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Strategic Thinking in Contests

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Abstract

We examine motives for over-bidding in contests using both individual and team contests. In team contests, subject pairs send suggested bids and messages to their teammates. Content analysis of the messages provides insight into an individual's bidding motives. In addition, we elicit measures of preferences, beliefs, and impulsiveness. We find that beliefs about others' bids and messages that emphasize winning (i.e., utility of winning) are the most robust predictors of over-bidding. Our results suggest that analyzing communication provides a rich window into an individual's thought process when making decisions, and can complement insights from elicited values from common decision tasks.

Keywords: Tullock contest, lottery contest, winner-take-all, two-headed contest, team contest, strategic thinking, communication, overbidding

JEL classification: C92

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1 Introduction

Contests are useful models for studying a wide variety of situations in which agents can expend costly effort to win a prize. Many examples can be found in political, economic, and social spheres, including running for political office, research to develop a new patent, applying for admission to college, getting a promotion within a firm, and dating a partner. Decades of experimental research on contests shows that, on average, people expend more effort than theory predicts. Indeed, it is not unusual that the total amount of resources spent on trying to win the contest exceeds the value of the prize. Accordingly, theoretical and experimental research has focused on trying to understand what drives 'overbidding' in contests. We contribute to this literature by designing an experiment that allows us to match contestants' behaviors with their strategic thinking in winner-take-all lottery contests (Tullock, 1980). Our findings shed light on the underlying motives driving overbidding in these common environments.

A number of theories have been proposed to explain overbidding in Tullock contests, including (i) the non-monetary utility of winning (Schmitt et al., 2004; Parco et al., 2005), (ii) confusion and mistakes (Anderson et al., 1998; Potters et al., 1998), (iii) risk preferences (Hillman and Katz, 1984; Millner and Pratt, 1989, 1991), (iv) loss aversion (Kahneman and Tversky, 1979; Shupp et al., 2013; Eisenkopf and Teyssier, 2013), (v) impulsiveness (Frederick, 2005; Sheremeta, 2018; Cox, 2017), (vi) limited cognitive ability (Gill and Prowse, 2016), and (vii) competitive maximization of relative payoffs (Herrmann and Orzen, 2008; Eisenkopf and Teyssier, 2013; Mago et al., 2016). Experimental tests show support for some of the proposed theories when a single factor is considered in isolation, which we summarize in the next section. By contrast, a recent study by Sheremeta (2018) uses a set of experimental tasks to jointly test all of these theories. The results suggest that impulsiveness is the primary driver of overbidding in lottery contests.

We take a different but complementary approach to analyzing the relative importance of each of these proposed explanations. In addition to using a similar portfolio of decision tasks, we attempt to uncover individuals' underlying motives for bidding in contests through analyzing strategic communication. In our experiment, we pair two subjects together to work as a team that makes a single joint decision on how much to bid for an 8-token prize in a lottery contest. Each team member simultaneously submits their suggested bid to their partner in tandem with a text message they can use to convey their reasoning behind their suggested bid. After the messages and suggested bids are sent, each team member submits their final bid, and one of the two final bids is randomly chosen as the binding team bid.[1] By analyzing the message a team member sends to his/her partner, we get a glimpse into an individual's thought process to better understand how players reason in lottery contests and what motivates their bidding decisions.[2]

This "two-headed" approach to studying communication has been used in other settings (e.g., Cooper and Kagel, 2005; Kagel and McGee, 2016; Cox and Stoddard, 2018; Cason and Mui, 2019). Our design is most similar to Burchardi and Penczynski (2014), who use the two-headed method to examine strategic thinking in guessing games. This approach can be likened to other methods used to elicit beliefs, preferences, or strategies in experiments. The underlying premise is that what subjects write in their messages to their partner in the two-headed contest reflects their individual motives for bidding in a standard contest (Burchardi and Penczynski, 2014). For comparison, subjects in our experiment also participate in a standard lottery contest in which they bid as individuals for an 8-token prize. With this experimental design, we compare suggested bids in the team contest with bids in the individual contest.[3] Hence, we depart from previous literature aimed at comparing individual bids with final group bids (Cox and Hayne, 2006; Sutter et al., 2009; Casari et al., 2016; Sheremeta and Zhang, 2010; Cheung and Palan, 2012), as our goal is to utilize the team setting to gain insight into motivations for individual behavior. Indeed, we find no significant difference between the average bid in the individual contest and the average initial suggestion for the team bid. Although suggesting a team bid that was equivalent to one's bid in the individual contest was the modal behavior of contestants, it was not universal. Nonetheless,

[1] Both members incur the cost of the single bid and, if the team wins the contest, both members win 8 tokens.

[2] Prior to the experiment, a set of chat categories was established based on the literature and the proposed theories for overbidding. Research assistants were then trained and coded the messages. Some additional categories were added based on reading a sample of the messages and finding some unexpected reoccurring themes, as discussed in the Results section.

[3] Sheremeta and Zhang (2010) examine group contests (four two-person teams bidding for a prize) and find bids in group contests are lower and have a smaller variance than bids in individual contests. Although team members could send free-form chat messages prior to finalizing bids, Sheremeta and Zhang (2010) do not analyze the content of chat messages.

contestants behavior was sufficiently consistent in these two tasks to improve our understanding of overbidding in contests.

To complement the analysis of team communication, and to better compare our results to the established literature, subjects also participate in a set of experimental tasks to elicit preferences, beliefs and cognitive abilities. Following Sheremeta (2018), subjects participate in a zero-prize contest to elicit their non-monetary utility of winning, two multiple price lists of lotteries to elicit their risk and loss preferences, a social value orientation task to elicit their social preferences, and the cognitive reflection test (CRT) to elicit their impulsiveness. Subjects also submit their beliefs about their opponents' bids after making their bidding decisions. Consistent with Sheremeta (2018), when controlling for these elicited values (before analyzing communication) we find that beliefs about opponents' bids and CRT scores are the only significant predictors of bids in the individual (i.e., standard) Tullock contest.

When introducing controls for the types of messages subjects send to their partners in the team contest, we find messages that emphasized winning were the largest robust predictor of bidding behavior. That is, those players that send messages focused on winning without considering the costs (e.g., "*let's bet it all to make sure we win*") tend to bid more. This finding is robust to specifications that consider communication categories separately as well as joint specifications that also include the elicited values. Moreover, messages emphasizing winning is a robust predictor of individual bids and suggested team bids, in all specifications.

Importantly, our joint specifications include two measures of the utility of winning; one for a participant's bid in a zero-prize contest (e.g., Sheremeta, 2010b; Price and Sheremeta, 2011; Sheremeta, 2018), and one for messages coded as emphasizing winning. The result that the messages that emphasized winning remains significant when bids for the zero-prize contest are controlled for suggests that the two metrics are not close substitutes. One possible reason the two metrics differ is that subjects may have a non-monetary utility of winning that is not completely independent of the prize value. For example, a subject may experience utility from winning, but only for non-zero prizes. Our results suggest that analyzing communication provides a rich window into an individual's thought process when making decisions, and may help explain behaviors in ways other elicited values cannot.

In the next section, we provide a summary of the experimental literature on Tullock contests and reasons for overbidding. We then introduce the experimental design and hypotheses, followed by the results and conclusion.

2 Theoretical Background and Related Literature

Our experiments focus on explaining overbidding in the classic rent-seeking model of Tullock (1980), in which two players compete for a prize of value v. In the Tullock contest, two players simultaneously make unrecoverable bids. Player i's probability of winning the prize is a function of both bids, as follows:

$$p_i(b_i, b_j) = \begin{cases} \frac{b_i}{b_i+b_j} & \text{if} \quad b_i + b_j > 0 \\ 0.5 & \text{if} \quad b_i + b_j = 0. \end{cases} \tag{1}$$

Assuming risk neutrality, player i's optimization problem is thus:

$$\max_{b_i} v p_i(b_i, b_j) - b_i. \tag{2}$$

Solving this optimization problem for $b_j > 0$ yields i's best response function[4]:

$$b_i(b_j) = \sqrt{v b_j} - b_j. \tag{3}$$

The analysis for player j is similar. Solving the best response functions for players i and j together yields the unique Nash equilibrium solution, $b^* = b_i = b_j = v/4$. Moreover, b^* is the maximum of the best response function, and higher bids are strictly dominated.

Millner and Pratt (1989) provide the first test of the Tullock (1980) model of rent seeking using controlled experiments. Subjects were placed in groups of two and could purchase lottery tickets in order to influence the probability they win an exogenous prize. In the simplest treatment, often called a *lottery* contest, a contestant's probability of winning the prize is equal to their proportion of

[4] The best response to $b_j = 0$ is not well-defined with continuous bids, but in the discrete case equals the smallest possible positive bid.

the total number of tickets purchased by the group. Millner and Pratt (1989) find that, on average, subjects expend more effort (i.e., purchase more lottery tickets) to win a prize than predicted by theory. The same general finding of overbidding (or over-investment in effort) relative to theory has been consistently reported over the course of the last two decades (e.g., Davis and Reilly, 1998; Potters et al., 1998; Anderson and Stafford, 2003; Sheremeta, 2010a,b, 2011; Sheremeta and Zhang, 2010; Savikhin and Sheremeta, 2013; Morgan et al., 2012). The experimental papers reporting overbidding in lottery contests are summarized in recent surveys (e.g., Sheremeta, 2013; Dechenaux et al., 2015).

Various theories have been proposed to explain overbidding in Tullock contests. We segment the remainder of this section by these different theories and summarize the relevant experimental evidence. This structured approach to discussing the state of the literature also helps motivate our experimental design. The elicitation exercises and chat categories we consider in our experiment are derived directly from the prevailing theories and empirical evidence explaining overbidding in contests.

2.1 Utility of Winning

A standard assumption is that players care only about monetary payoffs, such as the prize v from winning the contest. However, players may also get utility from winning the prize beyond its monetary value (Schmitt et al., 2004; Parco et al., 2005). A number of experiments examine non-monetary utility of winning by having players spend resources to win a prize of $0 (Sheremeta, 2010b; Price and Sheremeta, 2011; Sheremeta, 2018; Cason et al., 2018). These studies find that over 40 percent of players spend money trying to win, and show that expenditures in the zero-prize contests are highly correlated with expenditures in a standard contest with a monetary reward. However, when jointly controlling for other potential predictors for overbidding, Sheremeta (2018) finds that bids for zero-prize are not significantly correlated with bids for a prize of positive value.

2.2 Maximizing Relative Payoffs

Relative payoff maximization (Herrmann and Orzen, 2008; Eisenkopf and Teyssier, 2013; Mago et al., 2016) assumes players care about having higher payoffs than others, in addition to their own absolute payoff. For these *competitive* individuals, utility increases with advantageous payoff inequality relative to their opponent. While not required, relative payoff maximization is consistent with spiteful preferences (Hamilton, 1970), and with evolutionary contest theory (Hehenkamp et al., 2004). This model makes similar predictions to the utility of winning model, with identical bid functions under some parameter conditions. That is, players with more competitive preferences are expected to bid more in Tullock contests. The theory has been tested experimentally by using simple tests to elicit social preferences and then using the results as predictors of the bid function (Charness and Rabin, 2002; Sheremeta, 2018). While Sheremeta (2018) finds evidence that competitiveness and bidding are positively correlated when considered in isolation, the relationship is insignificant when considered jointly with other predictors. Moreover, Cox (2017) finds that average bids are similar when the rival player is a robot rather than a human subject.

2.3 Risk and Loss Aversion

The Tullock model has been extended to allow for risk averse subjects. In general, risk aversion has an ambiguous effect on bidding behavior in these theoretical models (Millner and Pratt, 1991; Dechenaux et al., 2015), although under certain assumptions risk aversion is predicted to lower bids (Treich, 2010). Experimental evidence indicates this to be true, as risk aversion is negatively correlated with expenditures in a Tullock contest (Millner and Pratt, 1991; Anderson and Freeborn, 2010; Sheremeta and Zhang, 2010; Price and Sheremeta, 2011; Sheremeta, 2011; Mago et al., 2013; Shupp et al., 2013; Sheremeta, 2018; Cason et al., 2018).[5] Likewise, the experimental evidence also shows a negative correlation between bidding behavior and measures of loss aversion (Shupp et al., 2013; Sheremeta, 2018). However, since most subjects are risk and loss averse, these preferences do not appear to be the primary explanations for overbidding.

[5]The earliest experimental study on risk aversion in Tullock contests is Millner and Pratt (1991), using a risk aversion task established by Murnighan et al. (1987). In more recent papers, the most common approach is to use the Holt and Laury (2002) lottery choice task to elicit risk preferences.

2.4 Impulsiveness

A more recent explanation for overbidding in Tullock contests leans on the dual-system theory of decision making by Kahneman (2011). Sheremeta (2018) posits that less impulsive participants (those using the more reflective System 2 decision making) will bid closer to the Nash equilibrium. To test this theory, both Cox (2017) and Sheremeta (2018) utilize the cognitive reflection test (CRT) which measures the impulsiveness of behavior (Frederick, 2005). Both find that more impulsive participants bid more in Tullock contests.

2.5 Other explanations

Other explanations for overbidding have been proposed and examined in the literature. Studies have examined mistakes and confusion as a possible predictor, finding that subjects who demonstrate a better understanding of the game (i.e., score higher on a quiz) tend to bid less than their more confused counterparts (Sheremeta, 2010b, 2018). Theory and experiments have been used to explore subjective probability weighting (Parco et al., 2005; Amaldoss and Rapoport, 2009; Sheremeta and Zhang, 2010), demographic and religious differences (Price and Sheremeta, 2015) and the impact of changing parameters (e.g., cost structure and prize rule) of the contest (Chowdhury et al., 2014).

With the findings from the large experimental literature on contests as a starting point, we look to contribute to this body of research by investigating strategic thinking in Tullock contests through content analysis of team communication.

3 Experimental design and hypotheses

In all parts of the experiment, except for the team contest, a decision maker is an individual subject. The team contest uses a two-heads team decision making design, which has been implemented in different ways in the literature (Cooper and Kagel, 2005; Kagel and McGee, 2016; Cox and Stoddard, 2018; Cason and Mui, 2019). We follow the experimental method introduced by Burchardi and Penczynski (2014). In the team contest, a single decision maker is a team, composed of two subjects who each submit bids. In the first stage of the team contest, each team member submits a suggested bid and a text message via the computer to the other team member. Subjects are instructed to use the message to convince their partners of the reasoning behind their suggested bids. Messages are limited to 200 words and subjects are instructed not to include identifying information or offensive language. After observing the other team member's suggested bid and message, each team member enters a final bid. One of the two final bids in a team is randomly chosen to be implemented in the payoff calculation. Each team member pays the chosen team bid amount and each receives the same reward from the contest. Thus, team members' monetary incentives are perfectly aligned. Messages sent between two team members were not observed by other teams and members on different teams could not communicate with each other.

The experiment has 8 parts. Instructions are in the electronic supplemental materials. Subjects receive no feedback about any part of the experiment until after completing all 8 parts. Part 1 is a standard two-player individual Tullock contest. Each player is endowed with 10 tokens and can make any bid in whole tokens between 0 and 10. The prize for winning the contest is 8 tokens, with a Nash equilibrium prediction of bidding 2 tokens. Bids are subtracted from the initial endowment of tokens. Each token is worth \$0.50.

Part 2 is the team contest described above. The team contest is similarly parameterized as the individual contest, the difference being that bids and rewards are assigned to both team members. The team contest always follows the individual contest so the suggested team bid and individual bid are independent observations. Once a team member observes his/her teammate's suggested bid and reads his/her teammate's message, subjects' decisions are no longer independent. Thus, final team bids are not independent from individual and suggested team bids.

Part 3 asks subjects to provide a guess about their opponent's bid in Parts 1 and 2. In Part 1, this is a subject's belief about the bid of the individual they are competing against. In Part 2, this is a subject's belief about the final team bid of the team they are competing against. Subjects receive an additional token for each correct guess.

Part 4 is an individual contest similar to Part 1, except the prize for winning the contest is 0 tokens. Each player is endowed with 5 tokens and can make any bid in whole tokens between 0 and 5 tokens. The zero-prize contest is meant to measure a subject's utility of winning, as any bid is wasteful.

Part	Task
Part 1	Individual Contest
Part 2	Team Contest
Part 3	Belief Elicitation
Part 4	Zero-Price Individual Contest
Part 5	Social Value Orientation
Part 6	Loss Aversion
Part 7	Risk Aversion
Part 8	Cognitive Reflection Task

Subjects	Sessions
188	10

Table 1: Decision Tasks Summary

Part 5 is the social value orientation task. Each subject is matched with another subject and allocated money between him/herself and the other subject in 6 decision rounds (Murphy et al., 2011).

Part 6 is a loss aversion task where subjects made 10 decisions between a lottery and a sure amount. One of the two outcomes in each lottery is a loss, while the certain amount is $0.00 (Shupp et al., 2013).

Part 7 is a risk aversion task where subjects made 10 decisions between a lottery and a sure amount. The lottery varies the probabilities of earning $1 or $0 and the certain amount is $0.50 (Anderson et al., 2006; Bruner, 2009).

Part 8 is the extended form of the Cognitive Reflection Test (CRT). The original CRT has three questions (Frederick, 2005). The extended form has those same three questions, plus an additional three questions (Toplak et al., 2014). Subjects are paid $0.25 for each correct answer. Table 1 lists each Part and summarizes the tasks.

A perfect strangers matching protocol is implemented for Parts 1-5. After completing Parts 1-8, subjects are shown the outcome and earnings from the experiment. Subjects are paid for either Part 1 or Part 2 (not both) based on a random draw made by the computer. Earnings in Parts 3, 4, and 8 are based on all of a subject's decisions in each Part. Earnings from Part 5 are based on two random draws that determined which round is used to calculate earnings and which subject is the allocator. Earnings from Parts 6 and 7 are based on decisions and outcomes from one of the 10 randomly chosen decisions from each part.

All experimental sessions were conducted at Appalachian State University between Spring 2018 and Fall 2018. Undergraduate subjects from a wide range of disciplines were recruited using ORSEE (Greiner, 2015). Subjects made all decisions on computers in private. All sessions were programmed and conducted in z-Tree (Fischbacher, 2007). Instructions (provided in Appendix AII) were read publicly by an experimenter while subjects followed along on their computer screens. For each of Parts 1-4, the instructions for a part were read, followed by subjects making decisions. Review questions were also answered by subjects in Parts 1 and 2. Review question answered incorrectly were attempted again on a new screen until answered correctly. Following the completion of Parts 1-4, subjects were told they could complete the remaining parts at their own pace and instructions were no longer read aloud publicly. Following the completion of all Parts, earnings were reported to subjects. Demographic questions and two questionnaires were then completed, a questionnaire on subjects' current emotional state and a 10-question Big 5 personality questionnaire (Rammstedt and John, 2007). On average, subjects earned approximately \$11.61 and each session lasted 45 minutes.

3.1 Hypotheses

We compare individuals with teams to examine the degree to which playing in teams affects bidding. We also use team chat logs to examine strategic thinking and motives for bidding. Team chat logs were coded into categories by two research assistants. The categories include references to issues such as winning, balancing costs and benefits, anticipating the other team's bid, mentioning risk, and impulsive bidding. Importantly, these categories are not mutually exclusive, and multiple categories may be coded simultaneously. Moreover, teams may be heterogeneous in their motives. We use team chat logs to examine the relative prevalence of various motives for overbidding as well as the degree to which discussions of these motives correlate with contribution decisions.[6]

Below we present our hypotheses about the correlation between bids in the individual and team contests (Parts 1 and 2) and chat messages. As the outcomes of the contests are not provided until the end of the experiment, and subjects do not observe their teammates' decisions/messages until prior to making final team decisions, we focus the analysis on individual and suggested team bids. Given our intention is to use the content of chat messages to explain overbidding, our first hypothesis is that players will overbid relative to Nash predictions.

Hypothesis 1 ***(Overbidding)***. *Individual and suggested team bids will be significantly higher than the Nash prediction.*

One of the more prominent explanations of overbidding in the literature suggests there is non-monetary utility associated with winning. To explore this, we examine the correlation between bids and messages that emphasized winning in the team contest.

Hypothesis 2 ***(Utility of Winning)***. *Discussion of winning as a primary motivation for bidding will be positively correlated with individual and suggested team bids.*

Alternative explanations for bidding behavior rely on social preferences. For instance, prosocial preferences might appear in bidding decisions because bids beyond the Nash equilibrium prediction are inefficient to both teams. On the other hand, competitive preferences might appear in bidding decisions if subjects want to earn more than other subjects or decrease other subjects' earnings. We explore whether contestants discuss maximizing the joint payoff of both teams, or if they discuss earning more than the other team, and to what extent such concerns can explain bidding behavior.

Hypothesis 3 ***(Pro-Social)***. *Discussion of maximizing joint payoffs of the two teams will be negatively correlated with individual and suggested team bids.*

[6]Some limitations are inherent in content analysis of team chats. RAs' interpretation of chat is subjective, and some subjects may omit some of their motives if they believe their teammate is likely to disagree. However, chat logs provide rich data and new insight into the decision-making process.

Hypothesis 4 ***(Competitive)***. *Discussion of wanting to earn more than the other team or lowering the earnings of the other team will be positively correlated with individual and suggested team bids.*

Still, other explanations of overbidding appeal to the risk preference of contestants. In previous studies, subjects who exhibit loss- and risk-averse preferences tend to bid lower, and subjects with risk-seeking preferences tend to bid higher. Hence, we examine whether chat messages coded as exhibiting either positive or negative attitudes towards risk and/or concentrating more on limiting potential losses rather than achieving potential gains are related to bids.

Hypothesis 5 ***(Loss and Risk Aversion)***. *Discussion of minimizing risk and/or losses will be negatively correlated with individual and suggested team bids.*

Hypothesis 6 ***(Risk Seeking)***. *Risk seeking messages will be positively correlated with individual and suggested team bids.*

Further, psychological theory suggests overbidding may be driven by impulsive behavior. Hence, we explore whether there is any link between chat messages with excessively vague reasoning or using clichés in place of reasoning and bidding behavior.[7]

Hypothesis 7 ***(Impulsive)***. *Impulsive messages will be positively correlated with individual and suggested team bids.*

Yet another reason for overbidding could be that contestants are confused about the rules of the contest. Content analysis of chat messages provides a measure of confusion about the contest when subjects clearly do not understand aspects of the decision environment.

Hypothesis 8 ***(Confusion)***. *Discussion displaying confusion about the contests will be positively correlated with individual and suggested team bids.*

[7]The category for using only clichés, catch phrases, etc. was added after reading a sample of messages and finding several such instances.

Discussion of balancing the costs and benefits from bidding would show that subjects are thinking analytically or in payoff maximization terms about their bidding decisions. We expect such analytical thinking to be associated with reduced overbidding.

Hypothesis 9 ***(Balancing Costs and Benefits)****. Discussion of the costs and benefits from bidding will be negatively correlated with individual and suggested team bids.*

In summary, we examine which chat codes have the strongest power to predict (over-)bidding in contests. As other studies applying the two-heads approach to different decision environments have gleaned substantial insight into subjects' strategic thinking, applying this approach to contests should provide similar insight into the important phenomenon of over-bidding.

Furthermore, by having subjects complete preference elicitation tasks after the team contest, we make a substantial methodological contribution by examining the correlation between chat messages and related elicitation tasks. The unique information obtained from the chat messages is likely to be correlated with related preference elicitation tasks. However, we think that chat messages provide an even richer data set for understanding strategic motives. If this is true, then the correlation between chat codes and related elicitation tasks will not be strong. Such a finding would provide evidence for the belief that chat messages and elicitation tasks are complements, rather than substitutes. For instance, if subjects receive utility from winning, but only for winning non-zero prizes, messages discussing winning as the primary motivation capture a more general utility of winning that may not present itself in a zero-prize contest. Such a finding would allow researchers to more confidently pursue content analysis as a viable method to understanding subjects' strategic motivations. Content analysis of chat messages from the two-heads approach has been used in a wide variety of economics experiments, starting with Cooper and Kagel (2005). However, to the best of our knowledge, our study is the first to seek to verify this methodology in this way.

In addition to team motives, we also believe the coded messages will reveal underlying motives in individual Tullock contests. In order to test this claim, subjects received no feedback after participating in the individual Tullock contest in Part 1 of our experiment. In Part 2, subjects are randomly re-matched with a different subject to form a team and send suggested team bids and messages to each other, again with no feedback from the individual Tullock contest in Part 1. Feedback first occurs only after each team member reads the other team member's message and suggested bid. Messages are sent directly after subjects make their individual bids, with their individual motivations fresh on their minds. This within-subject protocol was intentionally used to create the cleanest comparison between individual and suggested team bids. If individual and suggested team bids are similar, then we have strong evidence that strategic motives expressed in chat messages can be interpreted as motives for both individual and suggested team bids. We make the following conjectures.

Hypothesis 10 ***(Consistent Bidding)***. *Individual bids will not differ from suggested team bids.*

4 Results

4.1 Summary Statistics

Table 2 provides definitions and summary statistics of the elicited values used in the subsequent analysis. The variables are listed in the order of elicitation. The primary variables of interest are the individual bid and the suggested team bid. The two bid distributions have similar means, although the variance of suggested team bids is slightly smaller.[8] However, further analysis reveals that these two distributions differ more than these summary statistics might suggest. We explore the extent to which bids in the individual contest and suggested bids in the team contest can be explained by heterogeneity in elicited values from other tasks, which are summarized in the lower portion of Table 2. We also examine the ability of the content of messages in the team contest to explain individual and suggested team bidding behavior.[9] The content of messages was coded into an array of categories by two research assistants.[10]

[8]The paired t-test for equal means is insignificant (t=1.168, p=0.244). The F-test for equal variances is significant at the 10% level (F=1.305, p=0.069).

[9]On average, subjects took 226 seconds to write their messages and make their suggested bids, with a range of 90 to 292 seconds.

[10]One of the research assistants was an undergraduate economics majors at Virginia Commonwealth University and the other was a graduate student in data analytics at Appalachian State University.

Table 2: Summary of Elicited Values from Experimental Tasks

Elicited Values	Description	Mean	Std Dev	Min	Max
Individual Bid	Number of tokens bid in individual contest	4.01	2.36	0	10
Suggested Team Bid	Suggested number of tokens to bid in team contest	3.97	2.07	0	10
Final Team Bid	Number of tokens bid in team contest	3.80	1.96	0	10
Belief 1	Conjecture of opponent's bid in individual contest	3.87	1.85	0	10
Belief 2	Conjecture of opposing team's bid in team contest	4.32	1.95	0	10
Zero Prize Bid	Number of tokens bid in zero prize contest	0.59	1.24	0	5
Number Incorrect	Number of incorrect responses to instruction quiz	0.87	1.01	0	4
Number Safe - Risk	Number of safe choices in risk preference elicitation	5.37	2.02	0	9
Number Safe - Loss	Number of safe choices in loss aversion elicitation	4.68	1.44	0	9
SVO angle	Social value orientation	22.76	15.04	-13.05	55.37
CRT score	Number of correct responses in cognitive reflection task	4.01	2.36	0	6

Table 3 summarizes the results of the content analysis by providing the number of times each research assistant coded every category (out of 188 subject messages), as well as Cohen's κ (Cohen, 1960) for each category, which characterizes inter-rater reliability. Perfect agreement is represented by $\kappa = 1$, while $\kappa = 0$ indicates no more than chance agreement. In our analysis, we include only categories with at least a fair rate of agreement ($\kappa \geq 0.3$), based on the benchmark scale of Landis and Koch (1977). Agreement is too weak for the Confusion and Relative Payoff categories, and thus our results are inconclusive concerning Hypotheses 8 (Confusion) and 4 (Competitive). The Joint Profit category is also excluded from our analysis, as it was coded for only a single observation. Thus, we also find inconclusive results concerning Hypothesis 3 (Pro-Social). The results remain very similar if the Joint Profit category is included in our regressions.

Both the set of experimental tasks and the message content categories were chosen to correspond with factors that theoretically could cause bids to deviate from the standard Nash equilibrium prediction. Although we are primarily concerned with factors that lead to overbidding relative to

Table 3: Summary of Message Content Categories

Message Content	Description	Number of Times Coded RA 1	RA 2	Cohen's Kappa
Emphasized Winning	Primary goal of winning the contest. Competitive language. Not concerned about the balance of costs and benefits. Focused on reward.	22	29	0.570
Minimize Losses	Concentrating more on limiting potential losses than achieving potential gains. Only concerned about limiting how much money they will lose from bidding in the contest. Negative attitude toward losses.	10	26	0.398
Mentioning Risk	Concerned about bidding because the contest is uncertain/risky. Using terms like "safe" or "less risky" options. Any mention of risk.	73	51	0.289
Aversion to Risk	Negative attitude toward risk. When mentioning risk, specific concern about bidding too much because the chance of losing without receiving the reward.	33	28	0.472
Seeking Risk	Positive attitude towards risk.	3	4	0.854
Joint Profit	Conveys concern about bids being wasteful. Concern about opposing team's payoff.	1	1	1.000
Cost & Benefit	Considers both the costs and expected benefits of bidding. Might suggest a bid to maximizing earnings. Cares primarily with profiting from the contest. Not necessarily winning, but maximizing earnings.	139	85	0.387
Other Team's Bid	Trying to guess how much the other team will bid.	26	30	0.748
Relative Payoff	Wanting to get a higher payoff than the other team. May express a spiteful attitude.	1	1	-0.005
Impulsive - Vague	Stating they are not sure what they should do, either explicitly or implicitly. Not knowing why they suggested the bid. Knowingly vague explanation.	19	11	0.424
Impulsive - Cliché	Only using a catch-phrase, movie quote, song lyrics, cliché, etc.	2	7	0.435
Confusion	A clear example of not understanding how the contest works. A clear example of not understanding how payoffs are determined based on bids and winning/losing. Any other factually inaccurate statement about the experiment.	17	7	0.120

the Nash prediction, it is important to control for relevant factors affecting bidding behavior in the analysis.

It is useful to examine examples of some of the chat categories. Emphasized Winning is coded for messages focusing on winning the reward rather than balancing the costs and benefits of bidding. For example:

Because the more tokens we have the bigger a chance we have of winning

Minimize Losses is coded for messages emphasizing loss avoidance rather than winning or balancing costs and benefits. For example:

This is a good number because if not we gonna be some broke bois.

Aversion to Risk is coded for negative discussions of risk. Recall that our categories are not mutually exclusive in general, and this category in particular can overlap with Minimize Losses. The following is an example of Aversion to Risk:

I don't want to take the risk. 1 is a safe bet

In contrast with the previous category, Seeking Risk is coded for positive discussions of risk. For example:

risk it for the biscuit

The most frequently occurring category is Cost and Benefit, which is coded for messages that discuss balancing the advantages and disadvantages of bidding. For example:

It's high enough that we have a good probability without losing too many tokens but not too high.

In some cases, either costs or benefits appears to be given greater relative emphasis, but the Cost and Benefit category is still coded. For example:

low chance of winning but - less tokens if we lose. LETS GET THIS BREAD

When messages specifically try to anticipate the other team's bid, Other Team's Bid is coded. In the following example, a subject anticipates the Nash equilibrium result:

I think we should bid 2 because it is low cost and high reward. I assume the other team will also do the same.

After reading a sample of messages, we decided to split messages suggestive of impulsive decisions into 2 seperate categories. The first is Impulsive - Vague, which is coded for intentionally unclear messages, such as:

why not

Some cases coded as Impulsive - Vague included specific statements that the subject did not have an explanation for their suggested bid. For example:

no good reason

The second type of message suggestive of impulsive decision making is Impulsive - Cliché. The category is coded for messages mainly using catch phrases, pop culture references, etc., without clear reasoning. For example:

Go big or go home! Let's see what happens. Best of luck.

Other chat categories occurred too infrequently or were too difficult for the RAs to agree upon for inclusion in our main analysis. We omit examples of these categories.

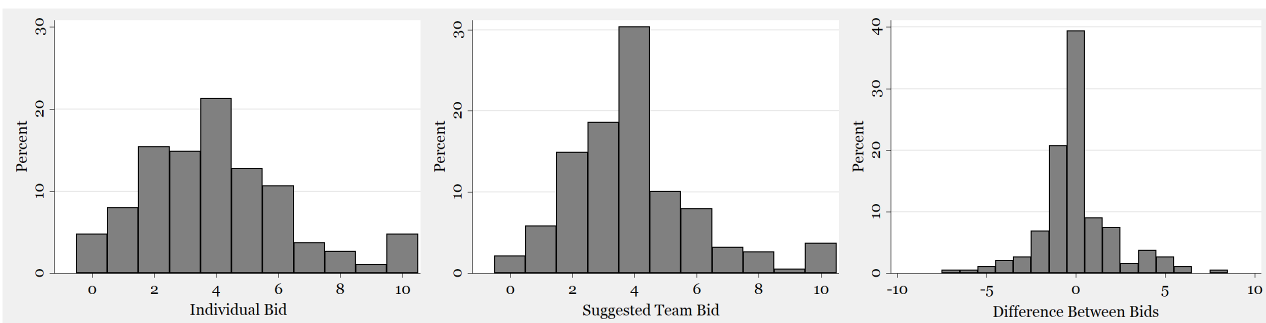

Figure 1: Distributions of Individual Bids, Suggested Team Bids, and the Differences

4.2 Bidding Behavior

Next, we compare the bid distribution for the individual contest and the distribution of suggested bids in the team contest in the left and middle graphs, respectively, of figure 1. In both cases we see bids from 0 to 10 tokens, with the modal bid being 4 tokens in either case. Unsurprisingly, the team contest appears to have altered the behavior of some contestants, as can be seen by the distribution of the difference in individual and suggested team bids in the right graph of figure 1. Roughly 35% of contestants' suggested team bids were below their individual bids, while the opposite was true of about 25% of contestants. Still, nearly 40% of contestants' suggested team bids were identical to their individual bids. Nonetheless, the correlation between the two bid distributions is significantly less than one ($\rho = 0.57$).[11]

Result 1 *Related to 10 (Consistent Bidding), individual bids and suggested team bids have similar means, but suggested team bids have smaller variance. Bids in both contests display significant overbidding relative to the Nash prediction, consistent with Hypothesis 1 (Overbidding).*

Given the difference between the two distributions, we conduct our subsequent analysis on both the bids in the individual contest and the suggested bids in the team contest to explore which factors influence bidding behavior. We conduct a regression analysis of bids in the individual contest and suggested bids in the team contest using both elicited values from experimental tasks as well as the results of the chat message content analysis as predictors. The estimation results from three separate models are reported in Tables 4 and 5 for bids in the individual contest and suggested team bids, respectively. The results when only elicited values are used to predict bids are reported in the first column. The results when only the content of messages are used as predictors are reported in the second column. In the third column, elicited values are combined with chat message content to predict bids. All regression models are estimated using ordinary least squares.[12]

There are a few notable results. First, there is a significant nonlinear relationship between bids in the individual contest and beliefs that is consistent with the theoretical best-response function. Second, the cognitive reflection task scores are the only other elicited value that exhibits a robust correlation with bids in the individual contest. Lastly, subjects who emphasized winning in their message bid significantly more than others in the individual contest.

Next we turn our attention to the regression analysis of the suggested bids in the team contest in Table 5. There are some similarities between the two sets of regression results, but also quite a few differences. These differences are not surprising given most contestants suggested a team bid

[11] The joint hypothesis test that the intercept is zero and the slope is one when individual bids are regressed on suggested team bids is significant at the 1% level ($F = 45.46$, $p < 0.001$).

[12] We performed a robustness check by conducting the regression analysis using only consistent bidders, those who bids in the individual contest were equivalent to their suggested team bid. Our main finding that subjects who emphasized winning in their message to their teammates bid significantly more is robust to the exclusion of inconsistent subjects. This analysis is reported in Appendix AI.

Table 4: Regression Analysis of Bids in the Individual Contest

Individual Contest Bids			
Elicited Values	Model 1	Model 2	Model 3
Belief	0.960***		1.061***
	(0.281)		(0.272)
Belief^2	-0.068**		-0.082***
	(0.029)		(0.028)
Number Incorrect	0.190		0.122
	(0.184)		(0.178)
Number Safe - Risk	0.147		0.078
	(0.120)		(0.115)
Number Safe - Loss	-0.042		0.033
	(0.083)		(0.080)
Zero Prize Bid	0.194		0.128
	(0.139)		(0.134)
SVO angle	-0.013		-0.017
	(0.011)		(0.011)
CRT score	-0.231**		-0.269***
	(0.102)		(0.099)
Chat Message Content			
Emphasized Winning		1.762**	1.925**
		(0.817)	(0.768)
Minimize Losses		0.085	0.773
		(0.889)	(0.852)
Risk Aversion		-0.503	-0.249
		(0.543)	(0.515)
Risk Seeking		1.418	1.190
		(1.449)	(1.354)
Balance Cost & Benefit		-0.812	-0.622
		(0.694)	(0.655)
Anticipate Other Team's Bid		0.721	0.927*
		(0.522)	(0.493)
Impulsive - Vague		0.067	0.292
		(0.886)	(0.844)
Impulsive - Cliché		-0.545	-0.760
		(1.472)	(1.394)
Constant	1.691	4.203***	1.678
	(1.107)	(0.678)	(1.210)
Observations	188	188	188
Adj R^2	0.134	0.101	0.228

Notes: Standard errors are reported in parentheses. Statistical significance is indicated by asterisks: * for 10%, ** for 5%, and *** for 1%.

Table 5: Regression Analysis of Suggested Bids in the Team Contest

Team Contest Suggested Bids			
Elicited Values	Model 4	Model 5	Model 6
Belief	0.441*		0.548***
	(0.232)		(0.194)
Belief^2	-0.010		-0.026
	(0.022)		(0.019)
Number Incorrect	0.180		0.166
	(0.150)		(0.126)
Number Safe - Risk	-0.023		-0.058
	(0.095)		(0.080)
Number Safe - Loss	-0.199***		-0.123**
	(0.068)		(0.057)
Zero Prize Bid	0.315***		0.190**
	(0.114)		(0.095)
SVO angle	-0.003		-0.002
	(0.009)		(0.007)
CRT score	-0.080		-0.090
	(0.083)		(0.069)
Chat Message Content			
Emphasized Winning		2.606***	2.404***
		(0.611)	(0.542)
Minimize Losses		-2.076***	-1.473**
		(0.665)	(0.598)
Risk Aversion		-0.671*	-0.667*
		(0.406)	(0.361)
Risk Seeking		1.205	1.284
		(1.083)	(0.955)
Balance Cost & Benefit		-0.826	-0.516
		(0.519)	(0.461)
Anticipate Other Team's Bid		0.474	0.439
		(0.390)	(0.349)
Impulsive - Vague		0.541	0.809
		(0.663)	(0.592)
Impulsive - Cliché		-0.724	-0.649
		(1.101)	(0.979)
Constant	3.413***	4.296***	3.211***
	(0.876)	(0.507)	(0.832)
Observations	188	188	188
Adj R^2	0.250	0.344	0.500

Notes: Standard errors are reported in parentheses. Statistical significance is indicated by asterisks: * for 10%, ** for 5%, and *** for 1%.

that differed from their bid in the individual contest.

First, we see that beliefs about the opposing team's bid is correlated with suggested team bids, but only the linear component is significant. Thus, suggested team bids are related to beliefs in a way that could lead to overbidding.

Result 2 *Both individual bids and suggested team bids are correlated with elicited beliefs.*

Consistent with bids in the individual contest, suggested bids in the team contest are positively correlated with messages that emphasize winning. However, bids in the zero-prize contest are also positively correlated with suggested team bids. This result suggests that utility of winning plays a role in overbidding.

Result 3 *Both individual bids and suggested team bid are positively correlated with messages that emphasized winning. Suggested team bids are positively correlated with bids in the zero-prize contest. These results are consistent with Hypothesis 2 (Utility of Winning)*

Loss aversion subjects suggest lower team bids. Both the number of safe choices made in the loss aversion task and messages that emphasized minimizing losses are negatively correlated with suggested team bids.

Result 4 *Suggested team bids are negatively correlated with elicited loss aversion and messages that emphasize minimizing losses, consistent with Hypothesis 5 (Loss Aversion).*

There is some evidence that risk aversion is associated with lower bids. Messages indicating risk aversion were correlated with lower suggested team bids. However, we find no such correlation for individual bids. Messages indicating a positive attitude toward risk are uncorrelated with individual and suggested team bids.

Result 5 *Related to Hypothesis 5 (Risk Aversion), suggested team bids are negatively correlated with messages that exhibited risk aversion, but individual bids are not. Furthermore, risk-seeking messages are not correlated with individual or suggested team bids, inconsistent with Hypothesis 6 (Risk Seeking).*

Unlike bids in the individual contest, there is no evidence that impulsiveness influenced suggested team bids. A possible explanation is that the process of justifying one's suggested bid to their teammate might diminish impulsive behavior.

Result 6 *Related to Hypothesis 7 (Impulsiveness), individual bids are negatively correlated with CRT scores, but suggested team bids are not. Furthermore, impulsive messages are not correlated with individual or suggested team bids.*

Lastly, we find no significant correlation of messages that emphasize balancing costs and benefits with either individual or suggested team bids.

Result 7 *Messages weighing both costs and benefits are uncorrelated with individual bids and suggested team bids, inconsistent with Hypotheses 9 (Balancing Costs and Benefits).*

The results for the suggested team bids are more consistent across types of predictors regarding what factors significantly affect bids. For instance, bids in the zero-prize contest and messages that emphasize winning are both positively correlated with suggested team bids, while only the latter is true of individual contest bids. For either individual or suggested team bids, the two types of predictors appear to complement each other. Not only are the estimated effects of one type of predictor robust to the inclusion of the other, but models that include both explain significantly more variation in bids than models that exclude one or the other.[13]

4.3 Correlation of Elicited Values and Message Content

To further demonstrate the complementarity between our two types of predictors, Table 6 reports correlations between elicited preferences and the relevant message content categories. In almost every case, there are only weak and insignificant correlations between elicited values and message

[13] Likelihood Ratio tests of goodness of fit were conducted to confirm statistical significance. For the individual contest, Model 3 has significantly better fit than Model 1 ($\chi^2 = 30.27, p < 0.001$) and Model 2 ($\chi^2 = 37.25, p < 0.001$). For suggested team bids, Model 6 again has significantly better fit than Model 4 ($\chi^2 = 84.90, p < 0.001$) and Model 5 ($\chi^2 = 59.73, p < 0.001$).

Table 6: Correlations between Elicited Values and Message Content

	Anticipating Other Bid	Confusion	Risk Aversion	Risk Seeking	Minimize Losses	Emphasized Winning	Maximize Joint Payoffs	Impulsive (cliché)	Impulsive (vague)
Belief	0.038								
Number Incorrect		0.001							
Safe Choices - Risk			0.050	0.018					
Safe Choices - Loss					0.014				
Zero Prize Bid						0.143**			
SVO angle							0.015		
CRT score								0.051	0.063

Notes: Statistical significance is indicated by asterisks: * for 10%, ** for 5%, and *** for 1%.

content. The sole exception is that contestants that emphasized winning in their message to their teammate also bid more in the contest with a prize of zero.[14]

Result 8 *Contestants that emphasized winning in their messages bid significantly more in the zero-prize contest.*

In summary, beliefs of opponents' bids and messages that emphasize winning appear to be relevant predictors of overbidding in both the individual contest and the team contest. Bids increase as contestants' conjectures of their opponents' bids increase. Furthermore, contestants that emphasized winning in their message to their teammate bid more than others. Taken together, these results suggest that overbidding in contests is partly due to beliefs that one's opponent will overbid, along with a strong desire to win.

5 Conclusion

We examine the relative importance of various theories of overbidding in contests by analyzing the strategic thinking of contestants. To do so, we implement a two-headed team decision-making design that assigns subjects to teams of two who bid on a prize against another team. This team contest involves a two-stage decision-making process where teammates submit a suggested bid to each other along with a message explaining their reasoning in the first stage before making their

[14] Regressing bid in the zero-prize contest on an indicator for messages that emphasize winning has an intercept of 0.51 and the coefficient for the winning indicator is 0.58. This implies that those who emphasized winning in their messages bid 0.58 tokens more on average in the zero-price contest.

final decisions in the second stage. One of the two final bids is randomly selected as the actual team bid. Thus, the experimental design incentivizes contestants to reveal why they think their suggested bid is in their best interest. By conducting a content analysis of the messages contestants send to their teammates, we gain insight into motivations of bidding behavior.

The content analysis consisted of two independent research assistants coding each message into various categories that describe general characteristics of the message. These categories were chosen to correspond with various theories of bidding behavior and were not necessarily mutually exclusive. We then use the message content codes to predict bidding behavior. We find messages that emphasize winning without consideration of cost are associated with significantly higher bids.

Our experimental design also makes two important methodological contributions to the literature. First, our contestants also participate in a standard two-player individual contest prior to the team contest. This feature allows us to compare bidding behavior in the team contest with individual bids, as well as explore the extent to which the message content in the team contest explains individual bids. On average, we find that the two bids do not differ significantly, though suggested team bids have somewhat smaller variance. Furthermore, subjects that emphasized winning in their justification of their suggested team bid also bid significantly more in the individual contest. Second, we also elicit contestants' preferences, cognitive abilities, and beliefs about their opponent's bid to be used in conjunction with the message content codes as predictors of bids. This approach permits us to explore the extent to which the content analysis is a substitute for the more traditional approach of eliciting values. Our results suggest the opposite: message content codes appear to complement the elicited values as predictors of bidding behavior. Not only are the estimated effects of one type of predictor robust to the inclusion of the other, but models that include both explain significantly more variation in bids than models that exclude one or the other.

Finally, previous research (Sheremeta, 2018) using only elicited values finds evidence that impulsiveness (as measured through CRT questions) is the leading predictor of overbidding in Tullock contests. We also find evidence of impulsive bidding in the individual contest. However, our analysis, including both elicited values and chat codes, suggests that utility of winning may be the strongest and most consistent predictor of behavior in Tullock contests.

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References

W. Amaldoss and A. Rapoport. Excessive expenditure in two-stage contests: Theory and experimental evidence. In *Game theory: Strategies, equilibria and theorems*. Nova Science Publishers, 2009.

L.A. Anderson and B.A. Freeborn. Varying the intensity of competition in a multiple prize rent seeking experiment. *Public Choice*, 143:237–254, 2010.

L.A. Anderson and S.L. Stafford. An experimental analysis of rent seeking under varying competitive conditions. *Public Choice*, 115:199–216, 2003.

S.P. Anderson, J.K. Goeree, and C.A. Holt. Rent seeking with bounded rationality: An analysis of the all-pay auction. *Journal of Political Economy*, 106(4):828–853, 1998.

S.P. Anderson, G. Harrison, M.I. Lau, and E.E. Rutström. Elicitation using multiple price list formats. *Experimental Economics*, 9(4):383–406, 2006.

D.M. Bruner. Changing the probability versus changing the reward. *Experimental Economics*, 12 (4):367–385, 2009.

K.B. Burchardi and S.P. Penczynski. Out of your mind: Eliciting individual reasoning in one shot games. *Games and Economic Behavior*, 84:39–57, 2014.

M. Casari, J. Zhang, and C. Jackson. When do groups perform better than individuals? a company takeover experiment. *Experimental Economics*, 19:764–791, 2016.

R.N. Cason and V.-L. Mui. Individual versus group choices of repeated game strategies: A strategy method approach. *Games and Economic Behavior*, 114:128–145, 2019.

R.N. Cason, W.A. Masters, and R.M. Sheremeta. Winner-take-all and proportional-prize contests: Theory and experimental results. *Journal of Economic Behavior and Organization*, Forthcoming, 2018.

G. Charness and M. Rabin. Understanding social preferences with simple tests. *Quarterly Journal of Economics*, 117(3):817–869, 2002.

S.L. Cheung and S. Palan. Two heads are less bubbly than one: team decision-making in an experimental asset market. *Experimental Economics*, 15:373–397, 2012.

Subhasish Chowdhury, Roman Sheremeta, and Theodore Turocy. Overbidding and overspreading in rent-seeking experiments: Cost structure and prize allocation rules. *Games and Economic Behavior*, (87):224–238, 2014.

Jacob Cohen. A coefficient of agreement for nominal scales. *Educational and psychological measurement*, 20(1):37–46, 1960.

D. Cooper and J. Kagel. Are two heads better than one? team versus individual play in signalling games. *American Economic Review*, 95:477–509, 2005.

C.A. Cox. Rent-seeking and competitive preferences. *Journal of Economic Psychology*, 63:102–116, 2017.

C.A. Cox and B. Stoddard. Strategic thinking in public goods games with teams. *Journal of Public Economics*, 161:31–43, 2018.

J.C. Cox and S.C. Hayne. Barking up the right tree: are small groups rational agents? *Experimental Economics*, 9:209–222, 2006.

D. Davis and R. Reilly. Do many cooks always spoil the stew? an experimental analysis of rent seeking and the role of strategic behavior. *Public Choice*, 95:89–115, 1998.

E. Dechenaux, D. Kovenock, and R.M. Sheremeta. A survey of experimental research on contests, all-pay auctions and tournaments. *Experimental Economics*, 18:609–669, 2015.

G. Eisenkopf and S. Teyssier. Envy and loss aversion in tournament. *Journal of Economic Psychology*, 34:240–255, 2013.

Urs Fischbacher. z-tree: Zurich toolbox for ready-made economic experiments. *Experimental economics*, 10(2):171–178, 2007.

S. Frederick. Cognitive reflection and decision making. *Journal of Economic Perspectives*, 19:25–42, 2005.

D. Gill and V.L. Prowse. Cognitive ability, character skills and learning to play equilibrium: A level-k analysis. *Journal of Political Economy*, 124(6):1619–1676, 2016.

B. Greiner. Subject pool recruitment procedures: organizing experiments with orsee. *Journal of Economic Science Association*, 1(1):114–125, 2015.

W.D. Hamilton. Selfish and spiteful behaviour in an evolutionary model. *Nature*, 228:1218–1220, 1970.

B. Hehenkamp, W. Leininger, and A. Passajennikov. Evolutionay equilibrium in tullock contests: Spite and overdissipation. *European Journal of Political Economy*, 20:1045–1057, 2004.

B. Herrmann and H. Orzen. The appearance of homo rivalis: Social preferences and the nature of rent seeking. *University of Nottingham Working Paper*, 2008.

A.L. Hillman and E. Katz. Risk-averse rent seekers and the social cost of monopoly power. *Economic Journal*, 94:104–110, 1984.

C.A. Holt and S.K. Laury. Risk aversion and incentive effects. *American Economic Review*, 92: 1644–1655, 2002.

J.H. Kagel and P. McGee. Team versus individiual play in finitely repeated prisoner dilemma games. *American Economic Journal: Microeconomics*, 8(2):253–276, 2016.

D. Kahneman. *Thinking, Fast and Slow.* Farrar, Straus and Giroux, 2011.

D. Kahneman and A. Tversky. Prospect theory: An analysis of decision under risk. *Econometrica*, 47:263–291, 1979.

J Richard Landis and Gary G Koch. The measurement of observer agreement for categorical data. *biometrics*, pages 159–174, 1977.

S.D. Mago, R.M. Sheremeta, and A. Yates. Best of three contest experiments: Strategic versus psychological momentum. *International Journal of Industrial Organization*, 31:287–296, 2013.

S.D. Mago, A.C. Savikhin, and R.M. Sheremeta. Facing your opponents: Social identification and information feedbacks in contests. *Journal of Conflict Resolution*, 60:459–481, 2016.

E.L. Millner and M.D. Pratt. An experimental investigation of efficient rent-seeking. *Public Choice*, 62:81–92, 1989.

E.L. Millner and M.D. Pratt. Risk aversion and rent seeking: An extension and some experimental evidence. *Public Choice*, 69:81–92, 1991.

J. Morgan, H. Orzen, and M. Sefton. Endogenous entry in contests. *Economic Theory*, 51:435–463, 2012.

J.K. Murnighan, A.E. Roth, and F. Shoumaker. Risk aversion and bargaining: Some preliminary results. *European Economic Review*, 31:265–271, 1987.

R.O. Murphy, K.A. Ackermann, and M.J. Handgraaf. Measuring social value orientation. *Judgment and Decision Making*, 6(8):771–781, 2011.

J.E. Parco, A. Rapoport, and W. Amaldoss. Two-stage contests with budget constraints: An experimental study. *Journal of Mathematical Psychology*, 49(4):320–338, 2005.

J.C. Potters, C.G. De Vries, and F. Van Winden. An experimental examination of rational rent seeking. *European Journal of Political Economy*, 14:783–800, 1998.

C.R. Price and R.M. Sheremeta. Endowment effects in contests. *Economics Letters*, 111:217–219, 2011.

C.R. Price and R.M. Sheremeta. Endowment origin, demographic effects and individual preferences in contests. *Journal of Economics and Management Strategy*, 24:597–619, 2015.

Beatrice Rammstedt and Oliver P. John. Measuring personality in one minute or less: A 10-item short version of the big five inventory in english and german. *Journal of Research in Personality*, 41(1):203–212, 2007.

A.C. Savikhin and R.M. Sheremeta. Simultaneous decision-making in competitive and cooperative games. *Economic Inquiry*, 51:1311–1323, 2013.

P. Schmitt, R. Shupp, K. Swope, and J. Cadigan. Multi-period rent-seeking contests with carryover: Theory and experimental evidence. *Economics of Governance*, 5:187–211, 2004.

R.M. Sheremeta. Expenditures and information disclosure in two-stage political contests. *Journal of Conflict Resolution*, 54:771–798, 2010a.

R.M. Sheremeta. Experimental comparison of multi-stage and one-stage contests. *Games and Economic Behavior*, 68:731–747, 2010b.

R.M. Sheremeta. Contest design: An experimental investigation. *Economic Inquiry*, 49:573–590, 2011.

R.M. Sheremeta. Overbidding and heterogenous behavior in contest experiments. *Journal of Economic Surveys*, 27:491–514, 2013.

R.M. Sheremeta. Impulsive behavior in competition: Testing theories of overbidding in rent-seeking contests. *Working Paper from Chapman University, Economic Science Institute*, 2018.

R.M. Sheremeta and J. Zhang. Can groups solve the problem of over-bidding in contests? *Social Choice and Welfare*, 35:175–197, 2010.

R. Shupp, R.M. Sheremeta, D. Schmidt, and J. Walker. Resource allocation contests: Experimental evidence. *Journal of Economic Psychology*, 39:257–267, 2013.

M. Sutter, M.G. Kocher, and S. StrauSS. Individuals and teams in auctions. *Oxford Economic Papers*, 61(2):280–394, 2009.

M.E. Toplak, R.F. West, and K.E. Stanovich. Assessing miserly information processing: An expansion of the cognitive reflection test. *Thinking & Reasoning*, 20(2):147–168, 2014.

Nicolas Treich. Risk-aversion and prudence in rent-seeking games. *Public Choice*, 145(3-4):339–349, 2010.

G. Tullock. Efficient rent seeking. In J.M. Buchanan, R.D. Tollison, and G. Tullock, editors, *Toward a Theory of the Rent-seeking Society*, pages 97–112. Texas A&M University Press, 1980.