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Should Managers Use Team-Based Contests?

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When designing contests to motivate employees, should managers organize employees to compete in teams or as individuals? We develop a behavioral economics model that shows that if contestants are averse to being responsible for the team's loss, a team-based (TB) contest can yield higher effort than an individual-based (IB) contest. This prediction is contrary to those of standard economics models, which favor IB contests over TB contests. We test the competing predictions using laboratory economics experiments. The results show that when contestants do not know each other, average effort levels in the TB and IB contests are not different. When contestants are allowed to socialize with potential teammates before making effort decisions, TB contests yield higher effort relative to IB contests. We also show that the relative efficacy of TB contests is driven by contestants' aversion to letting their team down.

Data, as supplemental material, are available at http://dx.doi.org/10.1287/mnsc.2013.1743.

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1. Introduction

Contests are among the most widely used forms of incentive contracts in practice. To better understand how contests can be designed to motivate employees, the extant literature has focused on three major questions: (1) When employees compete as individuals, what are the optimal number of winners and prize values in a contest (Kalra and Shi 2001, Chen et al. 2011)? (2) When employees work together in teams, how do team-based (TB) contests perform relative to other types of team-based incentive contracts (Nalbantian and Schotter 1997, Erev et al. 1993)? (3) How does effort in a team-based contest depend on team-based characteristics and the prize structure, such as the roles team members play, whether the team members split the winning prize equally (Amaldoss et al. 2000), and the degree to which team members communicate (Sutter and Strassmair 2009)? Interestingly, no study to date has examined the following question: When designing contests, should managers organize employees to compete as individuals or have them compete with each other in teams? One major reason why this gap in the literature exists is that conventional economic wisdom predicts that employees who are offered team-based incentive contracts will "fail to internalize the benefits that accrue to other members of the team when making effort decisions" (Prendergast 1999, p. 39). That is, economic models predict that free riding will occur and, consequently, effort in TB contests will be lower than effort in individual-based (IB) contests.

However, the free-riding prediction is based on an assumption that has been challenged by work in behavioral economics (e.g., Fehr and Schmidt 1999, Fischbacher and Gächter 2010, Chen and Li 2009, Ho and Su 2009). This literature refutes the standard assumption that people are purely self-interested and solely concerned with maximizing their own pecuniary payoffs by showing that social preferences (e.g., altruism, inequality aversion, social comparisons, and peer-induced fairness) can affect how people make decisions. Furthermore, it has been shown that the strength of an individual's social preferences can vary depending on factors such as familiarity with other players and whether outcomes are made public (e.g., Lim 2010, Goette et al. 2012).

In this paper, we posit that guilt aversion, which is defined as the propensity to make decisions to avoid feeling guilty (Dana et al. 2006, Charness and Dufwenberg 2006), is a type of social preference that may influence contestants' effort decisions in TB contests. Guilt is an emotion that is aroused when one does not live up to the expectations of others, especially when one's actions result in lesser payoffs for a relationship partner (Baumeister et al. 1994). We apply the concept of guilt aversion to TB contests by examining whether contestants' aversion to feeling responsible for their team's loss will influence them to exert more effort than would be predicted by standard economic models. Furthermore, we investigate whether this psychological driver of behavior is strong enough to outweigh the economic incentive to free ride. If this is the case, then effort in TB contests should be higher than effort in IB contests because there is little scope for guilt aversion in the latter.

Specifically, we develop a behavioral economics model that accounts for the possibility that employees, when organized to compete in a TB contest, will exhibit guilt aversion with respect to being responsible for the team's loss. We then compare effort in TB contests to that in IB contests and demonstrate that if guilt aversion is sufficiently strong, TB contests yield higher effort than IB contests. Next, we conduct a set of laboratory economic experiments to compare TB and IB contests empirically. In Experiment 1, we compare TB and IB contests under two different social settings that differ in the degree to which participants are likely to feel guilt aversion. In the first social setting, participants were randomly and anonymously assigned to teams, making them as similar to economic agents as possible. Interestingly, the experimental results show that even in this conservative environment, effort in TB contests is not lower than effort in IB contests. In the second social setting, participants socialized prior to making effort decisions, so that those in the TB contest condition were more likely to act in favor of social preferences due to feelings of guilt aversion. The results from this social setting support our analytical model and show that effort in TB contests can be higher than effort in IB contests.

We also conduct a series of experiments to check the robustness of our empirical findings and validate the behavioral economics model. In Experiment 2, we show that TB contests can elicit higher effort than IB contests even if contestants are matched with the same partner for only one decision round, instead of five rounds as in Experiment 1. This result shows that repeated interaction between teammates is not a necessary condition for the relative efficacy of TB contests. In Experiment 3, we provide stronger support for guilt aversion as a psychological driver of behavior in TB contests by examining effort in a TB contest where participants know in advance that they will *not* be informed of their partner's output. In this scenario, contestants have no way of comparing their output with their partner's and hence determine who is responsible for the team's loss, so the effect of guilt aversion on effort should be weaker. Consistent with our prediction, contestants exerted lower effort than when they could observe their teammate's output. This finding also suggests that when managers employ TB contests, it is important to create environments where team members can observe each other's output, so that the effect of guilt aversion would be stronger. In Experiment 4, we show that our proposed model of guilt aversion (based on the values of the behavioral parameters estimated from the data in Experiment 1) tracks effort decisions well in another set of contests.

To the best of our knowledge, there is no work that has directly examined effort across TB and IB contests. Amaldoss et al. (2000) study TB contests in a context where companies form strategic alliances to compete in patent races. They show that firms' investment (effort) levels depend on whether a prize is equally or proportionally split between team members and whether the member companies that form a team perform the same or different functions in determining team output. Nalbantian and Schotter (1997) show using laboratory experiments that TB contests can yield higher effort compared to other types of team-based contracts. Erev et al. (1993) conduct a field experiment that compares TB contests with team revenue-sharing contracts and individual piece-rate contracts (i.e., commission contract) in a social environment where participants who do not know one another were randomly matched into teams. They show that team contests induce output that is identical to output in individual piece-rate contracts and higher than output in revenue-sharing contracts. However, their paper did not examine IB contests. Sutter and Strassmair (2009) conduct laboratory experiments that examine different forms of communication in TB contests (e.g., within-team, across teams, and both) and find that allowing within-team communication during a decision task increases effort. Finally, as mentioned earlier, there is a stream of research that examines how to design optimal contests when contestants compete as individuals (e.g., Kalra and Shi 2001, Chen et al. 2011), but these papers did not study TB contests.[1]

Our paper extends the above literature by asking, if managers have a choice between organizing employees to compete in teams or as individuals, should they ever consider favoring TB contests? Our approach differs from the previous work on TB contests by modeling a psychological driver of behavior (i.e., guilt aversion) that can explain why TB contests

[1] See Dechenaux et al. (2012) for a comprehensive survey of the experimental literature on contests. There are several papers that examine how intergroup competition may be used to enhance within-group cooperation in public goods games (e.g., Bornstein et al. 1990, Bornstein and Erev 1994). These papers differ from the models used in the TB contest literature in that in the latter, the prize values are fixed by the contest organizer rather than by group contribution. There is also some research that studies the broader question of how various mechanisms can be used to increase the provision of public goods (e.g., Falkinger et al. 2000, Chen and Tang 1998). However, these papers do not compare individual- versus group-based incentives.

may induce higher effort than predicted by standard economic models, and also experimentally examining how effort in TB contests may vary in different social settings. Our study also differs from that of Sutter and Strassmair (2009) in that we do not study the effects of communication on effort—in our laboratory experiments, participants did not communicate in any of the experimental conditions.

2. Theory

Consider a contest that consists of $N = 4$ contestants.[2] The contestants are assumed to be risk neutral and have identical utility functions that are separable with respect to contest outcomes and costs of effort exerted. The output of contestant i is $y_i = f(e_i) + \varepsilon_i$, where e_i is contestant i's nonnegative effort level, $f(e_i)$ is an increasing and concave function of e_i, and ε_i is uniformly distributed over the interval $[-q, q]$ and independent across contestants. The stochastic term, ε_i, captures the uncertainty faced by contestant i, thereby reflecting the part of his output that is influenced by environmental shocks.

Contestants can be organized to compete in teams or as individuals. When the contest takes the form of a TB contest, the four contestants are divided into two teams, with two contestants in each team. The output for team t is $Y_t = \sum_{p=1}^{2} f(e_{tp}) + \sum_{p=1}^{2} \varepsilon_{tp}$, where $t = 1, 2$ represents teams and $p = 1, 2$ represents contestants within a team. The team with the higher team output (Y_t) wins the contest and receives $2w_H$ as the winning prize. This prize is equally split between the two contestants so that each contestant in the winning team gets w_H. The contestants in the losing team receive w_L each, which is greater than or equal to 0 but less than w_H.[3] When the contest takes the form of an IB contest, the four contestants are ranked based on their individual output. The two contestants with the highest output receive w_H each, whereas the remaining contestants receive w_L each.[4] Note that with the above mentioned contest structure, the number of prizewinners (two out of four) and the total payout $(2w_H + 2w_L)$ are identical across TB and IB contests.

2.1. Effort in Team-Based Contests

In TB contests, contestants maximize their expected utility by choosing an effort level that takes into consideration the trade-off between the utility of winning the contest and the cost of effort. Denoting the probability that a contestant receives the winning prize as $\text{Prob}(Win)_{TB}$ and the utility that a contestant gains from winning and losing the contest as $U(Win)_{TB}$ and $U(Lose)_{TB}$, respectively, the expected utility of contestant i is given by

$$EU_{iTB} = \text{Prob}(Win)_{TB} \times U(Win)_{TB} + [1 - \text{Prob}(Win)_{TB}] \times U(Lose)_{TB} - c(e_i), \quad (1)$$

where $c(e_i)$ is the cost of effort, which is an increasing and convex function in effort. Using e_{-i} to represent the effort of the other three contestants, we obtain the following first-order condition for contestant i in TB contests:

$$\frac{\partial \text{Prob}(Win)_{TB}}{\partial e_i}(e_i, e_{-i}) \times [U(Win)_{TB} - U(Lose)_{TB}] + \frac{\partial U(Win)_{TB}}{\partial e_i} \times \text{Prob}(Win)_{TB} + \frac{\partial U(Lose)_{TB}}{\partial e_i} \times [1 - \text{Prob}(Win)_{TB}] - \frac{\partial c(e_i)}{\partial e_i} = 0, \quad (2)$$

where the term $\partial\,\text{Prob}(Win)/\partial e_i$ is the marginal probability of winning a team contest, and $\partial U(Win)_{TB}/\partial e_i$ and $\partial U(Lose)_{TB}/\partial e_i$ represent the marginal change in utility from winning and losing due to an increase in effort, respectively.

We now turn to the specification of $U(Win)_{TB}$ and $U(Lose)_{TB}$. Applying findings from the social psychology and behavioral economics literatures on guilt aversion to our model (see Baumeister et al. 1994, Charness and Dufwenberg 2006), we build in the assumption that contestants organized in teams may feel guilty if they are perceived (by themselves or their teammates) to be the member who is responsible for the team's loss. Besides guilt aversion, we also allow for "social loss aversion," which is a psychological loss that contestants experience when they are on the losing side (Lim 2010, Chen et al. 2011), in the contestant's utility. Both guilt aversion and social loss aversion, if present, are expected to lead a contestant to exert more effort in TB contests. To capture

[2] In this paper, we restrict our attention to the case of $N = 4$ because solving for effort in team-based contests involves characterizing the convolution of random variables, which is analytically complex. The main focus of this paper is to compare TB and IB contests experimentally rather than analytically for a general N and different team sizes.

[3] In practice, besides the prizes from the contest, contestants may receive other payments (e.g., from linear schemes such as sales commissions), so that both absolute and relative output levels may be important. Because the focus of this paper is to examine how contestants behave under TB versus IB contests, we make the simplifying assumption that contestants are compensated only on contest outcomes.

[4] We consider an IB contest with two winners who receive w_H each, instead of a contest with only one winner, because we want to control for the number of winners and the value of the winning prize across TB and IB contests. We also conduct a laboratory experiment that compares effort across these different IB contests and show that there is no difference in effort. The results are reported in Footnote 9.

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these psychological drivers of behavior in the simplest manner possible, we let the utility functions for contestant i from winning and losing the contest be

$$U(Win)_{TB} = w_H \quad \text{and} \tag{3}$$

$$U(Lose)_{TB} = w_L - \theta \operatorname{Prob}(y_i < y_j)(w_H - w_L) - \beta(w_H - w_L), \tag{4}$$

where $\theta > 0$ and $\beta > 0$. In this utility specification, the parameter θ captures the degree of disutility contestant i feels from being the low performer in a losing team, and the term $\operatorname{Prob}(y_i < y_j)$ represents the probability that this guilt aversion occurs, that is, when contestant i's output is lower than his teammate j's output. We also assume that the disutility suffered by the contestant increases with $(w_H - w_L)$, which is the spread between the winning prize w_H and the losing prize w_L. The social loss aversion parameter β captures the degree of disutility the contestant suffers if he is perceived to be a "loser" when compared to other contestants. As in the case of guilt aversion, we build in the assumption that this disutility increases with the difference between the winning and the losing prizes. Importantly, the strength of the guilt aversion parameter, θ, and the social loss aversion parameter, β, can depend on the social setting within which a TB contest is run. For instance, how socially connected and familiar team members are with one another is likely to impact θ and β—we test this hypothesis experimentally in the subsequent sections of this paper. Note that if contestant i has no feelings of guilt aversion or social loss aversion, so that $\theta = \beta = 0$, then the model reverts to the standard economic model where $U(Lose)_{TB} = w_L$.

Given the above utility specification and the distribution of the noise term ε_i, we now solve for a pure-strategy Nash equilibrium (NE). We further restrict our attention to the symmetric pure-strategy Nash equilibrium where $e^*_{11} = e^*_{12} = e^*_{21} = e^*_{22} = e^*_{TB}$. To begin, note that $\partial U(Win)_{TB}/\partial e_i$, which is in the second term of Equation (2), is equal to 0 since $U(Win)_{TB}$ is not a function of e_i. Next, note that in the third term of Equation (2), $\partial U(Lose)_{TB}/\partial e_i$, is equal to $-\theta(\partial \operatorname{Prob}(y_i < y_j)/\partial e_i)(w_H - w_L)$. Furthermore, both $\operatorname{Prob}(y_i < y_j)$ and $\operatorname{Prob}(Win)_{TB}$ are equal to 1/2 when evaluated at the point of the symmetric pure-strategy equilibrium. Hence, the symmetric equilibrium effort in TB contests is the solution to the following first-order condition:

$$\frac{\partial \operatorname{Prob}(Win)_{TB}}{\partial e_i}(e^*_i = e^*_{TB}) \times \left[(w_H - w_L)\left(1 + \beta + \frac{\theta}{2}\right)\right] - \frac{\theta}{2}\frac{\partial \operatorname{Prob}(y_i < y_j)}{\partial e_i}(w_H - w_L) = \frac{\partial c(e_i)}{\partial e_i}. \tag{5}$$

2.2. Effort in Individual-Based Contests

In IB contests, the expected utility of contestants and the first-order condition with respect to effort are similar to Equations (1) and (2) for TB contests. To allow for a balanced comparison of effort in TB and IB contests, we also incorporate social loss aversion in IB contests and assume that the effect of this disutility is the same across the two types of contests. Specifically, we assume that $U(Lose)_{IB} = w_L - \beta \cdot (w_H - w_L)$.[5] Note that unlike the case of TB contests, $U(Lose)_{IB}$ is not a function of effort. As in Lim (2010), we assume that $U(Win)_{IB} = w_H$. Given the above utility specifications and assumptions, the symmetric equilibrium effort in IB contests, e^*_{IB}, is the solution to the following first-order condition:

$$\frac{\partial \operatorname{Prob}(Win)_{IB}}{\partial e_i}(e^*_i = e^*_{IB}) \times [(w_H - w_L)(1 + \beta)] = \frac{\partial c(e_i)}{\partial e_i}. \tag{6}$$

2.3. Comparison of Effort Across Team-Based and Individual-Based Contests

To characterize the closed-form equilibrium effort in TB and IB contests and to generate point predictions for the experiments, we adopt explicit functional forms for the production and cost of effort functions. Without loss of generality, we assume that $y_i = f(e_i) + \varepsilon_i = e_i + \varepsilon_i$ and $c(e_i) = ke_i^2$, where $k > 0$.

We start with TB contests (Equation (5)). In solving for the Nash equilibrium effort, the extant models of TB contests (e.g., Nalbantian and Schotter 1997, Sutter and Strassmair 2009) had assumed that the stochastic term influencing team output enters at the team level. However, because our objective is to compare effort across TB and IB contests, we assume that the stochastic term enters at the individual level. With this approach, solving for equilibrium effort in TB contests involves characterizing the convolution of the distribution of individual-level noise terms, which makes the derivation of the marginal probability of winning analytically more complex. We show in Appendix A that when $N = 4$, the marginal probability of winning a TB contest, $\partial \operatorname{Prob}(Win)_{TB}/\partial e_i$, reduces to $1/(3q)$ when evaluated at the point of the symmetric pure-strategy equilibrium. Moreover, because we know from the previous literature on IB contests that $\partial \operatorname{Prob}(y_i < y_j)/\partial e_i = -1/(2q)$ when evaluated at the point of the symmetric pure-strategy equilibrium (Kalra and Shi 2001, Chen et al. 2011), the term $-(\theta/2)(\partial \operatorname{Prob}(y_i < y_j)/\partial e_i)(w_H - w_L)$ in Equation (5) reduces to $(\theta/(4q))(w_H - w_L)$. Finally, the marginal

[5] We can also assume alternative reference points, such as the average prize value. However, changing the reference point does not affect the major results of this paper.

cost of effort $\partial c(e_i)/\partial e_i = 2ke_i$. With these results, the first-order condition for contestant i in TB contests becomes

$$\frac{1}{3q}\left[(w_H - w_L)\left(1+\beta+\frac{\theta}{2}\right)\right] + \frac{\theta}{4q}(w_H - w_L) = 2ke_i, \quad (7)$$

which yields the equilibrium effort

$$e^*_{TB} = \frac{1}{2kq}(w_H - w_L)\left(\frac{1+\beta}{3} + \frac{5\theta}{12}\right). \quad (8)$$

Next, we derive the equilibrium effort in IB contests. The marginal probability of winning in an individual-based contest, $\partial \operatorname{Prob}(Win)_{IB}/\partial e_i$, when evaluated at the symmetric pure-strategy equilibrium is $1/(2q)$ given that $\varepsilon_i \sim U[-q, q]$. Hence, the first-order condition for contestant i in IB contests reduces to

$$\frac{1}{2q}[(w_H - w_L)(1+\beta)] = 2ke_i, \quad (9)$$

and the symmetric equilibrium effort in IB contests is

$$e^*_{IB} = \frac{1}{2kq}(w_H - w_L)\frac{1+\beta}{2}. \quad (10)$$

Comparing the two expressions of effort in TB and IB contests (Equations (8) and (10), respectively) yields the following proposition:[6]

Proposition 1. *When $\theta > 2/5 + (2/5)\beta$, equilibrium effort in team-based contests is higher than that in individual-based contests. Otherwise, effort in IB contests is higher.*

Proposition 1 formally shows that if a contestant's degree of guilt aversion, θ, is sufficiently strong in TB contests, then equilibrium effort in TB contests will be higher than that in IB contests. Note that because the total payout is identical across the two types of contests, the contest that yields higher effort translates into greater profits. Moreover, if contestants care solely about the pecuniary rewards from winning or losing the contest (i.e., $\theta = \beta = 0$), as assumed in standard economics models, then effort in IB contests is higher.

Although the above analysis assumes a one-shot setting, the result in Proposition 1 also applies to the case where contestants interact repeatedly for a finite number of rounds. To see this, one can use backward induction to show that exerting the one-shot NE effort in every round for every contestant constitutes a subgame perfect Nash equilibrium (SPNE) of the finitely repeated game. Moreover, since the NE in the one-shot game is unique (given the assumptions of our model), this SPNE must also be the unique SPNE of the finitely repeated game. We summarize this discussion in Corollary 1:

Corollary 1. *In the finitely repeated TB and IB contests, playing the one-shot NE effort in every round for every contestant constitutes the unique SPNE.*

We proceed to test the predictions of our behavioral economics model using laboratory experiments.

3. Experiment 1

3.1. Experimental Design

We employ a 2×2 design by comparing participants' effort decisions in TB and IB contests across two social settings (labeled social conditions A and B). The rationale behind varying the social environment in which participants operate (even though conventional economic wisdom predicts that doing so will not affect effort) is that we expect the degree of guilt aversion to be stronger in an environment where team members feel more socially connected. In turn, we predict that higher levels of guilt aversion will lead to higher effort in TB contests.

The participants of the experiment were undergraduate business students at a large public research university in the United States. They received course credit for showing up on time to the experiment and earned cash based on their performance. Each of the four treatments consisted of three sessions, with each session involving either 12 or 16 participants (depending on the number of students who signed up for that session). There were a total of 15 decision rounds in each session, and we implemented the experiment using z-Tree software (Fischbacher 2007). Before the start of the 15 decision rounds, we also conducted three practice rounds that carried no monetary consequences to familiarize participants with the experimental procedure. At the end of each experimental session, participants were paid privately in cash and directed to leave the lab. Each participant earned \$9 on average and the range of earnings was from \$4 to \$15. The parameter values used to design the experiment were $w_H = 6.5$, $w_L = 1$, $q = 60$, and $k = 0.0008$. Given these experimental parameters, the effort predictions of the standard economic model (which assumes that $\theta = \beta = 0$) are 19.1 for TB contests and 28.6 for IB contests. Note that this design ensures that: (1) there is sufficient spread in effort between the TB and IB contests; and (2) the effort predictions of the standard economic model are not focal numbers.

3.2. Experimental Procedure

To begin, we label the TB and IB contests in each of the two social conditions (A and B) as TB-A, TB-B, IB-A,

[6] We also check that the second-order conditions are satisfied, and the parameters chosen in the experiment ensure an interior Nash equilibrium effort given the first-order conditions in Equations (7) and (9).

Table 1 Experimental Procedure in Experiment 1

	Treatment			
Description	TB-A	IB-A	TB-B	IB-B
Introductions and discuss common interests within group	×	×	✓	✓
Group Sudoku game	×	×	✓	✓
Teammates are group members	×	n.a.	✓	n.a.
Exact identities of teammates unknown	✓	n.a.	✓	n.a.
Competitors are from other groups	n.a.	n.a.	✓	✓
Identities of competitors unknown	✓	✓	✓	✓

✓, yes; ×, no; n.a., not applicable.

and IB-B, respectively. We first describe the experimental procedure in the TB-A treatment in detail, and then use it as a benchmark to explain the differences in the other three treatments. Table 1 also summarizes the key differences among the four treatments.

3.2.1. Team-Based Contest in Social Condition A. In the TB-A treatment, participants entered the lab, were seated apart from one another at separate computer terminals, and were delivered a set of experimental instructions for the decision tasks. Participants were told that they would be randomly and anonymously paired with another participant to form a team and compete with another (randomly and anonymously matched) two-person team for the first five decision rounds. Then, before the start of rounds 6 and 11, they would be rematched in the same manner with a new teammate and compete against a new team until the 15 decision rounds were completed.

The participants' decision task for each decision round was to select a *decision number* (e_i) between 0 and 75. They were informed that every decision number carried a corresponding *decision cost* ($0.0008e_i^2$). The full set of decision costs for decision numbers was provided to each participant in the format of a "Decision Cost Table." During each decision round, participants entered their decision numbers into the computer program and, upon doing so, the computer generated a *random number* (ε_i). This random number ranged between -60 and 60 (q), and each random number in this range had an equal chance of being drawn. The computer added the random number to the decision number that the participant chose to arrive at a participant's *final number* (y_i) for a given decision round.

Participants were informed that prizes would be awarded based on team performance; that is, their *team's final number* (Y_t), which was the sum of their final number and their teammate's final number, would be compared with that of the team they were competing against, and, depending on whether their team's final number exceeded or fell short of the competing team's final number, they would each receive 6.5 points (w_H) or 1 point (w_L). In either case, win or lose, participants were told that their own decision cost (in points) would be subtracted from the amount awarded.

In the experiment, the range of decision numbers and the decision costs faced by contestants, the distribution of random numbers, and how payoffs would be determined were common knowledge to all participants. Participants were told that they would know the final number of their teammate (y_j) and their team's final number (Y_t) after every decision round. The actual decision number chosen, the decision cost incurred, the random number drawn, and the payoff in each round were private knowledge to each participant.

3.2.2. Individual-Based Contest in Social Condition A. The IB-A treatment is identical to the TB-A treatment except for the following: (1) Participants competed against three other participants as individuals; (2) participants were awarded points based only on their own final number (y_i). They received 6.5 points (w_H) minus their own decision cost if their final number was higher than those of at least two competitors. Otherwise, they received 1 point (w_L) minus their own decision cost.

3.2.3. Team-Based Contest in Social Condition B. The TB-B treatment is identical to the TB-A condition except for the following differences. Upon entering the lab, participants were randomly seated in groups of four and were first asked to introduce themselves and discuss three common interests that the group shared. After that, we asked the participants to complete a Sudoku puzzle as a group. Note that during these socialization activities, the participants had no idea about the decision task that they would undertake and did not know that the people they had socialized with would be their partners in the experiment. We then had group members sit apart from one another at computer terminals and handed out the experimental instructions. Participants were told that they would be randomly and anonymously matched with one of the three members of the group to form a team and compete with another (randomly and anonymously matched) team from another group for the first five decision rounds. Again, before the start of rounds 6 and 11, they would be rematched in the same manner. The full instructions that were presented to participants in the TB-B treatment can be found in Appendix B.

Our prediction is that socialization among participants who would be teammates would increase the contestant's level of guilt aversion (θ) in TB contests, so that effort in the TB-B treatment would be higher than that in the TB-A treatment. Note that we allowed subjects to socialize only in a small group and that teammates were never competitors—in this way, the aversion to being responsible for the team's loss would not be contaminated by other-regarding preferences that could be operative when participants competed against former teammates. Finally, in contrast to Sutter and Strassmair (2009), we did not allow any communication between team members or across competing teams during the decision rounds.

3.2.4. Individual-Based Contest in Social Condition B. In the IB-B treatment, participants were randomly divided into groups of four upon entering the lab and went through the same socialization activity as in the TB-B treatment. During the experiment, while each participant competed against three other randomly and anonymously matched participants in the contest (as in IB-A) for the five decision rounds, they were told that none of the three competitors would be drawn from the participant's group from the socialization activity. After the first set of five decision rounds, participants were rematched in a similar manner until the fifteen rounds were complete.

Notice that in both the IB-A and IB-B treatments, participants were equally unfamiliar with their competitors across the two social conditions. Therefore, the degree to which contestants may make social comparisons with other contestants (which drives social loss aversion) should not differ in these two treatments, leading to our expectation that effort would not differ either.

3.3. Experimental Results

There were a total of 180 participants across the four treatments, with 44 participants in each of the TB-A, TB-B, and IB-A treatments and 48 participants in the IB-B treatment. Table 2 displays the summary statistics of effort in all four treatments. In social condition A, the average effort levels in TB and IB contests were 33.8 and 35.3, respectively. In social condition B, the average effort decisions in TB and IB contests were 43.5 and 37.3, respectively. The average effort level in every decision round for each of the four treatments is plotted in Figure 1.[7]

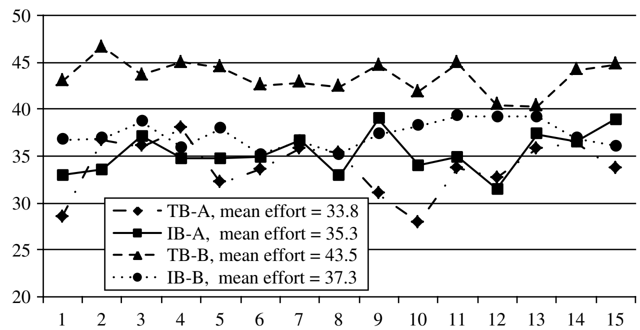
[7] We checked for learning effects in the effort decisions by comparing the average effort in decision rounds 1 to 8 with the average effort in rounds 9 to 15 for each treatment. In all four treatments, there were no differences in effort decisions across the two "halves" of the experiment at the 5% level. In the TB contest conditions, because participants were matched with a team member for five decisions rounds, we also checked for potential "latter-round defections" by comparing effort in the first three rounds against that in the last two rounds for each team. We found no differences in average effort in the first three rounds and the last two rounds in both social conditions A ($t = 0.90, p = 0.374$) and B ($t = -1.63, p = 0.111$). The "latter-round" effect was also missing in IB contests in both social conditions A ($t = -1.17, p = 0.249$) and B ($t = 0.35, p = 0.730$). We also found no significant differences in effort in the first four rounds versus the fifth round at the 5% level in all four treatments.

Table 2 Summary Results of Experiment 1

Treatment	Standard economic model prediction ($\theta = \beta = 0$)	Mean effort	Median	Inter-quartile range	Test against the standard economic model prediction
TB-A	19.1	33.8 (14.3)[a]	35	30.5	$t = 6.84$, $p = 0.000$
IB-A	28.6	35.3 (12.6)	35	30.0	$t = 3.53$, $p = 0.001$
TB-B	19.1	43.5 (11.8)	43	21.5	$t = 13.67$, $p = 0.000$
IB-B	28.6	37.3 (12.9)	35	25.0	$t = 4.67$, $p = 0.000$

[a] The numbers in parentheses are standard deviations.

Figure 1 Mean Effort Decisions Across Decision Rounds in Experiment 1



We now proceed to discuss the formal statistical tests we conducted to examine whether effort levels are significantly different across treatments. Because participants made multiple decisions, we clustered the standard errors at the subject level in all of the statistical tests to account for potential within-subject correlation.

3.3.1. Comparison with the Standard Economic Model. To begin, we compare participants' average effort levels against the predictions of the standard economic model, which assumes that $\theta = \beta = 0$. The last column of Table 2 shows that effort levels in all four treatments are significantly higher than those predicted by this model. This result suggests that contestants are also motivated by nonpecuniary preferences when making effort decisions.

3.3.2. Comparing Effort Across Social Conditions. Next, we compare effort levels across the different social conditions when the type of contest is held constant. The ordinary least squares (OLS) regression of effort in TB contests in Table 3 (Model 1) indicates that participants choose higher effort when they are paired with a teammate with whom they had socialized prior to making effort decisions ($t = 3.44$,

Table 3 OLS Regressions of Effort on Social Settings and Types of Contest

	Coefficient	Robust SE	t-stat.	p-value
Model 1: TB contests (#obs. = 1,320, #clusters = 88, $R^2 = 0.066$)				
Constant (base = social condition A)	33.8	2.16	15.68	0.000
Social condition B	9.6	2.80	3.44	0.001
Model 2: IB contests (#obs. = 1,380, #clusters = 92, $R^2 = 0.003$)				
Constant (base = social condition A)	35.3	1.91	18.51	0.000
Social condition B	2.0	2.67	0.74	0.463
Model 3: Social condition A (#obs. = 1,320, #clusters = 88, $R^2 = 0.001$)				
Constant (base = IB contest)	35.3	1.91	18.51	0.000
TB contest	−1.5	2.88	−0.52	0.601
Model 4: Social condition B (#obs. = 1,380, #clusters = 92, $R^2 = 0.034$)				
Constant (base = IB contest)	37.3	1.86	20.00	0.000
TB contest	6.2	2.58	2.38	0.019

$p = 0.001$).[8] This result is consistent with our prediction that the degree of guilt aversion θ will be higher if participants feel more socially connected to their teammates. In IB contests (Model 2 of Table 3), however, there is no difference in effort decisions across the two social conditions ($t = 0.74$, $p = 0.463$). As mentioned earlier, this result is unsurprising since the two social conditions in our experiment were manipulated to affect the degree to which participants are likely to feel connected to their teammates in TB contests, but not the degree to which social comparisons are made in IB contests.

3.3.3. Comparing Effort Across TB and IB Contests. We now turn to the comparison between TB and IB contests within the same social condition. Models 3 and 4 of Table 3 display the results of the OLS regressions of effort on the *type of contest* in social conditions A and B, respectively. First, note that in social condition A (i.e., when participants did not socialize with one another before the experiment), effort levels in TB and IB contests are not significantly different ($t = -0.52$, $p = 0.601$).[9] More importantly, in social condition B (i.e., when participants were organized into groups and socialized with group members), effort in TB contests is significantly higher than in IB contests ($t = 2.38$, $p = 0.019$). These results are consistent with the prediction that guilt aversion can be stronger when contestants are more familiar with their teammates, and that TB contests can yield higher effort than IB contests if the level of guilt aversion in the former is sufficiently strong.

Table 4 Estimates of Behavioral Parameters from Experiment 1

Parameters	Estimates	Robust SE	t-stat.	p-value
θ_A	0.430	0.11	3.91	0.000
θ_B	0.778	0.09	8.64	0.000
β_A	0.233	0.07	3.33	0.001
β_B	0.302	0.06	5.03	0.000

Log-likelihood (LL)
Full model: LL = −11,675.0
Nested models:
- $\theta_A = \theta_B = 0$ LL = −11,976.6 (Wald stat. = 78.38, $p = 0.000$)[a]
- $\theta_A = \theta_B$ LL = −11,698.4 (Wald stat. = 6.20, $p = 0.013$)
- $\beta_A = \beta_B = 0$ LL = −11,790.6 (Wald stat. = 33.89, $p = 0.000$)
- $\beta_A = \beta_B$ LL = −11,676.8 (Wald stat. = 0.55, $p = 0.459$)
- $\theta_A = \theta_B = \beta_A = \beta_B = 0$ LL = −12,333.2 (Wald stat. = 266.1, $p = 0.000$)

[a]The Wald statistic is used to test whether the restrictions in the nested models significantly reduce the fit. The likelihood ratio test is not appropriate in this context because the observations are not independent at the subject level.

3.3.4. Estimates of Behavioral Parameters. We now estimate the values of the psychological parameters in our behavioral economics model implied by the experimental data set. Specifically, we assume that $e_{irc} \sim \mathrm{N}(e_c^*, \sigma_c^2)$, where i represents the contestant, r indicates the decision round, c indicates which treatment (TB-A, IB-A, TB-B, or IB-B) the contestant competes in, e_c^* is the equilibrium effort in treatment c, and σ_c^2 is the variance of effort in treatment c. We estimate the behavioral parameters θ and β separately for social conditions A and B using maximum likelihood, with the standard errors clustered at the subject level.

The results are shown in Table 4. For social condition A, both the guilt aversion and social loss aversion parameters are positive and statistically significant at the 5% level. Specifically, we obtain $\theta_A = 0.430$ and $\beta_A = 0.233$, so that the condition required by Proposition 1 for effort to be higher in TB contests is not satisfied ($\theta_A = 0.430 < 2/5 + (2/5)\beta_A = 0.493$). For social condition B, the estimated behavioral parameters are $\theta_B = 0.778$ and $\beta_B = 0.302$, which satisfies the theoretical condition for higher effort in TB contests ($\theta_B = 778 > 2/5 + (2/5)\beta_B = 0.521$). The estimate of θ_B also

[8] For the results reported in this section, we also performed the corresponding nonparametric tests and confirmed that the results of the parametric tests hold.

[9] We also conducted another experiment to examine effort in IB contests with only one winner, where the winning prize is 12 points and the losing prize is 1 point, under social condition A. Note that the prize spread in this experiment is twice that of the IB contests in Experiment 1 ($12 - 1 = 2 * (6.5 - 1)$). The average effort in this contest is 38.2, which is not significantly different from the average effort in the IB-A treatment, which has two winners ($t = 0.90$, $p = 0.370$). There is also no significant difference from effort in the TB-A treatment ($t = 1.31$, $p = 0.193$).

suggests that a contestant's psychological disutility from feeling guilty is worth about 39 cents (0.778 multiplied by $\text{Prob}(y_i < y_j)$, which equals 0.5 in equilibrium) for every dollar difference between the winning and losing prizes. As expected, the guilt aversion parameter θ is significantly higher in social condition B than that in social condition A ($\chi^2(1) = 6.20$, $p = 0.013$), whereas β is not significantly different across the two social conditions ($\chi^2(1) = 0.55$, $p = 0.459$).

4. Validation Experiments

The results of Experiment 1 show that even when team members do not know each other, average effort levels in TB contests are not different from IB contests. However, when contestants are allowed to socialize with potential teammates before making effort decisions, TB contests yield higher effort relative to IB contests. Although these findings are consistent with the prediction of the guilt aversion model, it is important to check the robustness of the empirical findings and to provide more direct evidence for the role of guilt aversion in guiding contestants' effort decisions. In this section, we describe three experiments that address these issues.

4.1. Experiment 2: Are the Findings of Experiment 1 Robust?

In Experiment 1, participants in TB contests were matched with the same teammate for five decision rounds. Even though theory predicts that equilibrium effort would not change when contestants interact repeatedly for a finite number of rounds, it is still useful to check empirically whether the effort decisions in the TB contests were driven by repeated interaction between teammates. To do so, we conducted Experiment 2, which examined participants' effort decisions in a TB contest where they were matched with a teammate only once. More importantly, we were interested in whether effort in this one-shot TB contest would still be higher than in IB contests.

This experiment is identical to the TB-B treatment in Experiment 1, except that each participant was paired with a teammate just once. Because participants were socialized in groups of four, they played only a total of three decision rounds. There were a total of 64 participants across four experimental sessions, and the mean effort decision was 43.2 (see Table 5). This effort level is not significantly different from that in TB-B contests where participants were matched with the same teammate for five decision rounds ($t = -0.09$, $p = 0.931$). Moreover, average effort in this treatment remains higher than in the IB-B treatment in Experiment 1 ($t = 2.46$, $p = 0.015$). These results suggest that

Table 5 Summary Results of Experiments 2 and 3

Experiment	Treatment description	Mean effort	Median	Key results
2	TB contests where participants are paired with a teammate for only one decision round; participants socialized as in social condition B	43.2[a] (12.3)[b]	44	Effort is not different from the TB-B contest ($t = -0.09$, $p = 0.931$) and higher than effort in the IB-B contest ($t = 2.46$, $p = 0.015$)
3	TB contests identical to Experiment 2, except that contestants know that they cannot see their teammate's output after each round	31.1 (14.6)	32	Effort is lower than in the one-shot TB contest in Experiment 2 ($t = -3.85$, $p = 0.000$)

[a]Similar to Experiment 1, the effort prediction of the model assuming $\theta = \beta = 0$ is 19.1 in the TB contest.
[b]The numbers in parentheses are standard deviations.

repeated interaction between teammates is not a necessary condition for the efficacy of TB contests over IB contests.[10]

4.2. Experiment 3: Are Effort Decisions in TB Contests Driven by Guilt Aversion?

In Experiment 3, we conducted a more direct test of whether guilt aversion is a psychological driver of behavior in TB contests. We ran the same TB contest as in Experiment 2 (i.e., TB-B treatment with one-shot interaction) except for one modification—participants were told that they would *not* know what their partner's Final Number (i.e., their teammate's output y_j) was after each decision round.[11] The rationale for this design feature is as follows: If guilt aversion is the factor that drives higher effort in TB contests, and if contestants know that it is impossible to determine whether their output is higher or lower than their partner's, their concern about feeling guilty for dragging their team's performance down would be dampened. Consequently, effort in this treatment should be lower.

We conducted two experimental sessions, and a total of 28 participants made effort decisions for three

[10] In addition, we compared the average effort in Experiment 2 with another IB contest treatment where (unlike in Experiment 1) we let all participants socialize prior to informing them about the decision task. In this IB contest, participants competed against participants they had socialized with, but (like in all the experiments in this paper) did not know their competitors' exact identities. We found that effort in this IB contest was lower than effort in the TB contest in Experiment 2 ($t = -2.23$, $p = 0.028$).

[11] Participants also did not observe their team's final number (Y_t) at the end of each decision round.

Table 6 Predictions and Results of Experiment 4

Contest	Behavioral economics model prediction ($\theta_B = 0.778, \beta_B = 0.302$)	Standard economic model prediction ($\theta = \beta = 0$)	Mean effort	Test against the behavioral economics model prediction	Test against the standard economic model prediction
TB	63.2	27.8	59.5 (14.0)[a]	$t = -1.66$, $p = 0.106$	$t = 14.20$, $p = 0.000$
IB	54.3	41.6	49.1 (15.4)	$t = -1.93$, $p = 0.063$	$t = 2.76$, $p = 0.010$

[a]The numbers in parentheses are standard deviations.

decision rounds. The mean effort in this TB contest is 31.1 (see also Table 5). Although this effort level is still higher than predicted by the standard economic model ($t = 4.36$, $p = 0.000$), it is significantly lower than the average effort of 43.2 in Experiment 2 ($t = -3.85$, $p = 0.000$), where participants could see their teammate's output. This result provides further evidence that guilt aversion is a driver of effort decisions in TB contests. Moreover, since contestants' aversion to losing in a TB contest (captured by β) should not be affected by whether contestants' can see their teammate's output, the change in effort in Experiment 3 should be driven by a psychological mechanism that is distinct from changes in the level of social loss aversion.

4.3. Experiment 4: Can the Proposed Behavioral Model Predict Effort Decisions Well?

The main objective of this experiment is to further examine whether the proposed behavioral economics model captures the true psychological drivers of participants' behavior in TB and IB contests. If this is the case, then the behavioral economics model should also track effort decisions in other TB and IB contests well. In Experiment 4, we generated another set of TB and IB contests by changing the values of the winning prize w_H, the losing prize w_L, and also the prize spread $(w_H - w_L)$ relative to Experiment 1. Specifically, we increased w_H from 6.5 to 12 points and also w_L from 1 to 4 points, so that the prize spread also increased from 5.5 to 8 points. The values of the other contest parameters remained unchanged at $k = 0.0008$ and $q = 60$. We then studied this set of TB and IB contests experimentally under social condition B. As in Experiment 2, participants played a total of three decision rounds, and contestants in the TB (IB) contest were matched with the same partner (set of competitors) only once.

With this set of contest parameters, the effort predictions of the standard economic model (i.e., assuming $\theta = \beta = 0$) are 27.8 and 41.6 for the TB and IB contests, respectively. To generate the predictions of the behavioral economics model, we used the values of the behavioral parameters estimated from social condition B of Experiment 1. Using these estimates of $\theta_B = 0.778$ and $\beta_B = 0.302$, we obtained $e^*_{TB} = 63.2$ and $e^*_{IB} = 54.3$.[12] Note that the behavioral economics and standard economic models yield opposing predictions about the relative performance of TB and IB contests. Also, note that the predicted effort levels of both competing models are quite different from the theoretical and actual effort levels of Experiment 1.

There were a total of 40 and 32 participants in the TB and IB contests, respectively. Table 6 displays the results of Experiment 4. The mean effort level in the TB contest is 59.5, whereas it is 49.1 in the IB contest. The last column of Table 6 shows that these effort levels are significantly higher than those predicted by the standard economic model. More importantly, average effort in the TB contest is higher than in the IB contest ($t = 2.99$, $p = 0.004$), as predicted by the model with guilt aversion. Interestingly, these mean effort levels are not statistically different from the predictions of the behavioral economics model ($t = -1.66$ and $p = 0.106$ for the TB contest; $t = -1.93$ and $p = 0.063$ for the IB contest). The estimates of the behavioral parameters implied by the data in Experiment 4 are $\theta_B = 0.773$ and $\beta_B = 0.177$, which are both positive and significant at the 5% level. These values are very close to the estimates found in Experiment 1—in fact, the Wald test indicates that there are no differences among the two sets of parameter estimates ($\chi^2(2) = 2.74$, $p = 0.254$). Together, these results provide further evidence of the validity of our proposed behavioral model.

5. Discussion

We now proceed to discuss some caveats and limitations. First, we must emphasize that our results do not imply that TB contests will always perform at least as well as IB contests. The social environments in our laboratory experiments were such that adversarial or competitive relationships among team members were limited. If these relationships exist, then IB contests could be more effective.

Second, our utility specification that captures guilt aversion may not be the best one—although we show in Experiment 4 that it can track behavior well, there

[12] Given the changes in the values of experimental parameters and predicted effort levels, we had to expand the range of decision numbers that contestants could select (from $0 \sim 75$ to $0 \sim 85$).

could be other functional forms that can predict behavior better across a wider array of TB contests. Although we believe that aversion to feeling responsible for the team's loss is a primary psychological driver of behavior in TB contests and present empirical evidence that is consistent with this hypothesis, there may be other psychological factors that can also influence effort decisions. For example, within-group comparisons may exist among team members, and some contestants may derive utility gains from being the team member that contributes the most to the team's victory. Naturally, the presence and strength of these factors will depend on the social environment and the nature of the relationships among team members.

Third, we have assumed that contestants are identical in abilities or market endowments. If teammates are heterogeneous, the nature and degree of guilt aversion among the various "types" of contestants may be different. For example, a weaker contestant who is paired with a stronger team member may feel even more guilty if his team loses, because the stronger team member might have been a prizewinner if he had been matched with another strong contestant or if he had competed individually. On the other hand, implementing a TB contest in a social environment that has heterogeneous contestants may be more challenging because employees with higher abilities are likely to be reluctant to be matched with those with weaker abilities.

Fourth, note that the model in this paper assumes no task complementarities among team members, that is, each contestant can complete his work solely by himself. There is an emerging stream of empirical research that shows that when task complementarities are present in the work environment, team-based incentives can be more effective than individual-based incentives. For example, Hossain and List (2012) conduct field experiments with employees working in the same factory and show that team-based target bonuses (particularly bonuses that were framed as a deduction or loss, rather than as a gain) can raise productivity more than individual-based target bonuses. Our paper extends this literature by showing that team-based incentives can also be more effective in environments where employees need not work in groups to complete their tasks.

Finally, we studied very simple TB contests that consisted of two-member teams. Furthermore, the prizes were equally split between team members. If a team consists of many members, there may be greater incentive to free ride; on the other hand, depending on the relationships among the team members, contestants may experience greater disutility if they are responsible for a decline in the payoffs of many team members. If the team prize can be divided unevenly among team members (e.g., proportional to output) in TB contests, effort will likely increase due to within-team competition (Rapoport and Amaldoss 1999); however, the degree of guilt aversion in contestants may decline correspondingly. We believe that it will be fruitful for future research to compare TB and IB contests with more contestants and more complex prize structures.

6. Conclusion

This paper examines whether TB contests can induce higher effort than IB contests under certain conditions. We develop a behavioral economics model that accounts for guilt aversion that contestants in TB contests may have with respect to not wanting to let the team down. We show theoretically that if guilt aversion is sufficiently strong, effort in TB contests will be higher relative to IB contests, which is contrary to the conventional economic wisdom. We then test this prediction for a four-person contest using a series of laboratory economics experiments. The results show that, consistent with the predictions of our model, effort in TB contests is higher than effort in IB contests when participants socialized with their teammates before making effort decisions.

Our experimental results suggest that TB contests can be effective incentive contracts that managers can employ to motivate effort, and, perhaps more importantly, that managers need to pay attention to the social environment in which employees operate when offering team-based incentives. Specifically, TB contests are more likely to generate higher output than IB contests when the potential for guilt aversion in the former type of contest is strong. Managers can influence the factors that affect the strength of guilt aversion, for example, by pairing employees who know each other well as teammates, or by conducting social activities that increase team cohesion, so that team members have strong connections and empathy for one another. In addition, as shown in Experiment 3, managers should provide the opportunity for teammates to observe each other's contributions to the team. Otherwise, the effect of guilt aversion on employees' effort may be weakened.[13]

Supplemental Material

Supplemental material to this paper is available at http://dx.doi.org/10.1287/mnsc.2013.1743.

Appendix A. Derivation of the Marginal Probability of Winning in Team-Based Contests

Consider a contest where $N = 4$ contestants are divided into two teams so that each team has two contestants. These

[13] This prescription is also in line with the finding of Knez and Simester (2001), who show that mutual monitoring among coworkers is critical to the efficacy of a group incentive.

two teams compete based on the team output $Y_t = \sum_{p=1}^{2} e_{tp} + \sum_{p=1}^{2} \varepsilon_{tp} = E_t + \eta_t$, where $\varepsilon_{tp} \sim U[-q, q]$, $t = 1, 2$ represents teams, and $p = 1, 2$ represents contestants within teams, $E_t = \sum_{p=1}^{2} e_{tp}$ and $\eta_t = \sum_{p=1}^{2} \varepsilon_{tp}$. The team with higher team output wins the TB contest.

Killmann and von Collani (2001) show that the general density function for the convolution of independent and identically distributed uniform random variables is

$$f^{(N/2)}(\eta) = \begin{cases} \dfrac{1}{(N/2-1)!(2q)^{N/2}} \displaystyle\sum_{i=0}^{\tilde{n}(N/2,\,\eta)} (-1)^i \binom{N/2}{i} \\ \quad \cdot \left(\eta + \dfrac{N}{2}q - 2qi\right)^{N/2-1} \quad \text{for } -\dfrac{N}{2}q \le \eta \le \dfrac{N}{2}q, \\ 0 \quad \text{otherwise,} \end{cases} \tag{A1}$$

where $\tilde{n}(N/2, \eta)$ is defined as the largest integer that is no more than $(\eta + (N/2)q)/(2q)$. When $N = 4$, the density function of η_t becomes

$$f^2(\eta) = \begin{cases} 0 & \text{for } \eta < -2q, \\ \dfrac{\eta + 2q}{(2q)^2} & \text{for } -2q \le \eta < 0, \\ \dfrac{-\eta + 2q}{(2q)^2} & \text{for } 0 \le \eta < 2q, \\ 0 & \text{for } \eta > 2q. \end{cases}$$

To solve for the probability of winning and the marginal probability of winning in TB contests, we need to consider the following two cases.

Case 1: $E_1 - E_2 \ge 0$. (1) *Probability of winning for team* 1. We first consider the case where $E_1 - E_2 \ge 0$ and examine the probability of winning for team 1. Given any random realization of η_1, team 1 wins the contest only if $E_1 + \eta_1 > E_2 + \eta_2$, i.e., $\eta_2 < E_1 + \eta_1 - E_2$. The probability that η_2 satisfies the above condition determines the conditional probability of team 1 being the winning team given a realization of η_1:

$$\text{Prob}(\textit{team } 1 \textit{ wins} \mid \eta_1) = \int_{-2q}^{E_1+\eta_1-E_2} f^2(\eta_2)\, d\eta_2. \tag{A2}$$

With the above setup, we solve for the probability of winning and the marginal probability of winning for team 1 by considering all possible realizations of η_1:

- $-2q \le \eta_1 \le -E_1 + E_2$. When $-2q \le \eta_1 \le -E_1 + E_2$, the density function for η_1 is $(\eta_1 + 2q)/(2q)^2$, and the conditional probability of winning for team 1 is $\int_{-2q}^{E_1+\eta_1-E_2} (\eta_2 + 2q)/(2q)^2\, d\eta_2$.
- $-E_1 + E_2 \le \eta_1 < 0$. When $-E_1 + E_2 \le \eta_1 < 0$, the density function for η_1 is still $(\eta_1 + 2q)/(2q)^2$, and the conditional probability of winning for team 1 is $\frac{1}{2} + \int_0^{E_1+\eta_1-E_2} (-\eta_2 + 2q)/(2q)^2\, d\eta_2$.
- $0 \le \eta_1 < -E_1 + E_2 + 2q$. When $0 \le \eta_1 < -E_1 + E_2 + 2q$, the density function for η_1 is $(-\eta_1 + 2q)/(2q)^2$, and the conditional probability of winning for team 1 is $\frac{1}{2} + \int_0^{E_1+\eta_1-E_2} (-\eta_2 + 2q)/(2q)^2 d\eta_2$.
- $-E_1 + E_2 + 2q \le \eta_1 \le 2q$. When $-E_1 + E_2 + 2q \le \eta_1 \le 2q$, the density function for η_1 is $(-\eta_1 + 2q)/(2q)^2$, and the conditional probability of winning is for team 1 is one because we already assume that $E_1 - E_2 \ge 0$ so that $E_1 + \eta_1$ is always larger than $E_2 + \eta_2$.

Now, we can calculate the unconditional probability that team 1 wins by integrating the respective density functions over all possible realizations of η_1:

$$\begin{aligned} &\text{Prob}(\textit{team } 1 \textit{ wins}) \\ &= \int_{-2q}^{-E_1+E_2} \left(\int_{-2q}^{E_1-E_2+\eta_1} \frac{\eta_2 + 2q}{(2q)^2}\, d\eta_2 \right) \frac{\eta_1 + 2q}{(2q)^2}\, d\eta_1 \\ &\quad + \int_{-E_1+E_2}^{0} \left(\frac{1}{2} + \int_0^{E_1-E_2+\eta_1} \frac{-\eta_2 + 2q}{(2q)^2}\, d\eta_2 \right) \frac{\eta_1 + 2q}{(2q)^2}\, d\eta_1 \\ &\quad + \int_0^{-E_1+E_2+2q} \left(\frac{1}{2} + \int_0^{E_1-E_2+\eta_1} \frac{-\eta_2 + 2q}{(2q)^2}\, d\eta_2 \right) \frac{-\eta_1 + 2q}{(2q)^2}\, d\eta_1 \\ &\quad + \int_{-E_1+E_2+2q}^{2q} 1 \times \frac{-\eta_1 + 2q}{(2q)^2}\, d\eta_1. \end{aligned} \tag{A3}$$

(2) *Probability of winning for team* 2. Next, we solve for the probability of winning for team 2. Because there are only two teams in the TB contest, the probability of winning for team 2 is simply

$$\text{Prob}(\textit{team } 2 \textit{ wins}) = 1 - \text{Prob}(\textit{team } 1 \textit{ wins}). \tag{A4}$$

(3) *Marginal probability of winning*. We then calculate the marginal probability of winning for each member in a team by differentiating formulas (A3) and (A4) with respect to e_{1p} and e_{2p}, respectively. Because we find that the expressions of the marginal probability of winning are identical across all members, to economize on space, we report only the expression of the marginal probability of winning for the first member of team 1 here:

$$\begin{aligned} &\frac{\partial\, \text{Prob}(\textit{team } 1 \textit{ wins})}{\partial e_{11}} \\ &= -\frac{1}{96q^4} \big[-3e_{11}^3 - 3e_{12}^3 + 3e_{21}^3 + 9e_{21}^3 e_{22} + 9e_{21}e_{22}^2 + 3e_{22}^3 \\ &\quad - 3e_{11}(e_{12} - e_{21} - e_{22})(3e_{12} - 3e_{21} - 3e_{22} - 8q) \\ &\quad + 12e_{21}^2 q + 24e_{21}e_{22}q + 12e_{22}^2 q - 32q^3 \\ &\quad + 3e_{12}^2(3e_{21} + 3e_{22} + 4q) \\ &\quad - 3e_{12}(e_{21} + e_{22})(3e_{21} + 3e_{22} + 8q) \\ &\quad + e_{11}^2(-9e_{12} + 9e_{21} + 9e_{22} + 12q) \big]. \end{aligned} \tag{A5}$$

Because we restrict our attention to the symmetric pure-strategy Nash equilibrium where $e_{11}^* = e_{12}^* = e_{21}^* = e_{22}^* = e_{TB}^*$, the marginal probability of winning for each member in each team reduces to $1/3q$.

Case 2: $E_1 - E_2 < 0$. To solve for the probability of winning and the marginal probability of winning when $E_1 - E_2 < 0$, we start with team 2 instead. Because the two teams are symmetric, the probability that team 2 wins when $E_1 - E_2 < 0$ is exactly given by (A3) when E_1 and E_2 are switched. Hence, following the same logic as in Case 1, we can show that the marginal probability of winning for each member in each team in this case is $1/3q$ as well.

Appendix B. Experimental Instructions for Team-Based Contest in Social Condition B (TB-B)

B.1. Introduction

This is an experiment in decision making. The instructions are simple, if you follow them carefully and make good decisions, you could earn a considerable amount of money, which will be paid to you in cash immediately and privately after the experiment. What you earn today partly depends on your decisions, partly on the decisions of others, and partly on chance. Do not look at the decisions of others, talk, laugh, or engage in any activities unrelated to the experiment. You will be warned if you violate this rule the first time. If you violate this rule twice, we will cancel the experiment immediately and your earnings will be $0.

B.2. Decision Steps
At the start of the experiment, each participant will be assigned to a group of four, and the composition of each group will remain unchanged throughout the experiment. There are a total of 15 decision rounds in this study.

In the first round, you will be randomly and anonymously matched with another participant from your group to form a team. This individual will remain your teammate for five rounds. Your team will be randomly and anonymously matched with another team (that also has two participants) from another group. This team will remain your competitor for five rounds. In other words, both your teammate and your competitor remain the same for five rounds. In the sixth round, you will be randomly and anonymously rematched with another participant from your group (who will be your teammate) and another team that is made up of two participants from the other groups (who will be your competitor). You will proceed for another five rounds in this format, and then the same process will occur in the 11th round. The experiment will come to a completion after 15 rounds.

Please refer to the "Decision Cost Table" now. Your task in every round is to select a *decision number*, which ranges from 0 to 75. Associated with each decision number is a *decision cost*, which is listed on the same row in the next column. After you have selected your decision number, the computer will generate your *random number*. This random number ranges from −60 to 60. Each number in this range has an equal chance of being drawn.

After this, the computer will generate your *final number*, which is calculated as follows:

$$\textit{final number} = \textit{your decision number} + \textit{your random number}.$$

Note that if you choose a higher decision number, your final number will be higher. However, choosing a higher decision number also means that you will have to pay a higher decision cost. The final numbers of the other participant in your team and those in the other team are determined in exactly the same manner.

The computer will then generate your *team's final number* as follows:

$$\begin{aligned}&\textit{team's final number}\\&\quad = \textit{your final number} + \textit{the final number of the}\\&\qquad \textit{other participant in your team}.\end{aligned}$$

The team's final number of the other team that your team is matched with is also determined in the same manner.

The computer will rank the team's final numbers of the two matched-up teams from high (first) to low (second).

If your team is ranked first, your team will receive a *fixed payment* of 13 points, which will be equally split between you and your teammate. If your team is ranked second, your team will receive a fixed payment of 2 points, which will be equally split between you and your teammate.

B.3. Determining Your Point Earnings and Cash Earnings
Your point earnings in each round will be

(a) 6.5 *points minus your decision cost*, if your team is ranked first.

(b) 1 *point minus your decision cost*, if your team is ranked second.

We will repeat the same procedure in every round. In each round, you will choose a decision number. (You may pick the same one or a different one.) The computer will generate your random number, calculate the final number and the team's final number, rank the team final numbers for the two teams, and then compute your payoff for that round. Recall that the identities of the participants you are matched with in the same team and in the other team remain the same for five rounds and then change. Your *total point earnings* will be the sum of your point earnings across the 15 rounds. Also, note that the computer will generate a random number separately in every round and that the values of random numbers that have been drawn do not affect the values of future numbers that will be drawn.

Your *cash earnings* will be your total point earnings multiplied by 0.2. The more points you earn, the more money you will make. We will pay everyone *privately* after all the participants have completed the experiment.

Before we begin the experiment, we will also go through three practice rounds to familiarize you with the procedure. In these practice rounds, you will be playing against the computer (and not the other participants) and there will be no monetary payoffs. Are there any questions?

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