reward or not, and the 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** under the appropriate heading.

GREEN GAME: At the end of each period, your allocation and the sum of all allocations in your group are reported on the outcome screen as shown below. To aid you in your calculation, you are also shown your income from your individual account and your income from the group account. Once the outcome screen is displayed you should record your results for the period on your **Personal Record Sheet** under the appropriate heading.