Effect of cheap talk in an asymmetric contest: An experimental investigation

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Abstract

In this paper, we explore the dynamics of two-player Tullock games when one contestant knows their effort cost in private, and there is one-sided asymmetric information. It investigates how, in contrast to contexts with comprehensive knowledge, effort levels, player behavior, and contest results are impacted by information asymmetry. The study uses experimental methodologies to investigate how pre-play communication, or cheap talk, influences strategic choices in these competitions. By comparing cheap talk situations with and without, the research demonstrates the impact of cheap talk on effort levels, especially when contestants have varied ability asymmetries. Results show that when high- and low-ability players compete, communication can decrease overbidding and boost efficiency. The results have practical significance for competitive situations such as political campaigns, procurement, and lobbying, and they also add to the body of literature on incomplete information contests. Subsequent investigations could examine distinct contest configurations, communication procedures, and behavioral remedies to enhance contest layout and minimize inefficiencies from excessive bids.

1 Introduction:

Competitions in which two players vie for a single prize by exerting effort are prevalent across various domains, including sports, business, and political arenas. Consider a chess match where competitors employ strategic maneuvers, or a cricket game where a tailender batsman defends against a seasoned bowler. Similarly, in kabaddi, players' exertion levels critically determine their likelihood of winning. In these contests, asymmetries in knowledge, skill, or resources significantly influence the effort levels each player decides to exert, impacting their probability of success.

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The seminal work of Tullock et al. ((1993)) laid the foundation for understanding contests where participants simultaneously expend efforts to win a prize. Traditional models assume that contestants aim to maximize their expected payoff, influenced by the aggregate efforts of all players. These strategic interactions rely heavily on the contestants' private information and their understanding of their opponents. For example, a novice chess player might exert less effort against a renowned opponent, anticipating a lower probability of success. Similarly, established firms in strategic marketing alliances often possess more information about market potential than new entrants, and experienced farmers typically understand the benefits of new fertilizers better than novices.

A significant complexity in many contests arises from information asymmetry. Often, one player may have private information about their own or their opponent's cost structure, creating a one-sided asymmetry. Asymmetric models have been pivotal in explaining complex scenarios in economics and political strategy, such as political lobbying (Franke et al. ((2013)), Gregor ((2011)), strategic alliances (Clark and Riis ((1998))), and patent races (Cornes and Hartley ((2005)), Konrad* ((2005))). These studies underscore the impact of resource and information asymmetries on player behavior and contest outcomes. Further research has explored equilibrium strategies in Tullock contests with asymmetric information (Aiche et al. ((2019)),Einy et al. ((2013))) and the effects of signaling on players' beliefs and effort levels (Heijnen and Schoonbeek ((2017)), Denter et al. ((2014)), Münster ((2009))). Unlike signaling, costless pre-play communication, or "cheap talk", can influence players' strategies without directly affecting the prize value contingent on winning (Cason et al. ((2012)); Farrell ((1987))).

Despite the rich literature on complete information Tullock contests (Skaperdas ((1996)), Clark and Riis ((1998)); Rai and Sarin ((2009))), the analysis of contests under incomplete information remains relatively underdeveloped (Fey ((2008)), Wasser ((2013))). Experimental studies on contests typically focus on complete information scenarios, with few exploring the dynamics of incomplete information (Brookins and Ryvkin ((2014))).

This study delves into Tullock contests under one-sided asymmetric information, where one player's effort cost is known to one contestant but not the other. We aim to understand how this asymmetry affects effort levels and player behavior compared to complete information settings. Furthermore, we explore the role of pre-play communication, specifically cheap talk, on contestants' behavior and effort levels through experimental methods. By comparing scenarios with and without cheap talk, we seek to determine how costless communication influences strategic decisions in asymmetric contests. Players' private information is modeled as their type—either high or low—with a given probability distribution. To simplify the analysis, we restrict the contest to two players.

The role of information asymmetry in contests is well-documented in theoretical studies (Hurley and Shogren ((1998a)), Hurley and Shogren ((1998b)),Wärneryd ((2003)),Schoonbeek and Winkel ((2006))). Yet, there is a paucity of experimental research examining how one-sided asymmetric information impacts player behavior and outcomes. This study addresses this gap by experimentally investigating the effects of such asymmetry on effort levels. Additionally, while the impact of cheap talk has been studied in coordination games (Farrell ((1987)); Brandts et al. ((2019))), its role in contests remains underexplored. Our research contributes to the literature by examining how cheap talk influences strategic behavior in the presence of information asymmetry.

This chapter is structured as follows. Section 2 provides a comprehensive literature review. Section 3 presents the theoretical framework for both complete and one-sided asymmetric information scenarios. Section 4 discusses numerical solutions for specific parameter values. The experimental setup and procedures are detailed in Section 5, followed by the experimental results in Section 6. Finally, Section 8 reviews our findings, discusses policy implications, and suggests directions for future research.

In summary, our study contributes to the emerging literature on incomplete information contests by experimentally investigating one-sided asymmetric information and the role of cheap talk. By comparing results from scenarios with and without cheap talk, we provide new insights into how information asymmetry and communication influence strategic behavior and effort in competitive environments. This research offers significant implications for understanding strategic interactions in various real-world contexts, from corporate competitions to political campaigns.

2 Relation to Literature:

For complete information on the Tullock contest, there is an extensive analysis in the literature that has analyzed full axiomatic characterization Skaperdas ((1996)), Clark and Riis ((1998)) for a player with one type of investment, Rai and Sarin ((2009)) for a player with multiple types of investment. Existence of equilibrium and its uniqueness have been provided in Pérez-Castrillo and Verdier ((1992)), Baye et al. ((1994)), Cornes and Hartley ((2005)), Yamazaki ((2008)), Chowdhury and Sheremeta ((2011)) and Chowdhury et al. ((2009)). Work of Glazer and Konrad ((1999)), Cohen and Sela ((2005)), Franke et al. ((2013)) are related to payoff structure and Schweinzer and Segev ((2012)), Fu and Lu ((2006)) focus on structure of optimal prize.

Analysis of Tullock's contest with incomplete information is not very rich in literature and is comparatively a recent development. Notable studies that consider asymmetric information includes Fey ((2008)), Wasser ((2013)), Einy et al. ((2015)).

2.1 Complete information in contests:

The existing theoretical and experimental literature on contest theory is primarily more enriched when it comes to analyzing complete information situations. Most of the experimental literature testing the prediction of such types of contests considers mainly simultaneous move and symmetric equilibrium cases. Some important theoretical analyses of simultaneous move rent-seeking contests under complete information consider equilibria with homogeneous success function (Malueg and Yates ((2006))) and risk aversion (Cornes and Hartley ((2012))). The first experimental study of a simultaneous move lottery contest was conducted by Millner and Pratt ((1989)). Under the complete information setup, some early experiments include symmetric and asymmetric contest (Shogren and Baik ((1991)),Potters et al. ((1998)),Shupp et al. ((2013))), sequential-move contest (Weimann et al. ((2000)), Fonseca ((2009))), different competitive conditions (Anderson and Stafford ((2003))), multi-stage contest (Amegashie et al. ((2007)), Sheremeta ((2010))), uncertain prize contest(Oncüler and Croson ((2005))). Recently, the focus has shifted towards analyzing incomplete information contests. Though there has been progress in studying incomplete information contest theory, the experimental analysis of such cases has yet to get that much attention.

2.2 Incomplete information in contests:

While there is well-known literature on simultaneous move contests with complete information, recent attention has increased on the theory of contests with incomplete information. Theoretical analysis of symmetric equilibrium of lottery contests with incomplete information are analyzed by Ryvkin ((2010)) and Wasser ((2013)) [1].In Brookins and Ryvkin ((2014))'s work, they compare the result of a contest under two situations with respect to the players' marginal cost of effort—one is under complete information, and the other is under incomplete information. Along with the overbidding, they find that under complete information, players submit higher bids when they have higher marginal cost and lower bids when they have lower marginal cost. However, this does not hold under incomplete information.

Rent-seeking model of contest (Buchanan et al. ((1980))) have got most attention from the experimental economists and over dissipation incidents have been extensively explored(Sheremeta ((2013))).

The existing experimental literature on contests primarily focuses on complete information about players' valuation of prizes or the cost of effort. With respect to the incomplete information in the contest, there has not been much progress theoretically and experimentally, where there are only two players who privately know their type (i.e., their valuation for the prize or their cost per unit of effort). While the theoretical analysis of contests with complete information is well enriched, the theoretical analysis of incomplete information contests is still growing. Fey ((2008)) and Ryvkin ((2010)) have explored theoretical analysis of bidding in symmetric contests of partial information. In particular, Fey ((2008)) demonstrated that the Buchanan et al. ((1980)) contest model of two players with private uniformly distributed marginal costs of effort has a smooth symmetric equilibrium bidding function. The existence also holds for arbitrary cost distributions, arbitrary player counts, and more general contest success functions, as demonstrated by Ryvkin ((2010)).

Hurley and Shogren ((1998a)) and Schoonbeek and Winkel ((2006)) present models with two-sided incomplete information in which both players' valuations are either high or low. Hurley and Shogren ((1998b)) and Schoonbeek and Winkel ((2006)) present models with one-sided incomplete information.

Analysis of the contest becomes interesting when there exists an asymmetry of information. In a two-player contest, players can have different valuations about the prize, and this information may not be known to all. Sometimes only one player can have private information about this valuation, i.e. one sided private information (Hurley and Shogren ((1998a)), Hurley and Shogren ((1998b))) or there can be two-sided private information. In Wärneryd ((2003))'s analysis, prize valuation is identical for both players, but the actual value is known only to one player.

[1] Similar incomplete information analysis of all pay auctions can be found in the work of Krishna and Morgan ((1997)) and Moldovanu and Sela ((2001)).

General analysis of Tullock contest with incomplete information structure is a bit complex due to the difficulty of getting closed form solution without assuming a specific distribution of player's type[2].

2.3 Asymmetry in contests:

The key idea in asymmetric contests pivots around the point that players may have differences in unit effort cost in contests due to differences in resources or abilities. In asymmetric contests, players with limited resources have the incentive to exert more effort to achieve a higher probability of winning; thus, they spend more resources compared to symmetric contests (Tullock ((1980))). In a two-player contest with cost asymmetry due to differing marginal cost of effort, the player having lower marginal cost of effort exerts more effort than his/her opponent(Baye and Hoppe ((2003))).

Even when players are of equal strength, the absolute degree of strength affects the total quantity of damage done or resources wasted. However, asymmetry in strength is an important factor when deciding how much force to use against an opponent. Efficiency, cost, and prize valuations are usually the three variables of interest that have been used to model asymmetry in contests. Efficiency controls how diligence affects a prize's chance or its distribution. High costs limit the range of behaviors, leading to a favorable reward for the player. Due to the nature of the contest or the fact that different players place varying values on prizes with the same monetary value, prize values may vary. A low-cost or highly efficient player may set forth additional efforts for a given prize value. For the typical kinds of competitions, these widely used primitives have well-studied asymmetries. These type of asymmetries have been well documented in literature[Gradstein and Konrad ((1999)), Baik ((1994)), Baik ((2004)), Baik ((2008)), Franke et al. ((2013)), Nti ((1999)), Epstein and Nitzan ((2002))]. Another prevailing set of asymmetry in contest with respect to the information has also been studied extensively in literature by Hurley and Shogren ((1998a)), Einy et al. ((2013)), Hurley and Shogren ((1998b)), Wärneryd ((2013)), Grosskopf et al. ((2010)), Warneryd ((2006)). Constraints on the budget, particularly in the case of conflict games, are also a source of asymmetry in the contest. This type of asymmetry are most common in the crowd-sourcing contests[Kovenock and Roberson ((2010)),Vojnović ((2015)),Friedman ((1958))], Colonel Blotto games(Roberson ((2006))).

2.4 Information disclosure and communication:

A number of experiments have been conducted based on the rent-seeking model of Buchanan et al. ((1980)). In all these analyses, a departure from the theoretical prediction of the equilibrium outcome has been observed. Thus, overbidding/overspending becomes a prominent phenomenon (Potters et al. ((1998))). In fact, most studies report excessive expenditure by the player in comparison to the risk-neutral equilibrium prediction of the model, even after adjusting for variations in the number of competitors, the amount

[2]For a discrete distribution, closed form solution can be found in Malueg and Yates ((2004)), Münster ((2009)) and for continuous distribution,Ewerhart ((2010))

of rent, and other variables that have an impact on equilibrium expenditures. Following Fallucchi et al. ((2013b)), we can summarize existing experiments on the Tullock contest.

Our study can be linked to the growing literature on communication and informational aspects in contests. To the best of our knowledge, no attempts have been made to study the above-mentioned aspect in a contest in the experimental and lab setup. Thus, our study can be the first to do that. The second aspect that uniquely differentiates our study from the existing literature on contest theory is that we introduce communication in the form of 'cheap talk.' So, our study can broadly be linked with the literature on information transmission and signaling (Spence ((1978)) and Crawford and Sobel ((1982))).

3 Theoretical Framework:

3.1 The model:

Suppose two players exert efforts in a contest to win the prize of value V. The players have different abilities to transfer their efforts into performance. The probability of winning is determined as per the stand Tullock contest form, where the contest success function is defined as:

$$p_i(e_i, e_j) = \begin{cases} 0 & \text{if } e_i = e_j = 0; \\ \frac{{e_i}^r}{{e_i}^r + {e_j}^r} & \text{otherwise.} \end{cases} \tag{3.1}$$

where r is the return to scale parameter.

We start with a Bayesian game τ with $i, j = 1, 2, j \neq i$.

Let $t_i, t_i \in \theta_i = \{h, l\}$ denotes the type of player i which is their private information and A_i be their set of actions.
Contestant i is of type θ_i, which is independently drawn from the distribution of types

$$\theta_i = \begin{cases} h & \text{with probability p;} \\ l & \text{with probability (1-p).} \end{cases} \tag{3.2}$$

With $l > h > 0$[3] and $p \in [0, 1]$.

Two risk-neutral contestants exert effort e_1 and e_2, and each has a probability of winning a prize equal to p. Everything but the realized θ_i is common knowledge. The cost of effort is assumed to be linear in nature, and the marginal cost equals the inverse of the player's type.

3.2 Under complete information:

Under public information [following Nti ((1999))],

Let the prize value be = 1. Hence, the expected utility of contestant i is given by :

[3]We assume that the cost of effort for the high type will be lower than that of the low type given the same amount of effort.

$$\pi_i(e_i, e_j) = E[u_i(e_i, e_j)|R] = E[\frac{{e_i}^r}{{e_i}^r + {e_j}^r}|R]$$

where R is the common knowledge information regime.

Now,

$$\begin{aligned} \pi_i &= P_i(e_i, e_j).V_i - \frac{e_i}{\theta_i} \\ &= \frac{{e_i}^r}{{e_i}^r + {e_j}^r}.V_i - \frac{e_i}{\theta_i} \end{aligned} \tag{3.3}$$

Now differentiating equation ((3.3)) with respect to e_i, we get for high type contestant:

$$\begin{aligned} \frac{\partial \pi_i}{\partial e_i} &= \frac{r{e_i}^{r-1}.({e_i}^r + {e_j}^r) - {e_i}^r(r{e_i}^{r-1})}{({e_i}^r + {e_j}^r)^2}.V_i - \frac{1}{\theta_i} = 0 \\ &= \frac{r{e_i}^{r-1}{e_j}^r}{({e_i}^r + {e_j}^r)^2}.V_i - \frac{1}{\theta_i} = 0 \end{aligned} \tag{3.4}$$

When both contestants are of 'h' type:

let us assume that, in this case, the effort levels of contestants 1 and 2 are given by e_1 and e_2, respectively. So, using equation ((3.4)), we get:

$$\begin{aligned} \frac{r{e_1}^{r-1}.{e_2}^r}{({e_1}^r + {e_2}^r)^2}.V_1 = \frac{r{e_2}^{r-1}.{e_1}^r}{({e_1}^r + {e_2}^r)^2}.V_2 = 1 \\ \implies \frac{e_1}{V_1} = \frac{e_2}{V_2} \end{aligned} \tag{3.5}$$

For contestant 1, using equation ((3.5)), we get from equation ((3.4)):

$$\begin{aligned} \frac{r{e_1}^{r-1}.{e_2}^r}{({e_1}^r + {e_2}^r)^2}.V_1 &= \frac{1}{h} \\ \implies \frac{r{e_1}^{r-1}.\frac{V_2^r}{V_1^r}.{e_1}^r}{({e_1}^r + \frac{V_2^r}{V_1^r}.{e_1}^r)^2}.V_1 &= \frac{1}{h} \\ \implies \frac{r.V_2^r.V_1^r.V_2^{-1}.e_1^{2r-1}}{e_1^{2r}.(V_1^r.V_2^r)^2}.V_1^{2r} &= \frac{1}{h} \end{aligned} \tag{3.6}$$

Putting the value of $V_1 = V_2 = V$ (since we have assumed common value contest) in the last line of equation ((3.6)), we get:

$$\begin{aligned} \frac{r.V.e_1^{-1}}{4} &= \frac{1}{h} \\ \implies e_1 &= \frac{rhV}{4} \end{aligned} \tag{3.7}$$

Similarly, we can find values for e_2. So, when both contestants are of the 'h' type, get:

$$e_1 = e_2 = e_{hh} = \frac{rhV}{4} \tag{3.8}$$

When both contestants are of 'l' type:

In a similar way, we can say that when both contestants are of 'l' type:

$$e_1 = e_2 = e_{ll} = \frac{rlV}{4} \tag{3.9}$$

When one contestant is of 'h' type and the other contestant is of 'l' type:

Let us consider that contestant 1 is of the 'h' type and exerts e_1 level of effort, and contestant 2 is of the 'l' type and exerts e_2 level of effort.

So, applying equation ((3.4)) for both the contestants, we get:

$$\frac{re_1{}^{r-1}.e_2{}^r}{(e_1{}^r + e_2{}^r)^2}.V_1 = \frac{1}{h} \tag{3.10}$$

and

$$\frac{re_2{}^{r-1}.e_1{}^r}{(e_1{}^r + e_2{}^r)^2}.V_2 = \frac{1}{l} \tag{3.11}$$

Dividing equation ((3.10)) by ((3.11)) equation , we get:

$$\begin{aligned} \frac{V_1.r.e_2^r.e_1^r.e_1^{-1}}{V_2.r.e_1^r.e_2^r.e_2^{-1}} &= \frac{l}{h} \\ \implies \frac{V_1.h}{V_2.l} &= \frac{e_2^{-1}}{e_1^{-1}} = \frac{e_1}{e_2} \end{aligned} \tag{3.12}$$

Now, putting $V_1 = V_2 = V$ (since we have assumed common value contest), the last line of equation ((3.11)) gets reduced to:

$$\begin{aligned} \frac{e_1}{e_2} &= \frac{h}{l} \\ \implies e_1 &= \frac{h}{l}.e_2 \\ \implies e_2 &= \frac{l}{h}.e_1 \end{aligned} \tag{3.13}$$

From equation (([3.13](#))), since $l > h$, it implies $e_2 > e_1$.

Proposition 3.1. *The player whose unit effort cost is higher expends more effort in equilibrium irrespective of the value of returns to scale parameter (r)*

Proof. see Appendix A.A □

Proposition 3.2. *When opposite type of contestants plays each other (i.e., when h type contestant plays against l type contestant or l type contestant plays against h type contestant), the fraction of player's effort to unit cost effort ratio ($\frac{e_i}{m}$ where $m = \frac{h}{l}$) increases with the unit cost of effort ratio under complete information contest with constant return to scale parameter (i.e. $r = 1$).*

Proof. see Appendix A.B □

When two opposite type players play each other under constant return to scale ($r = 1$) contest :
In this case, we calculate the winning probability and expected payoffs. The equilibrium winning probability for h type player against a type player is:

$$p_{hl}{}^* = \frac{e_{hl}}{e_{hl} + e_{lh}} \tag{3.14}$$

And the equilibrium winning probability for l type player against the type player is:

$$p_{lh}{}^* = \frac{e_{lh}}{e_{hl} + e_{lh}} \tag{3.15}$$

The expected payoffs are:

$$\pi_{hl}{}^* = V.\frac{e_{hl}}{e_{hl} + e_{lh}} - \frac{e_{hl}}{h} \tag{3.16}$$

$$\pi_{lh}{}^* = V.\frac{e_{lh}}{e_{hl} + e_{lh}} - \frac{e_{lh}}{l} \tag{3.17}$$

Now for player h, differentiating equation ((3.16)) twice, we get:

$$\frac{\partial \pi_{hl}{}^*}{\partial e_{hl}} = \frac{V.e_{lh}}{(e_{hl} + e_{lh})^2} - \frac{1}{h} \tag{3.18}$$

$$\frac{\partial^2 \pi_{hl}{}^*}{\partial e_{hl}{}^2} = -2V.\frac{e_{lh}(e_{hl} + e_{lh})}{(e_{hl} + e_{lh})^4} < 0 \tag{3.19}$$

$$\frac{\partial \pi_{lh}{}^*}{\partial e_{lh}} = \frac{V.e_{hl}}{(e_{hl} + e_{lh})^2} - \frac{1}{l} \tag{3.20}$$

$$\frac{\partial^2 \pi_{lh}{}^*}{\partial e_{lh}{}^2} = -2V.\frac{e_{hl}(e_{hl} + e_{lh})}{(e_{hl} + e_{lh})^4} < 0 \tag{3.21}$$

Now let us simplify equation ((3.16)).

$$
\begin{aligned}
{\pi_{hl}}^* &= \frac{V.h.e_{hl} - e_{hl}(e_{hl} + e_{lh})}{h(e_{hl} + e_{lh})} \\
&= \frac{V.h.e_{hl} - {e_{hl}}^2 - e_{hl}.e_{lh}}{h(e_{hl} + e_{lh})}
\end{aligned} \tag{3.22}
$$

Now,

$$
\begin{aligned}
V.h.e_{hl} - {e_{hl}}^2 - e_{hl}.e_{lh} &= \frac{h.V.V.r.l^r.h^{r+1}}{(h^r + l^r)^2} - \frac{V^2.r^2.l^{2r}.h^{2r+2}}{(h^r + l^r)^4} - \frac{V^2.r^2.l^{2r+1}.h^{2r+1}}{(h^r + l^r)^4} \\
&= \frac{h.V^2.lh^2}{(h+l)^2} - \frac{V^2.l^2.h^4}{(h+l)^4} - \frac{V^2.l^3.h^3}{(h+l)^4} \quad \text{[using r = 1]} \\
&= \frac{V^2.l.h^3}{(h+l)^2} - \frac{V^2.l^2.h^3(h+l)}{(h+l)^4} \\
&= \frac{V^2.l.h^3}{(h+l)^2} - \frac{V^2.l^2.h^3}{(h+l)^3} \\
&= \frac{V^2.l.h^3(h+l) - V^2.l^2.h^3}{(h+l)^3} \\
&= \frac{V^2.l.h^4 + V^2.l^2.h^3 - V^2.l^2.h^3}{(h+l)^3} \\
&= \frac{V^2.l.h^4}{(h+l)^3}
\end{aligned} \tag{3.23}
$$

And,

$$
\begin{aligned}
h(e_{hl} + e_{lh}) &= h[\frac{V.r.l^r.h^{r+1}}{(h^r + l^r)^2}] + \frac{V.r.h^r.l^{r+1}}{(h^r + l^r)^2} \\
&= h[\frac{V.l.h^2}{(h+l)^2} + \frac{V.h.l^2}{(h+l)^2}] \quad \text{[using r = 1]} \\
&= h.\frac{V.l.h^2 + v.h.l^2}{(h+l)^2} \\
&= h.\frac{V.l.h(h+l)}{(h+l)^2} \\
&= \frac{V.l.h^2}{(h+l)}
\end{aligned} \tag{3.24}
$$

If we divide equation ((3.23)) by equation ((3.24)), we will get same value of ((3.22)). So, dividing equation ((3.23)) by equation ((3.24)), we get:

$$\begin{aligned}\pi_{hl}{}^{*} &= \frac{V^2.l.h^4}{(h+l)^3} X \frac{(h+l)}{V.l.h^2} \\ &= \frac{V.h^2}{(h+l)^2}\end{aligned} \tag{3.25}$$

Thus,

$$\pi_{hl}{}^{*} > 0 \tag{3.26}$$

Similarly, we can show that,

$$\pi_{lh}{}^{*} > 0 \tag{3.27}$$

That means equilibrium expected profits are positive.

Proposition 3.3. *Given $h < l$, the Tullock contest, where two opposing type players with asymmetric unit effort cost, has a pure strategy Nash Equilibrium under complete information with constant return to scale ($r = 1$).*

Proof. see Appendix A.C □

This completes our required proof.

3.3 Under one sided asymmetry:

payoffs for player 1 and player 2 are given as:

$$\pi_{1_i} = [p(\frac{e_{1_i}}{e_{1_i} + e_{2_H}}) + (1-p)(\frac{e_{1_i}}{e_{1_i} + e_{2_L}})].V - \frac{e_{1_i}}{\theta_i} \tag{3.28}$$

$$\pi_{2_i} = [\frac{e_{2_i}}{e_{2_i} + e_{1_i}}].V - \frac{e_{2_i}}{\theta_i} \tag{3.29}$$

For the optimal effort of player 1, differentiating eq((3.28)) with respect to the effort of player 1 of any type, we get

$$\frac{\partial \pi_{1_i}}{\partial e_{1_i}} = [p.\frac{e_{2_H}}{(e_{1_i} + e_{2_H})^2} + (1-p).\frac{e_{2_L}}{(e_{1_i} + e_{2_L})^2}].V - \frac{1}{\theta_i} = 0 \tag{3.30}$$

Now, when player 1 is of type H, then eq((3.30)) becomes:

$$[p.\frac{e_{2_H}}{(e_{1_H} + e_{2_H})^2} + (1-p).\frac{e_{2_L}}{(e_{1_H} + e_{2_L})^2}].V = \frac{1}{h} \tag{3.31}$$

And when player 1 is of type L, then eq((3.30)) becomes:

$$[p.\frac{e_{2_H}}{(e_{1_L} + e_{2_H})^2} + (1-p).\frac{e_{2_L}}{(e_{1_L} + e_{2_L})^2}].V = \frac{1}{l} \tag{3.32}$$

Similarly, for the optimal effort of player 2, differentiating eq(((3.29)) with respect to the effort of player 2 of any type, we get

$$\frac{\partial \pi_{2_i}}{\partial e_{2_i}} = [\frac{e_{1_i}}{(e_{1_i} + e_{2_i})^2}].V - \frac{1}{\theta_i} = 0 \tag{3.33}$$

$$\implies (e_{2_z} + e_{1_j})^2 = Vze_{1_j} \qquad \text{where} \quad z \in \{h, l\} \& j \in \{l, h\} \tag{3.34}$$

Now we solve for the best response function of player 2. If the solution is positive call it be ${e_{2_z}}^*$. To compute the best response function for player 2, we have the following three cases:

Case A: $e_{1_j} = 0$

In this case, putting $e_{1_j} = 0$ in equation ((3.28)), we have:

$$ {e_{2_z}}^* = \text{undefined} \tag{3.35}$$

Case B: $0 < e_{1_j} < vz$

From equation ((3.34)), we get:

$$ {e_{2_z}}^* = \sqrt{Vze_{1_j}} - e_{1_j} > 0 \tag{3.36}$$

Case C: $e_{1_j} \geqslant vz$

In this case, minimum value of π_{2_i} is attained at ${e_{2_z}}^* = 0$, which yields $\pi_{2_i} = 0$.

So, the best response function for player 2 will be given by:

$$BR_{2_z}(e_{1_j}) = \begin{cases} undefined & \text{,if } e_{1_j} = 0; \\ \sqrt{vze_{1_j}} - e_{1_j} & \text{,if } 0 < e_{1_j} < Vz; \\ 0 & \text{,otherwise} \end{cases} \tag{3.37}$$

where $\quad z \in \{h, l\} \quad \& \quad j \in \{l, h\}$.

Now we solve for the best response function of player 1. If the solution is positive call it be $\hat{e1_j}$. Also call Z_2 the set of $\{(e_{2_H}, e_{2_L})\}$ such that $V[\frac{p}{e_{2_H}} + \frac{1-p}{e_{2_L}}] < j$.

We need to consider the following three cases:

Case I: $e_{2_H} = e_{2_L} = 0$

In this case, from equation ((3.28)), we have:

$$\pi_{1_i} = -\frac{e_{1_i}}{\theta_i} \tag{3.38}$$

This implies that the payoff for player 1 is non-positive for any positive effort level e_{1_i}. Therefore, the best response for player 1 is undefined when $e_{2_H} = e_{2_L} = 0$.

Case II: $(e_{2_H}, e_{2_L}) \notin Z_2 \cup \{(0,0)\}$

In this case, we have:

$$V\left(\frac{p}{e_{2_H}} + \frac{1-p}{e_{2_L}}\right) \geqslant j \tag{3.39}$$

Substituting this condition in equation ((3.28)) for player 1's payoff function, we get:

$$\pi_{1_i} \geqslant \left[p\left(\frac{e_{1_i}}{e_{1_i} + e_{2_H}}\right) + (1-p)\left(\frac{e_{1_i}}{e_{1_i} + e_{2_L}}\right)\right] j - \frac{e_{1_i}}{\theta_i} \tag{3.40}$$

The right-hand side of the inequality in equation ((3.40)) is maximized when $e_{1_i} = \hat{e}1_j$, which is the solution to equation ((3.30)) with $\theta_i = j$. Therefore, the best response for player 1 is to exert an effort level of $\hat{e}1_j$, i.e., $BR_{1_j}(e_{2_H}, e_{2_L}) = \hat{e}_{1_j}$.

Case III: $(e_{2_H}, e_{2_L}) \in Z_2$

In this case, we have:

$$V\left(\frac{p}{e_{2_H}} + \frac{1-p}{e_{2_L}}\right) < j \tag{3.41}$$

Substituting this condition in equation ((3.28)) for player 1's payoff function, we get:

$$\begin{aligned}\pi_{1_i} &< \left[p\left(\frac{e_{1_i}}{e_{1_i} + e_{2_H}}\right) + (1-p)\left(\frac{e_{1_i}}{e_{1_i} + e_{2_L}}\right)\right] j - \frac{e_{1_i}}{\theta_i} \\ &\leqslant j - \frac{e_{1_i}}{\theta_i}\end{aligned} \tag{3.42}$$

Since $\theta_i \in h, l$ and $j \in h, l$, we have $j/\theta_i \leqslant 1$. Therefore, the maximum value of π_{1_i} is attained when $e_{1_i} = 0$, which yields $\pi_{1_i} = 0$.

Hence, we show that the best response function for player 1 is characterized by:

$$BR_{1_j}(e_2) = \begin{cases} undefined & \text{,if } e_{2_H} = e_{2_L} = 0; \\ \hat{e_{1_j}} & \text{,if } (e_{2_H}, e_{2_L}) \notin Z_2 \cup \{(0,0)\}; \\ 0 & \text{,otherwise} \end{cases} \tag{3.43}$$

4 Numerical solution:

Let us set the following parameter:
the valuation of prize is (V) = 50 and probability (p)= $\frac{1}{2}$
; value of h (unit effort cost of high type)is 1/3, and the value of l(unit effort cost of low type) is 1.

Given these parameters, we find the following values at equilibrium (theoretical prediction).
For complete information

$$e_{hh} = \frac{1}{12} = 0.083; \qquad e_{hl} = \frac{1}{16} = 0.0625; \qquad e_{lh} = \frac{9}{16} = 0.5625; \qquad e_{ll} = \frac{1}{4} = 0.25$$

For one sided asymmetry, when player 2 has full information and player 1 has one sided information, given the assumed parametric values, we can compute for equilibrium outcomes as follows:

When player 1 has higher cost(i.e. C_l):

$$e_{1_l} \approx 0.66; \qquad e_{2_{hl}} \approx 2.66; \qquad e_{2_{ll}} \approx 5.09$$

When player 1 has low cost(i.e. C_h):

$$e_{1_l} \approx 0.61; \qquad e_{2_{hl}} \approx 2.58; \qquad e_{2_{ll}} \approx 4.93$$

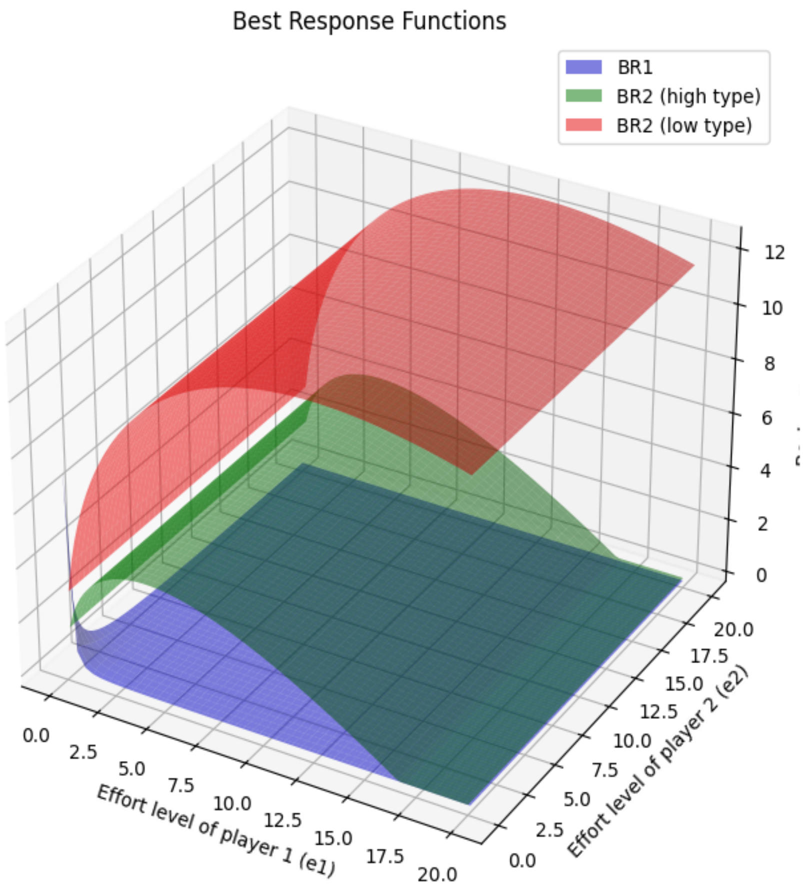


Figure 1: Plot when player 1 is of high type

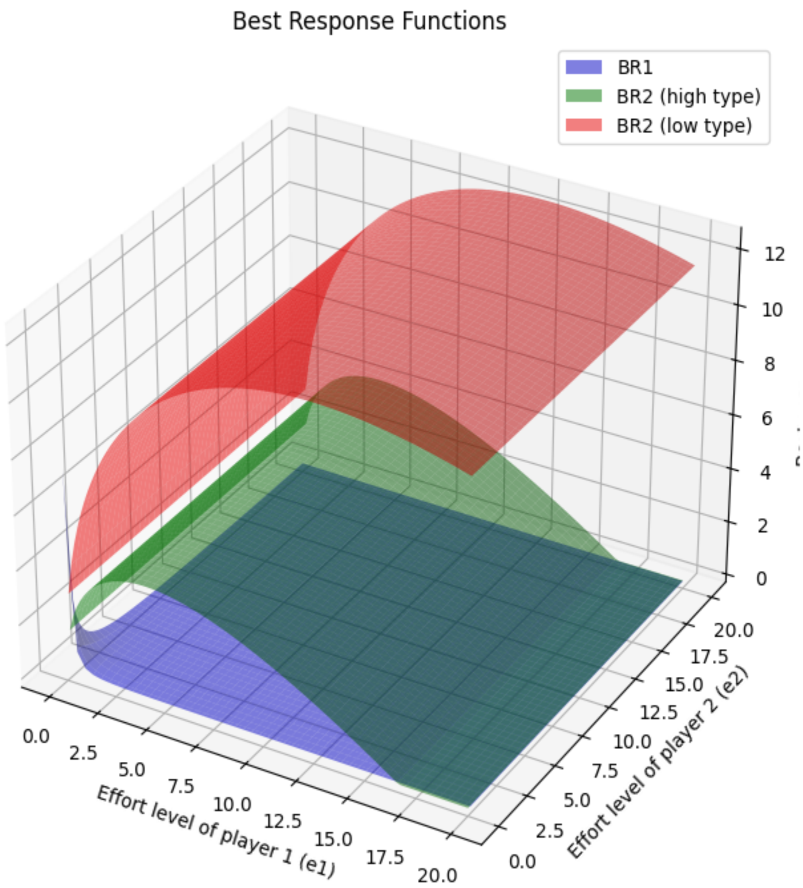


Figure 2: Plot when player 1 is of low type

5 Experimental Setup:

5.1 Experimental design:

We have conducted three experiments following a 2 x 2 design in which we vary by varying information (cheap talk communication or no cheap talk communication) or symmetry settings(HH, HL, LL). We conducted a series of 5 sessions between April 01 to April 25 (Year 2022) and collected data from 160 participants using O-tree(Chen et al. ((2016))). We basically played three games, namely asymmetric contest[HH], asymmetric contest[LL], and asymmetric contest[HL]; HH means both players are High type, LL means both players are Low type, and HL means one player is High type, and the opponent player is Low type. The following table (table 1) gives a summary of all our sessions. No participants dropped out during the whole experiment. Payments were made mostly in cash, but some participants took payments through UPI transfer mode.

Table 1: Experimental design and treatment level (160 total subjects)

Communication between players	Contest type		
	HH	HL	LL
Yes	22 subjects,15 periods	36 subjects,15 periods	22 subjects,15 periods
No	22 subjects,15 periods	36 subjects,15 periods	22 subjects,15 periods

5.2 Experimental process:

The experimental session is computerized using O-tree(Chen et al. ((2016))) to record the subject decision and all relevant information. Upon arriving in the experimental session, subjects are randomly assigned to a place in the room.

In part 1, each subject is randomly matched into groups of 2 and goes through 15 rounds for decision-making in the corresponding contest game. The group remains fixed for the whole period of experiment[4]. In this part of the game, they receive a welcome note and instructions about the experiment and the tasks ahead. After that, each subject goes through an attention check page. This is done to ensure they fully understand the experiment's logic and payoff function. Once they successfully pass the attention check step, they are allowed to participate in the experiment. All participants can leave the experiment at any stage. However, in our experiment, no participant dropped out. Each participant gets a participation fee just for appearing in our experiment.

In part 2 of the experiment, all participants are required to make some decisions. Based on the decision, they receive a payoff, which gets added to their final payoff at the end of the experiment. This is done to elicit their risk preference. Then, subjects participate in a real-effort task, Task-decoding for a finite number of time periods (this follows methods, as employed by Erkal et al. ((2011))). Each subject is given a set of words in the same order as the other subjects and instructed to encrypt the words by changing the letters to numbers according to the encryption table. Based on this real effort task, they are being ranked. Based on these ranks, their costs are defined from a pre-defined set of costs. Notably, we apply this strategy to allocate cost structure between two players in our experimental contest for HH, LL, and HL-type cases. That means, when we are playing HH-type games, two types of players get different costs based on the outcome of their Task-decoding result[5]. When two contestants of the same type face each other, they are informed about their true types and the possible two cost structures between them. In HH games, both players know they are HIGH type but might have different unit effort costs. Similarly, this happens in LL

[4]Fixed and random group designs are common in contest literature[Fallucchi et al. ((2013a))]. In fixed group design, it is quite straightforward to focus on behavioral dynamics. That is why we have adopted a fixed group design.

[5]In reality, the same type of players can have different unit effort costs due to differences in resources, strategy, or ability. For example, consider two types of players with asymmetric skills or resources. The unit effort cost level for that high-type player with comparative more resources or better skill may be lower than another high-type player (here the opponent player) with fewer resources or lesser skill(Corchón ((2007)), Vojnović ((2015))). This holds true if we consider that both players in the contest are of a low type.

games, too. Out of the two competing subjects, one subject is informed about his own cost as well as the opponent's cost. But the other subject is informed about his\her own cost only. Thus one sided asymmetry is formed between the players.

In the next stage, groups participate in the contest games as described on their instruction page. In each round, subjects are endowed with 20 experimental tokens. They bid any amount within the range (0,20). The player who bids more wins the prize of valuation 50. Before they bid, they are asked to submit their belief about the opponent player's bid. In cheap talk communication treatment, treatment groups are allowed to send and receive messages to each other's opponent before making the final bid. They can send any message to their respective opponent. They play one practice round. This round's outcome and payoff are not considered for the final payoff. Then, they play a continuous 15-round contest experiment game. randomly, one round from this set of 15 rounds is selected for each participant, and the amount they earn in that selected round is paid to them.

At the end of the experiment, they participate in a survey that contains demographic parameters.

5.3 Experimental parameters and hypothesis:

In our experiment, we set the following parameter:
the valuation of prize is (V) = 50 and probability (p)= $\frac{1}{2}$
value of h (unit effort cost of high type)is 1/3, and the value of l(unit effort cost of low type) is 1.

Based on our proposed experimental design, we are interested in examining the following hypotheses:

H1: The distribution of bid of players for HH, HL, LL type contests are different.

H2: Average belief amount is higher in cheap talk communication than without communication treatment in HH, HL, LL contests.

H3: The cheap talk communication does not impact the player's effort level in a one-sided asymmetric information HH,HL and LL contests.

6 Experimental Result:

We start with an overview of 2400 bids available in our experiment. Figure 3 shows the distribution of mean bids for each player over the types of contests and separated by treatments. Table 2 provides summary statistics on the individual bids for each treatment. The description of all variables used in our analysis are given in table 13.

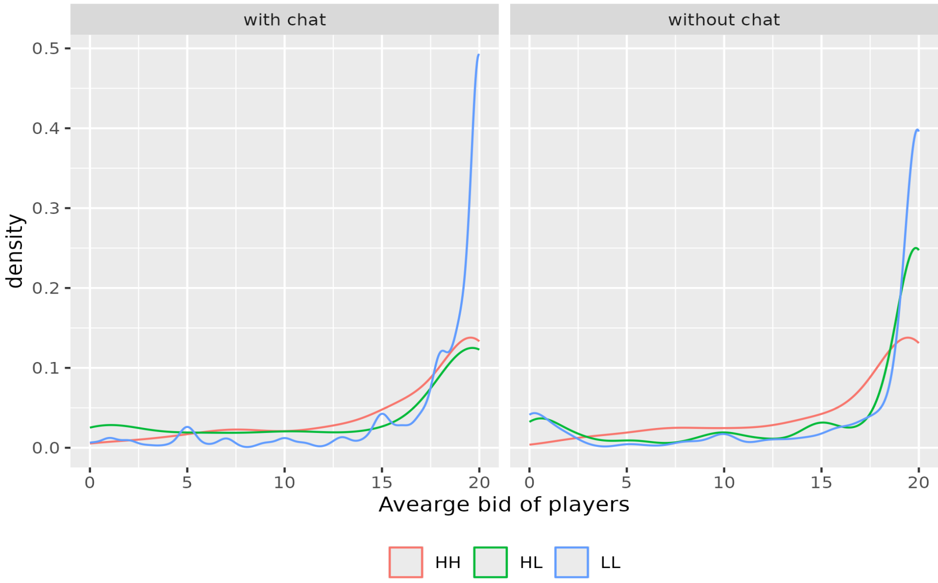


Figure 3: Distribution of mean bids for each player over the types of contests for with chat and without chat treatments

Table 2: Descriptive statistics on individual bids

COMMUNICATION TYPE	**HH** (1)	**HL** (2)	**LL** (3)	**ALL** (4)
WITHOUT CHAT	15.68 (5.29) n=330	15.82 (6.58) n=540	16.58 (6.27) n=330	16 (6.18) n=1200
WITH CHAT	15.88 (5.22) n=330	14.59 (7.04) n=540	17.57 (4.5) n=330	15.75 (6.1) n=1200
Each cell contains the mean, standard deviation (in parentheses) and n indicates no of observations. The column (4) pools the bids of the three types				

Table 3 shows the outcomes of several pairwise Wilcoxon rank sum tests with continuity correction comparisons of bid densities, or average bids, from various contest kinds. There are three different sorts of contests: HH (when both players value the reward highly but they differ in ability, unit costs are different), HL (where one player values the prize highly and the other poorly and also differs in ability), and LL (where both players value the prize low but they differ in ability; hence unit costs are different). Three further types of comparisons are made: contests with chat, contests without chat, and pooled data (which combines contests with and without chat).

HL vs. HH (Pooled Data): When considering the pooled data (contests with and without chat combined), the p-value of 0.1 shows no statistically significant difference between the average bids in HL contests and HH contests. This implies that players in HL contests and players in HH contests do not, on average, bid very differently.

HL vs. LL (Pooled Data): When taking into account the pooled data, the p-value of 0.00 shows a statistically significant difference between the average bids in HL contests and LL contests. This implies that participants in LL contests and players in HL contests, on average, bid differently.

HL vs. HH (Without Chat): When analyzing solely the contests without chat, the p-value of 0.0044 shows a statistically significant difference between the average bids in HL contests and HH contests. This implies that the average bids in HL contests are substantially different from those in HH contests, even in the absence of communication throughout the contest.

Table 3: Multiple pairwise-comparison for bid density

Pairwise comparisons using Wilcoxon rank sum test with continuity correction(p-values)						
Contest type	**Contest (pooled data)**		**Contest (with chat)**		**Contest (without chat)**	
	HH	**HL**	**HH**	**HL**	**HH**	**HL**
HL	0.1	-	0.00	-	0.0044	-
LL	0.00	0.00	0.00	0.026	0.0003	0.3156
P value adjustment method: BH						

HL vs. LL (Without Chat): When examining solely the contests without chat, the p-value of 0.3156 shows that there is no statistically significant difference between the average bids in HL contests and LL contests. This shows that the average bids in HL contests are not significantly different from those in LL contests in the absence of communication during the contest.

HL vs. HH (With Chat): When analyzing solely the contests with chat, the p-value of 0.00 shows a statistically significant difference between the average bids in HL contests and HH contests. This implies that the average bids in HL contests are significantly different from those in HH contests when players are able to engage with each other during the game (via chat).

HL vs. LL (With Chat): Taking into account only the contests with chat, the p-value of 0.026 shows a statistically significant difference between the average bids in HL contests and LL contests.

These findings shed light on the ways that symmetric valuation competitions (HH and LL types) and one-sided asymmetric contests (HL type) differ in terms of average bidding behavior and the potential effects of chat or other forms of communication on bidding behavior. So, we formally present results for this as follows:

Result 1. (**Bid density**)
(a). Pooled Data (Contests with and without Chat Combined):

- There is no statistically significant difference between the average bids in HL contests and HH contests.
- There is a statistically significant difference between the average bids in HL contests and LL contests.

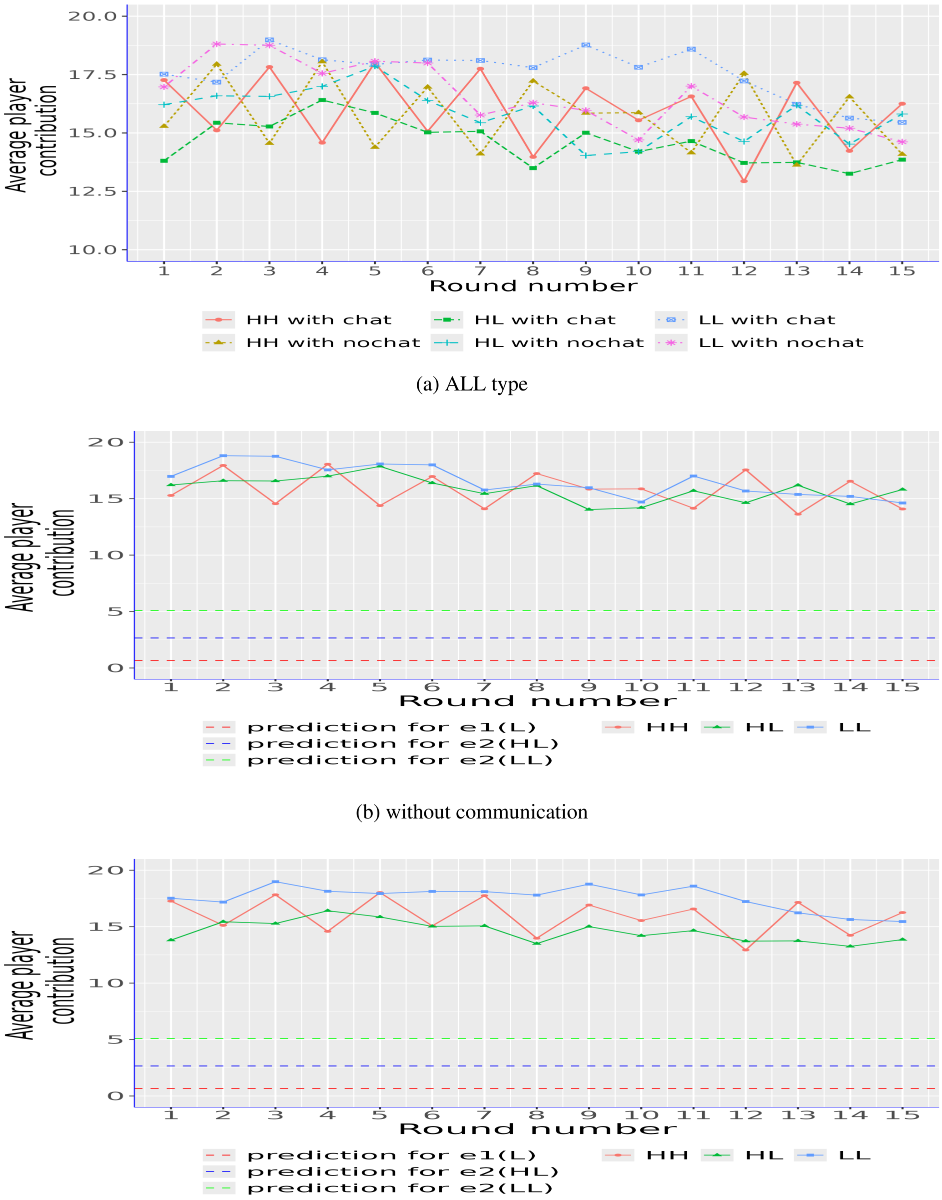
(b). Contests with Chat:

- The average bids in HL contests differ significantly from those in HH contests.
- The average bids in HL contests differ significantly from those in LL contests.

(c). Contests without Chat:

- The average bids in HL contests differ significantly from those in HH contests.
- There is no statistically significant difference between the average bids in HL contests and LL contests.

6.1 Average player bid:



(a) ALL type

(b) without communication

(c) with communication

Figure 4: Comparison of average player contribution(bid) of all types across the rounds[a]

[a]Here all values are theoretical predictions without any communication. We take the maximum values for e_{1_l}, $e_{2_{hl}}$, $e_{2_{ll}}$ for simplifying illustration purpose. The maximum values are taken from the values shown in section 4

Given the previous result, we compare the average individual effort(bid) in a contest for three different types of contests. First, we consider the overall scenario in panel (A) of figure 4[6]. The same has been shown separately in panel (B) and panel (C). Panel (B) shows this without the communication rule, and panel (C) shows this for the communication rule. Figure 16 shows the player contribution for both the treatments for HH, HL, and LL type contests, and figure 5 depicts the comparison plot of mean player contribution(bid) between treatments across the rounds.

Table 5 summarizes the average effort levels for each type of player and relevant statistical parameters. Using the table, we can compare the average effort level of players for both with cheap talk and without cheap talk treatments. We use the 'Wilcoxon signed-rank test' for our statistical comparison purposes. In the case of HH contests, though somewhat greater than without communication (15.7), the mean player contribution in HH contests with communication (15.9) is not statistically significant (p-value = 0.66). This shows that when both participants are of high type, the presence or lack of communication does not significantly alter the players' bidding behavior. The insignificance of the coefficient on cheap talk in column (1) in table 4[7] confirms this. The average player contribution in HL contests with communication (14.6) is significantly lower than in HL contests without communication (15.8), as indicated by the p-value of 0.00, which is highly statistically significant (at the 1% level). The negative as well as the significance of the coefficient on cheap talk in column (2) in table 4 indicates the same. This implies that in HL contests, the introduction of communication (chat) significantly lowers player contributions (bids) compared to contests without communication. With a p-value of 0.01, which is statistically significant at the 5% level, the mean player contribution in LL contests with chat (17.6) is significantly higher than in LL contests without chat (16.6). This implies that the existence of communication (chat) increases player contributions (bids) significantly in LL contests compared to contests without chat. But, we do not find the coefficient on cheap talk in column (3) in table 4 to be significant.

Overall, the findings show that different forms of contests have distinct effects of communication on bidding behavior. In HH and LL contests, communication has little effect on bidding; in contrast, in HL contests, it has different consequences. Communication reduces player contributions in HL games. This could be because of signaling, coordination, or strategic factors relating to the asymmetry in valuations. These results emphasize how crucial it is to consider how communication and contest asymmetry interact to comprehend and forecast bidding behavior in contests.

Result 2. (**Player bid(contribution)**)

- (a.) In the HH contest, cheap talk communication does not significantly impact the individual bidding level.
- (b.) In the HL contest, cheap talk communication significantly impacts the individual bidding level. Though over-bidding persists, the average effort level is significantly

[6]We take the maximum values for e_{1_l}, $e_{2_{hl}}$, $e_{2_{ll}}$ for simplifying illustration purpose i showing predicted values in the figure. The maximum values are taken from the values shown in section.

[7]The description of all variables used in regression analysis are given in table 13

lower under the cheap talk communication rule than without cheap talk communication.

- (c.) In LL contests, cheap talk communication significantly impacts the individual bidding level. The average effort level is significantly higher under the cheap talk communication rule than without cheap talk communication.

6.2 Over bidding:

Following Sheremeta ((2013)), we compute for each player, their overbidding rate[8]. Regression results for over-bidding are shown in table 14. For HH contest (column (1) in table 14), risk preference has a significant positive effect on the over-bidding rate (coefficient = 6.08, $p < 0.001$), indicating that risk-seeking behavior is associated with higher over-bidding rates in HH contests. However, in the HL and LL contests (column (2) & column (3) respectively in table 14), the effect of risk preference is not significant. Rank also has a positive and significant coefficient ($\beta = 1.95, p < 0.01$) in the HL contests, suggesting that low-ability players tend to over-bid more than high-ability players, and the effect of rank is not significant in the HH and LL contests. The interaction term between risk preference and rank in HH contests is negative and significant, implying that the effect of risk-seeking behavior on over-bidding differs between high-ability and low-ability players in HH contests. In all three contests (HH, HL, and LL), firmer belief (about winning) is associated with a significantly lower over-bidding rate, suggesting that firmer beliefs about the opponent's contribution reduce over-bidding. Winning the current period (Win) is associated with a lower over-bidding rate in the HL and LL contests but not in the HH contest, suggesting that winning in the current period reduces over-bidding rates in HL and LL contests. Winning in the previous period ($\text{Win}_{i_{(t-1)}}$) is significant and positive in the HL contest but not in the other two contests. Our findings that the winning faction in HL and LL contests spends less than the losing faction is in line with the findings of Bhattacharya and Rampal ((2019)), Cason and Khan ((1999)). A non-monetary reward for winning—that is, people are overly motivated and status-seeking—has been put out in the literature as an explanation for over-contribution. It's feasible that the players' intermediate positions as the competition goes on will determine how useful victory is. Berger and Pope ((2011)), Eriksson et al. ((2009)) demonstrate how a team may increase their effort level even when they are well behind. In our scenario, people who don't make it through the first round would value a victory more than those who did and, hence, be more eager to participate. The cheap talk dummy variable is not significant in the HH contest. Importantly, in LL contest, the cheap talk communication variable has a positive and significant coefficient(coefficient = 2.77, $p < 0.01$), suggesting that communication leads to higher over-bidding in HL contests. But in contrast, the cheap talk communication variable in LL contest has a negative and significant coefficient(coefficient = −3.46, $p < 0.001$), implying that communication reduces over-bidding in LL contests.

[8] overbidding rate is calculated as $\frac{playercontribution-expectedbid}{expectedbid}$

Table 4: Determinants of player contribution

	Dependent variable: Player contribution		
	HH Contest (1)	HL Contest (2)	LL Contest (3)
Rank(= 2)	-0.73	-1.35^{*}	-0.48
	(0.83)	(0.70)	(0.91)
Cheap Talk(= 1)	-0.05	-3.69^{*}	2.87
	(1.28)	(2.16)	(2.54)
Belief	0.48^{***}	0.10	0.36^{***}
	(0.13)	(0.10)	(0.13)
Period	-0.06	-0.13^{*}	-0.20^{***}
	(0.05)	(0.07)	(0.07)
$\text{Win}_{i_{(t-1)}}$	-2.79^{***}	-5.01^{***}	-3.98^{***}
	(0.80)	(0.76)	(0.72)
Cheap Talk:Belief	0.005	0.17	-0.07
	(0.08)	(0.12)	(0.16)
Present bias	0.53	-0.29	2.38^{**}
	(1.12)	(1.41)	(1.03)
Risk preference	-0.42	-1.60^{*}	-1.04
	(0.87)	(0.92)	(0.83)
Constant	11.00^{***}	19.25^{***}	14.24^{***}
	(2.46)	(1.96)	(2.49)
Clustered?	Yes	Yes	Yes
Observations	609	1,059	638
R^2	0.35	0.24	0.30
Adjusted R^2	0.34	0.24	0.29
Residual Std. Error	4.27	6.03	4.65

Note: $^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$; Numbers in parenthesis are robust standard errors clustered at the group level.

From panel (B) and panel (C) of figure 4, it is evident that the average observed effort in contest for all treatments is significantly greater than the theoretical prediction. In other words, figure 4 depicts the over-expenditure across the rounds. This finding is consistent with earlier contest experiment results [Sheremeta ((2015)), Sheremeta ((2013))].

We can summarize all these findings in the following result:

Result 3. (**Over bidding**)
Risk preference significantly increases over-bidding in HH contests, especially for lower ranks, while belief about winning decreases over-bidding across all contests; cheap talk increases over-bidding in HL but decreases it in LL in comparison to no communication treatment, and winning current/previous periods reduces over-bidding in HL and LL contests.

6.3 Probability of winning:

Table 15 presents the results of a Tobit maximum likelihood regression model, where the dependent variable is the winning probability in different types of contests: HH Contest (Column 1), HL Contest (Column 2), and LL Contest (Column 3). The explanatory variables include contribution, cheap talk, risk preference, rank, present bias, belief, period, and interaction terms between risk preference and rank, as well as cheap talk and rank. The model estimates are provided separately for each contest type and their respective standard errors, number of observations, log-likelihood values, and Wald test statistics.

In the HH Contest (Column (1) in table 15), several factors significantly influence the winning probability. Higher contributions are associated with a higher winning probability, as expected. Risk preference and lower rank (being a low-ability player) decrease the winning probability, while beliefs about the opponent's contribution also negatively affect the winning probability. The interaction term between risk preference and rank is positive and significant, suggesting that risk-seeking behavior may have a different effect on the winning probability for low-ability players compared to high-ability players. Higher beliefs about the opponent's contribution also negatively impact the winning probability. In the HL Contest ((Column (2) in table 15)), player contribution and risk-seeking behavior have a positive and significant effect on the winning probability. However, lower rank and higher beliefs about the opponent's contribution decrease the winning probability. The positive and significant coefficient on the present bias variable indicates that present-biased players (those who heavily discount future payoffs) have a higher winning probability in HL contests. The interaction between risk preference and rank is negative and significant, implying that risk-seeking behavior benefits high-ability players more than low-ability players in HL contests. Interestingly, the cheap talk communication interacted with rank has a positive and significant effect, suggesting that communication may provide an advantage to low-ability players in HL contests. In the LL Contest ((Column (3) in table 15)), player contribution positively affects the winning probability. In contrast, risk preference, lower rank, and higher beliefs about the opponent's contribution have a negative effect. The cheap talk communication variable has a negative and significant coefficient, indicating that communication decreases the winning probability in LL contests. The interaction between cheap talk and rank is positive and significant, implying that communication may provide some advantage to low-ability players in LL contests.

Across all contests, the period has a positive and significant coefficient (except in HH contests), suggesting that winning probabilities tend to increase as the experiment progresses, potentially due to learning effects or strategic adjustments over time. The Wald test statistics indicate that the overall models are highly significant for all three contest types. We can summarize this in the following result:

Result 4. (**Winning probability**)
Player contribution increases the winning probability across all contest types, while risk preference, lower rank, and beliefs about the opponent's contribution generally decrease it; cheap talk communication provides an advantage to low-ability players in HL contests but reduces the winning probability in LL contests, and interactions between risk preference, rank, and communication highlight the differential effects on players based on ability asymmetry.

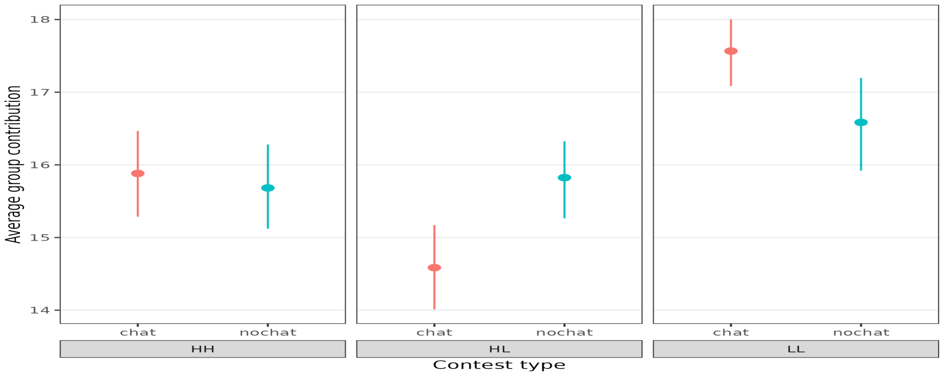


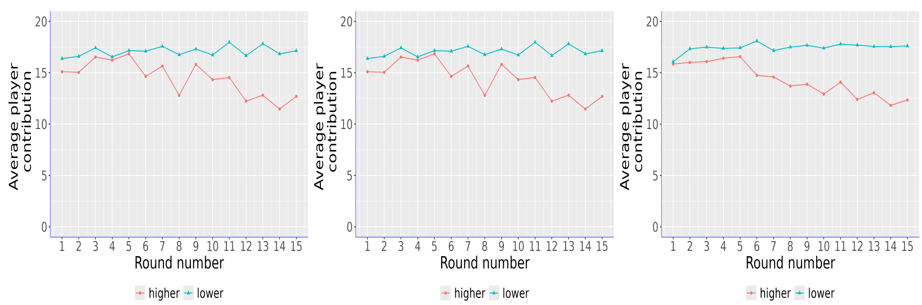
Figure 5: Comparison of mean player contribution(bid) between treatments across the rounds

Table 5: Within group comparison (communication)

Contest type	MEAN PLAYER CONTRIBUTION		WILCOXON P-VALUE
	Chat (1)	NoChat (2)	(3)
HH	15.9 (1.58)	15.7 (1.55)	0.66
HL	14.6 (0.944)	15.8 (1.09)	0.00 ***
LL	17.6 (1.07)	16.6 (1.41)	0.01**

Note: Values in parenthesis show the standard errors; n in each cell indicates the number of observations; P-values show the significance of difference of mean player contribution between column (1) & column (2) values; $*$ & $***$ in column (3) indicate significant at 5 percent and 1 percent level respectively.

6.4 Pattern of individual contribution:



(a) with chat (b) without chat (c) both

Figure 6: Round wise Average contribution of players for different marginal cost

Table 6: Average player contribution across cost types

COMMUNICATION TYPE	MEAN PLAYER CONTRIBUTION UNDER MARGINAL COST		WILCOXON P-VALUE
	higher cost (1)	lower cost (2)	(3)
with chat	14.4 (1.68)	17.1 (0.480)	0.00***
without chat	14.2 (1.92)	17.8 (0.806)	0.00***
both (with & without chat)	14.3 (1.60)	17.4 (0.437)	0.00***

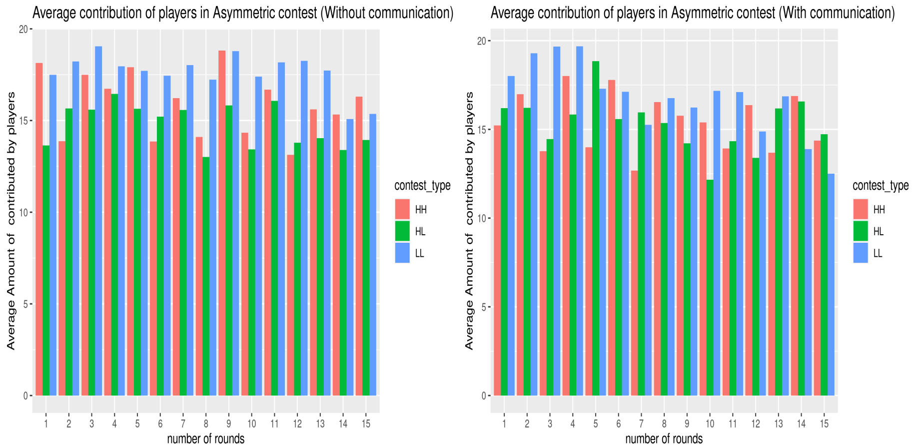
Note: Values in parenthesis show the standard errors; n in each cell indicates the number of observations; P-values show the significance of difference of mean player contribution between column (1) & column (2) values; $*$ & $***$ in column (3) indicate significant at 5 percent and 1 percent level respectively.

Here, we compare the average player contribution for players with higher marginal effort costs and those with lower marginal effort costs. Figure 6 plots round-wise average average player contribution for different marginal costs. Panel (A), panel (B), and panel (C) in figure 6 depict this information with cheap talk and without cheap talk communication treatment and for pooled data, respectively. Table 6 shows the relevant statistical analysis. Under cheap talk treatment, an average contribution for players with the higher marginal cost is significantly lower (Wilcoxon p-value is < 0.01). The same result holds without cheap talk treatment as well (Wilcox p-value is < 0.01). When we combined all the data, i.e., combining baseline and treatment data, we also found that the average contribution for players with the higher marginal cost is significantly lower (Wilcoxon p-value is < 0.01). This finding is consistent with the earlier findings of Baye and Hoppe ((2003)).

Result 5. A Player with a lower marginal effort cost exerts significantly more effort than a player with a higher marginal effort cost.

Figure 7 plots the round-wise average contribution of players for 15 rounds aggregated by their types. Panel (A) and panel (B) in figure 7 depict this information without cheap talk and with cheap talk communication treatment, respectively. Both in panels (A) and (B), for most of the rounds, height average bids are made by LL-type players. This is also evident from table 5.

Result 6. Given all types of players, the highest average bids are observed in the contest when a Low-type type player faces a Low-type opponent.



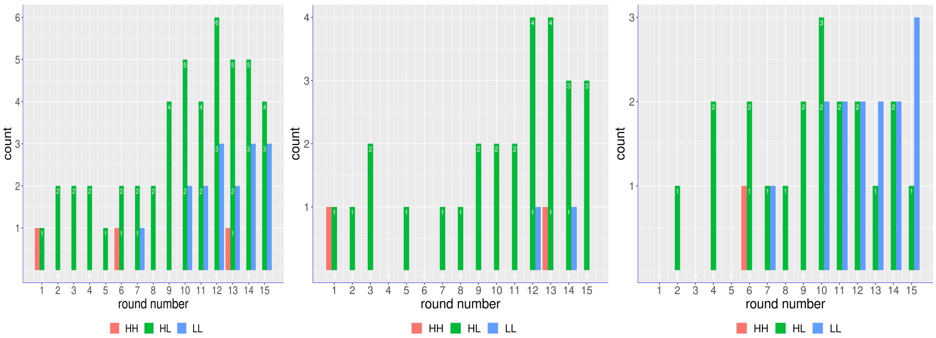
(a) without chat

(b) with chat

Figure 7: Round-wise Average contribution of players

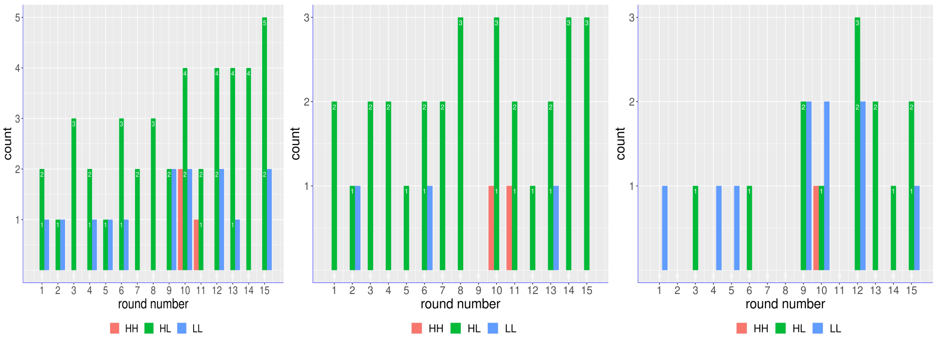
Table 16 shows the relative frequency chart of effort by players given different contribution ranges in our experimental data. This is shown for all three types of contests, namely HH, HL, and LL, as well as for both treatments (namely, with and without cheap talk). If we focus on the HH type of contests, maximum bids are made in the range of (19,20], followed by in the range of (18,19] when treatments are pooled together as well as for each treatment. Similar patterns are observed for LL and HL-type contests. One contrasting behavior was observed for HL players. In comparison to both HH or LL type of players, numerically, a large number of bids are made within the lowest range, i.e., in the range of (0,1] or (1,2]. This holds true for all treatment types for HL players.

Result 7. When there is an asymmetry in the opposing player's type, significantly more bids are observed in the lowest bidding range, although a maximum number of bids are observed in the highest bidding range.



(a) All treatment (b) with chat (c) without chat

Figure 8: Round wise zero contribution of players



(a) without chat (b) with chat (c) with chat

Figure 9: Round wise full contribution of players

6.5 Individual Belief:

Here, we consider the player's belief about the intended amount of bid by his/her opponent in the contest. This will help us analyze players' behaviour, given the accuracy of their beliefs. Figure 11 shows the average players' belief amount over the experimental session. Given there are two types of players (either High type or Low type) and two possible outcomes in the experiment (either win or lose), we plot all four possible outcomes for a better comparison. Panel (A) in figure 11 shows this for players pooled over all treatments, and panel(B) and panel (C) depict this information without cheap-talk communication treatment and with cheap-talk communication treatments, respectively. Table 7 provides the relevant statistical results.

Table 7: Within statistical comparison of player belief amount

TREATMENT TYPE	CONTEST RESULT	MEAN PLAYER BELIEF AMOUNT		WILCOXON P-VALUE (3)
		Higher (1)	Lower (2)	
ALL	WINNER	17.9 (0.319)	6.44 (1.07)	0.00***
	LOOSER	17.7 (0.415)	6.29 (0.845)	0.00***
WITH CHAT	WINNER	17.8 (0.371)	6.70 (1.29)	0.00***
	LOOSER	17.7 (0.530)	6.25 (0.927)	0.00***
WITHOUT CHAT	WINNER	18.1 (0.388)	6.10 (1.36)	0.00***
	LOOSER	17.7 (0.606)	6.45 (1.29)	0.00***

Note: Values in parenthesis show the standard errors; n in each cell indicates the number of observations; P-values show the significance of difference of mean player contribution between column (1) & column (2) values; $*$ & $***$ in column (3) indicate significant at 5 percent and 1 percent level respectively.

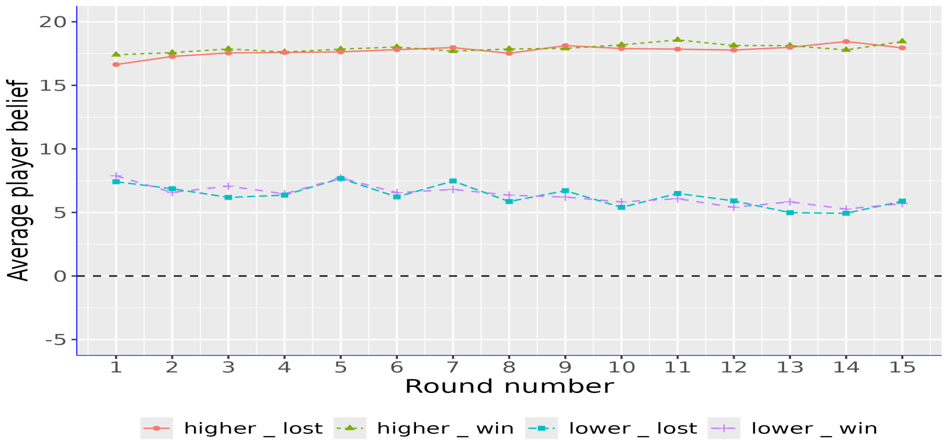
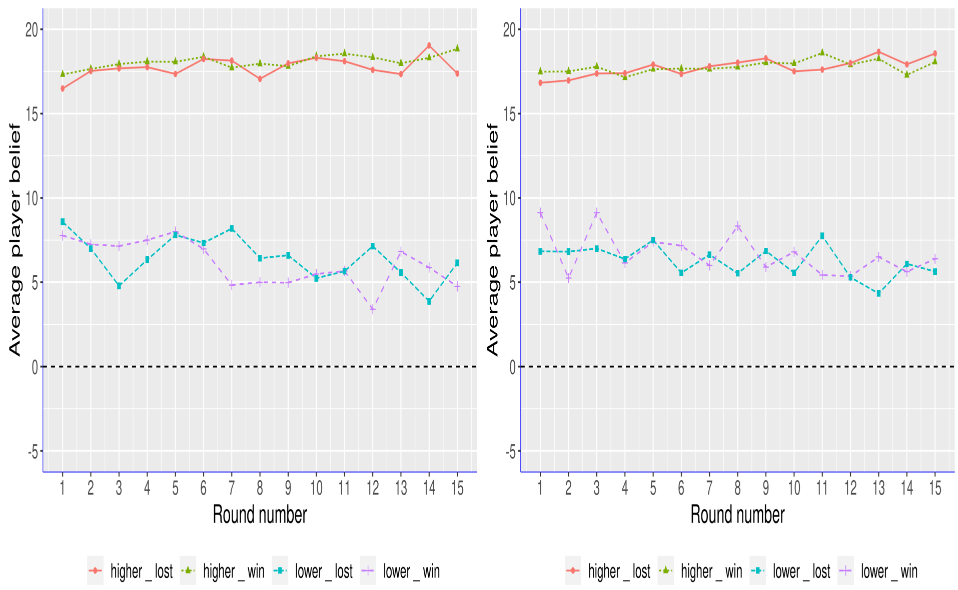


Figure 10: Comparison of average player belief amount of all types across the rounds(All types)



(a) without communication

(b) with communication

Figure 11: Comparison of average player belief amount of all types across the rounds (by treatment)

From figure 11, we find that the average belief of a High-type player is much higher than that of the Low-type players, irrespective of the outcome of the contest. For high-type players, there is almost no variation in average belief, taking into account their winning or losing status in the contest, but for low-type players, we find clear variation in average belief as the session progresses. This result holds true both without cheap talk communication treatment and with cheap talk communication treatment. Referring to table 7, when the winning players in the contest are considered alone, the mean belief is significantly higher for High type players in comparison to Low type players (the combinations of mean belief amount for High and Low types are 17.8 & 6.7 for cheap talk treatment, 18.1 & 6.1 for no cheap talk treatment, 17.9 & 6.44 when pooled over all treatments; the p-value of 0.00 implies the difference is significant.) This result is persistent if we consider only the loser players in the contest.

Result 8. Irrespective of the contest result or the communication treatment, the High-type players' belief amount about the opponent's bid is significantly higher than the Low-type player.

6.6 Individual Difference:

Given players' beliefs, we explore more of players' contributions. From the data of our experiment, we construct a new variable called 'diff,' which is the difference between player contribution amount and player belief amount. For simplicity of our analysis, we categorize player belief amount as 'Higher' if it is greater than 10, else 'Lower'[9]. This is done to get a sense of how players with a 'Higher' or 'Lower' belief amount perform in the winning and losing cases in the contest. It is to be noted that the difference between player contribution amount and player belief amount may be positive or negative[10].

Figure 12 & 13 shows the average players' difference over the experimental session. Given there are two types of players (either Higher belief or Lower belief) and two possible outcomes in the experiment (either win or lose), we plot all four possible outcomes for a better comparison. Panel (A) in figure 13 shows this for players pooled over all treatments, and panel(B) and panel (C) depict this information without cheap-talk communication treatment and with cheap-talk communication treatments, respectively.

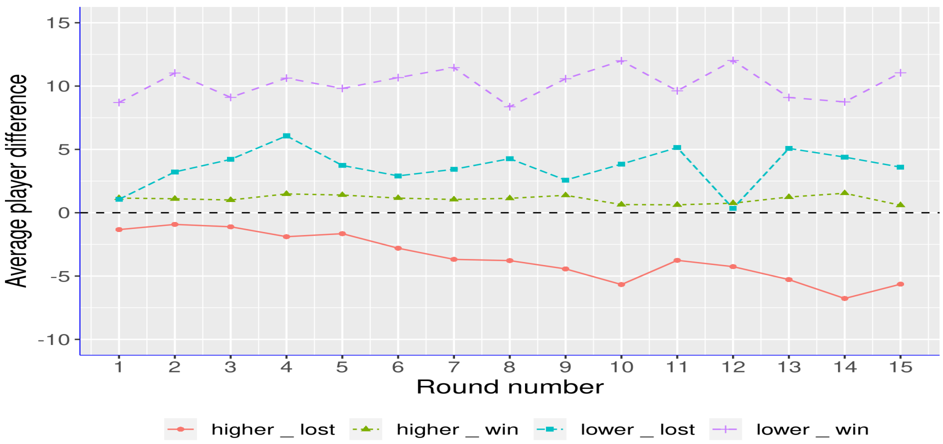
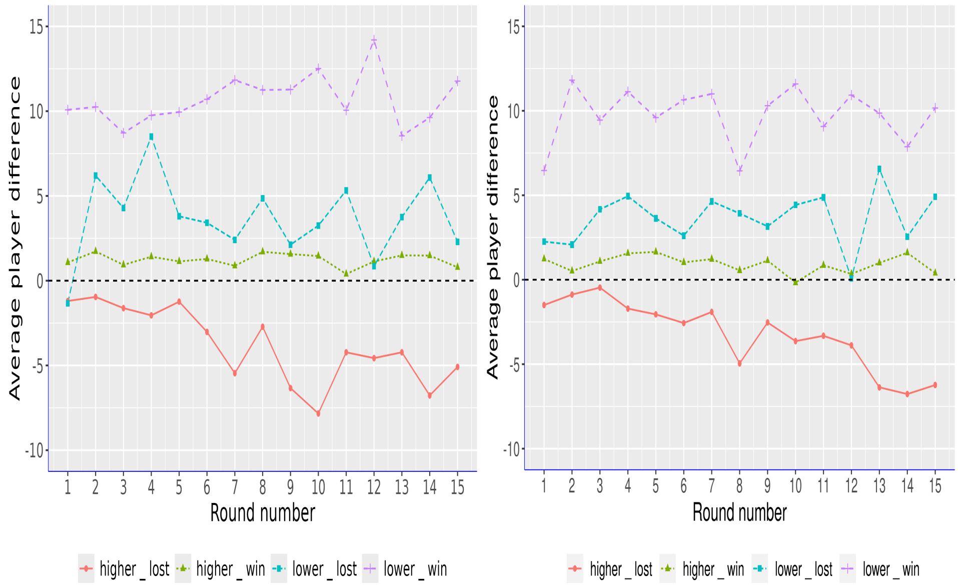


Figure 12: Comparison of player difference amount of all types across the rounds (all types)

[9]We take 10 as the reference point since it is the mean value of available endowment for each player as total endowment available to each one is 20 at the start of each round.

[10]The horizontal dotted line in figure 13 denotes the demarcation line between positive and negative difference



(a) without communication (b) with communication

Figure 13: Comparison of player difference amount of all types across the rounds

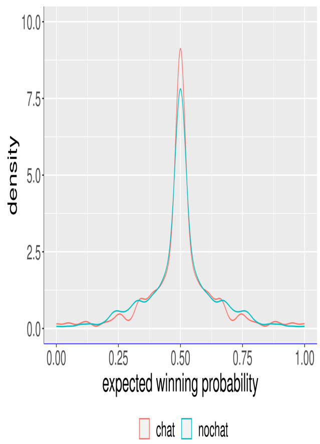
Here, it is noteworthy to mention that a player's belief is nothing but his/her perceived notion about the action of his/her opponent. Some interesting observations come out from figure 13. We do not find any player with a 'Lower' belief to have any negative difference[Panel(A) and Panel (C)]. That means that for a player with a 'Lower' belief, he/she does not contribute less than the perceived bidding amount of his/her opponent[except in one case in panel (B)]. In contrast, we find observations where the player with 'Higher' beliefs has a negative difference. This only happens in cases where a player with a 'Higher' belief has lost the contest, irrespective of the communication treatment. This later phenomenon is more interesting as these players have contributed less than their believed amount. This implies there is a contradiction between their belief and actual bid given the belief.

Result 9. No player with a 'Lower' belief contributes less than the perceived bidding amount of his/her opponent in the contest under cheap talk communication treatment.

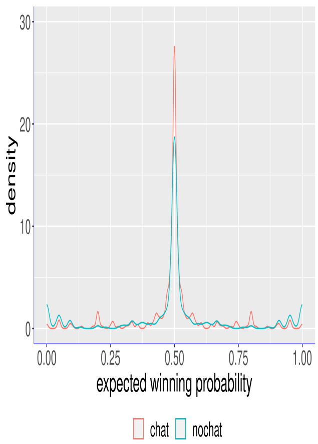
Result 10. In losing cases, a Player with a 'Higher' belief contributes less than the perceived bidding amount of his/her opponent in the contest, irrespective of the communication treatment.

6.7 Main behavioral (i)regularities:

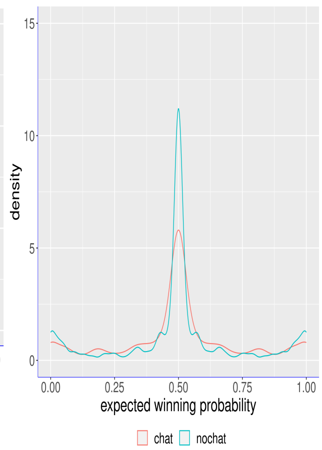
In order to analyze the pattern of general behaviour, we first explore the distribution of expected winning probabilities that the players believed they would accomplish when making decisions(bids)[shown in figure 15]. This expected winning probabilities are calculated using player's belief and player's own contribution.



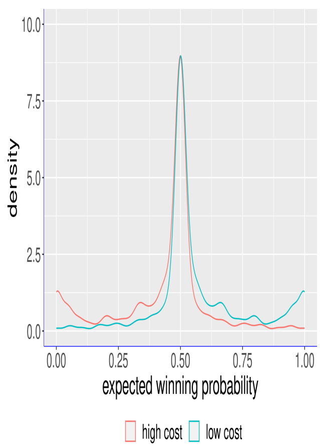
(a) HH type



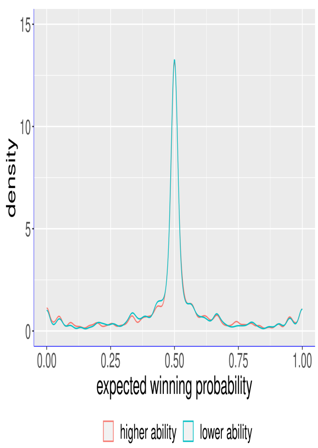
(b) LL type



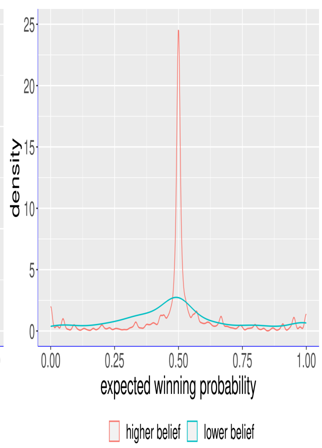
(c) HL type



(d) cost heterogeneity

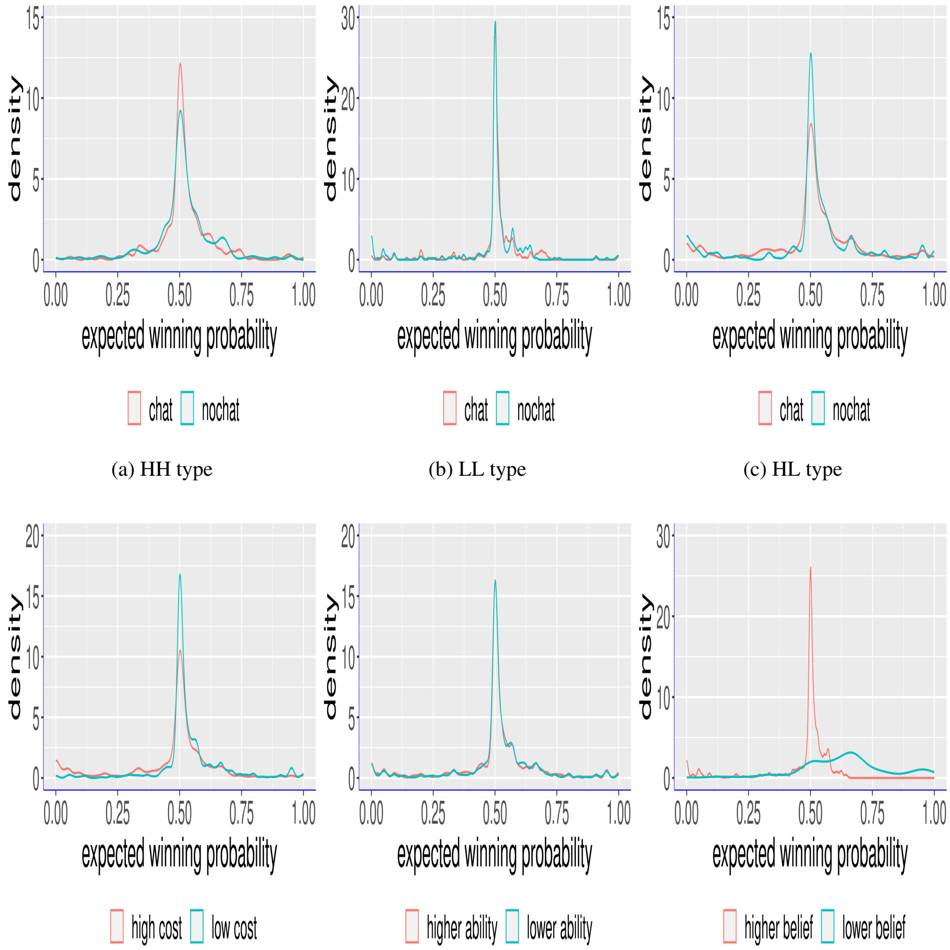


(e) ability heterogeneity



(f) belief heterogeneity

Figure 14: : Winning probability distribution by Treatment, Cost, and Contest type. EXPECTED WINNING PROBABILITY is calculated based on own investments and opponent investment



(a) HH type (b) LL type (c) HL type

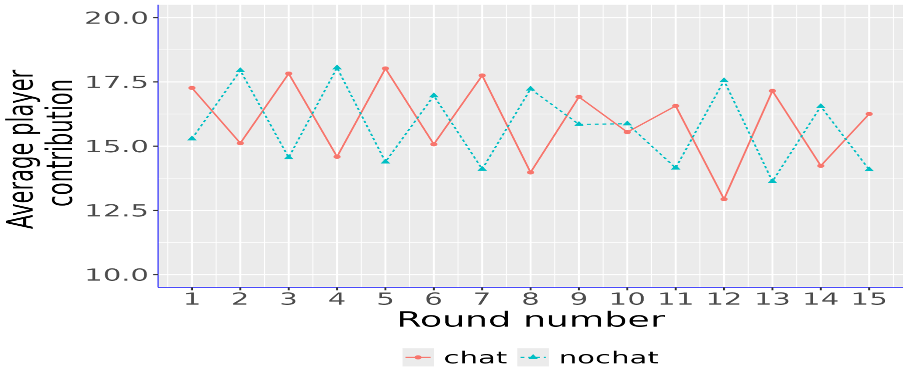
(d) cost heterogeneity (e) ability heterogeneity (f) belief heterogeneity

Figure 15: : Expected winning probability distribution by Treatment, Cost, and Contest type. EXPECTED WINNING PROBABILITY is calculated based on own investments and reported beliefs

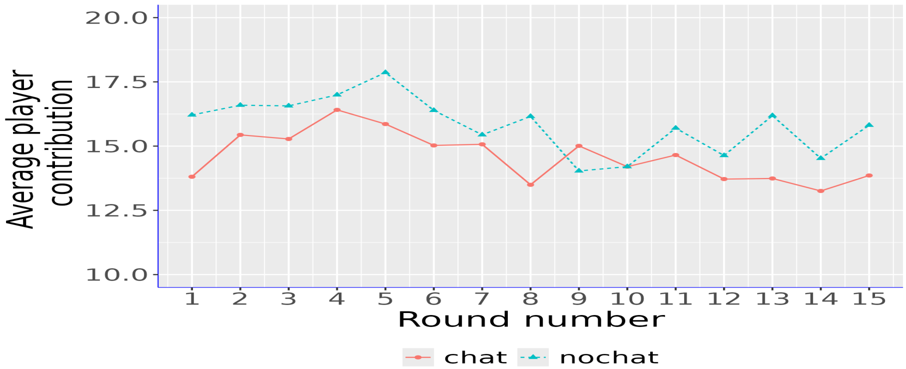
First, we find that, under communication asymmetry, all types of players expect a similar pattern of winning probability. A significantly large portion of mass distributions are around 0.5 (shown in panel (A), (B), (C) in fig 13). Secondly, The same pattern is observed for cost heterogeneity (shown in panel (D) in fig 13) as well as for ability heterogeneity(shown in panel (E) in fig 13). Thirdly, for belief heterogeneity, all types of players do not expect a similar pattern of winning probability; for players with lower belief, the expectation is less than 0.5.

Result 11. Given asymmetry, subjects aspire for equal expected winning probability except for belief asymmetry.

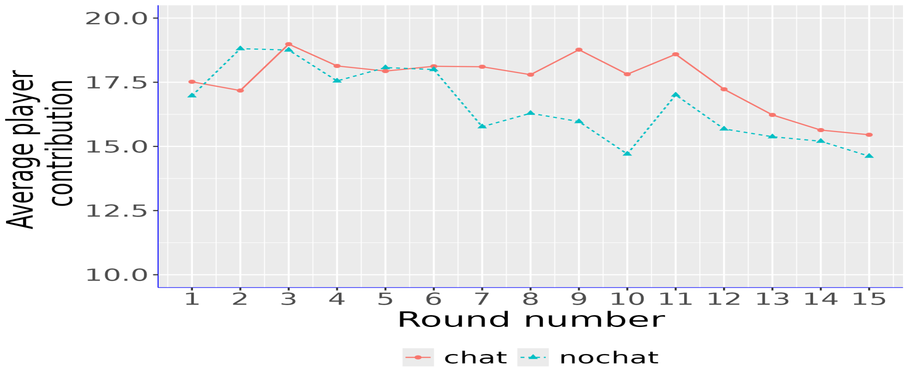
7 Robustness check:



(a) HH type



(b) HL type



(c) LL type

Figure 16: Average player contribution across the rounds

Here, we depict and compare the earlier shown scenario of table 5 separately for HH, HL, and LL type contest in the figure 16. The red line refers to the with communication (cheap-talk) treatment, and the green line refers to the without communication (No cheap-talk) treatment. Table 5 shows the mean for both the treatments for all types of players aggregated over the 15 rounds. Although there is a declining trend (except for HH type), the average effort continues to be much higher than what is predicted by Nash equilibrium.

Table 5 summarizes the average effort levels for each type of player and relevant statistical parameters. Using the table, we can compare the average effort level of players for both with cheap talk and without cheap talk treatments. We use the 'Wilcoxon signed-rank test' for our statistical comparison purposes. As shown in figure 4, the dotted lines represent the theoretical prediction of individual effort levels. From panel (B) and panel (C) of figure 4, it is evident that the average observed effort in contest for all treatments is significantly greater than the theoretical prediction. In other words, figure 4 depicts the over-expenditure across the rounds. This finding is consistent with earlier contest experiment results [Sheremeta ((2015)), Sheremeta ((2013))].

If we consider the HH type first, the mean effort is 15.9 tokens for cheap talk treatment and 15.7 tokens for without cheap talk treatment. The p-value of 0.72 implies there is no significant effect of treatment when a 'High' type player faces another 'High' type player. When a 'Low' type player faces another 'Low' type player, we find a significant effect of our cheap talk treatment. The mean player effort level is significantly higher under cheap talk (mean value is 17.6 tokens and 16.6 tokens under cheap talk and without cheap talk, respectively, and the p-value is 0.00). For a high-type player, when facing a low-type player or vice-versa, the mean value under cheap talk treatment is significantly lower (p-value is 0.00). This clearly shows that for different player types, when facing the same or opposite type of player, the effect of cheap talk differs from one type to another player type. There is no uniform trend of communication effect on individual effort level.

One interesting comparison will be if we are able to compare among all sorts of possible combinations of types of players irrespective of the treatment variable. For this purpose, we employ the Tukey contrasts method for multiple comparisons of means as shown in table 8. The graphical display for this pair-wise comparison is shown in figure 17. From the figure, we find a significant mean difference in bids between LL-type and HH-type contests, LL-type and HL-type contests under cheap talk communication treatment, between LL-type contests under cheap talk communication treatment (LL_C) and HH-type contests under no cheap talk communication treatment (HH_N), between HL type players under cheap talk communication treatment(HL_C) and LL type contest under no cheap talk communication and treatment(LL_N), between HL type contest under no cheap talk communication treatment(HL_N) and LL type contest under cheap talk communication and treatment (LL_C).

In table 8, 9, and 10, we compare multiple means together following Tukey's HSD method. Table 9 & 10 statistically analyze all possible combinations (there are three combinations–HL-HH, LL-HH, LL-HL) of contest types in terms of their average contribution(bid) for cheap talk treatment and without cheap talk treatment respectively and in table 8, it is shown for the whole contest for all treatments (15 combinations, see table 8)[11]. Figure 17, 18 and 19 plot the relevant information for the Graphical display of pair-wise comparisons with confidence interval[12].

Figure 17: Graphical display of pair-wise comparisons from Tukey's HSD for the contest data [Here 'C' represents with chat & 'N' represents no-chat]

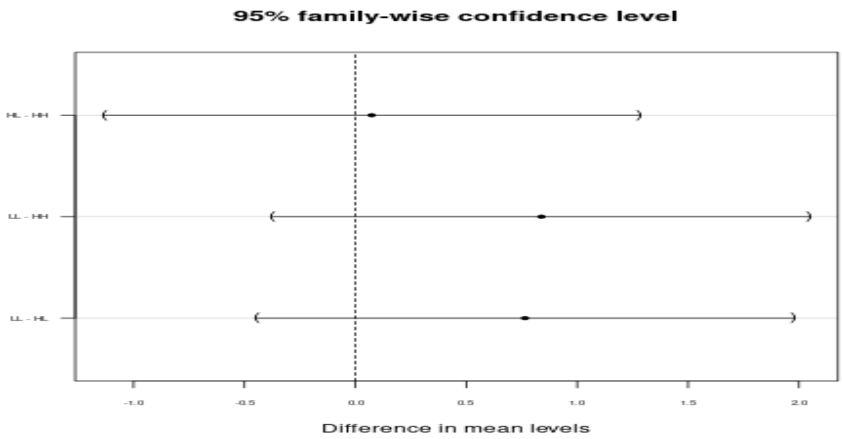


Figure 18: Graphical display of pair-wise comparisons from Tukey's HSD for the contest data under without communication (nochat) treatment

[11]Here for a pair of combination, the null hypothesis assumes it to be equal and the p-value shows the level of significance

[12]Any confidence intervals that don't contain 0 show that the groups are different.

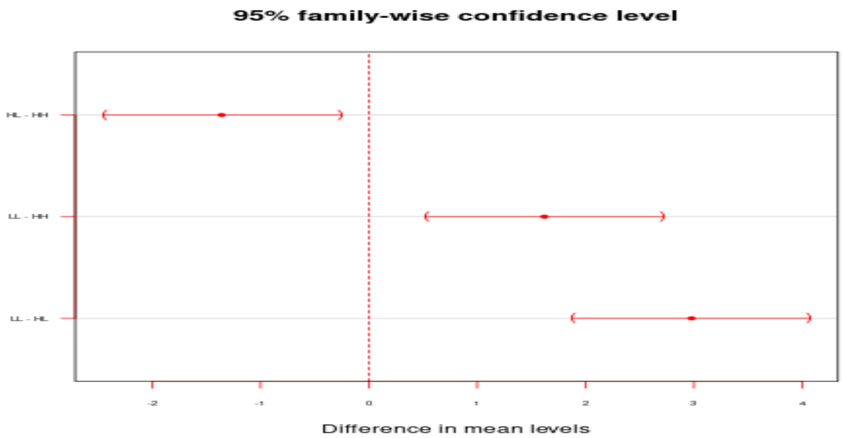


Figure 19: Graphical display of pair-wise comparisons from Tukey's HSD for the contest data under communication(chat) treatment

Table 8: Multiple types of contests comparison (all types)

Simultaneous Tests for General Linear Hypotheses		
Multiple Comparisons of Means: Tukey Contrasts		
Contest (with & without communication)		
Linear Hypotheses:	**Estimate**	**Pr(>|t|)**
HH_N - HH_C == 0	-0.2	0.99
HL_C - HH_C == 0	-1.36	0.06
HL_N - HH_C == 0	-0.17	0.99
LL_C - HH_C == 0	1.62	0.01 *
LL_N - HH_C == 0	0.64	0.76
HL_C - HH_N == 0	-1.16	0.15
HL_N - HH_N == 0	0.07	0.99
LL_C - HH_N == 0	1.82	0.00 **
LL_N - HH_N == 0	0.84	0.49
HL_N - HL_C == 0	1.23	0.11
LL_C - HL_C == 0	2.98	<0.00 ***
LL_N - HL_C == 0	1.99	<0.00 ***
LL_C - HL_N == 0	1.75	0.01 **
LL_N - HL_N == 0	0.76	0.59
LL_N - LL_C == 0	-0.98	0.31
Note: $^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$ (Adjusted p values reported – single-step method)		

Table 9: Multiple types of contests comparison (all types) under without-communication treatment

Simultaneous Tests for General Linear Hypotheses		
Multiple Comparisons of Means: Tukey Contrasts		
Contest (without communication)		
Linear Hypotheses:	**Estimate**	**Pr(>|t|)**
HL - HH == 0	0.07	0.99
LL - HH == 0	0.84	0.22
LL - HL == 0	0.76	0.28
Note: $^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$ (Adjusted p values reported – single-step method)		

Table 10: Multiple types of contests comparison (all types) under communication treatment

Simultaneous Tests for General Linear Hypotheses		
Multiple Comparisons of Means: Tukey Contrasts		
Contest (with communication)		
Linear Hypotheses:	**Estimate**	**Pr(>|t|)**
HL - HH == 0	-1.36	0.01 *
LL - HH == 0	1.62	0.002 **
LL - HL == 0	2.98	<1e-04 ***
Note: $^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$ (Adjusted p values reported – single-step method)		

To check the determinants of player contribution, we run two more regressions, one is for winning factions(shown in table 11) and other one is for losing faction(shown in table 12). From these two tables, we find that coefficients on cheap talk dummy variable are negative and significant in HL contest for both winning and losing factions.In fact, both in tables 11 and 12, higher belief about the opponent players expected bid is positively and significantly associated with player contribution level. As these are the core finding in subsection 6.1, our results pertaining to HL contest do not vary in we consider the winning or losing factions.

Table 11: Determinants of player contribution(for winning group)

	Dependent variable: Player contribution		
	HH Contest (1)	HL Contest (2)	LL Contest (3)
Rank(= 2)	-1.17^{**}	-2.15^{***}	-0.26
	(0.25)	(0.34)	(0.18)
Cheap Talk(= 1)	0.37	-1.45^{*}	1.01^{*}
	(1.49)	(0.75)	(0.59)
Belief	0.37^{***}	0.13^{***}	0.18^{***}
	(0.07)	(0.03)	(0.02)
Cheap Talk:Belief	-0.02	0.04	-0.06^{*}
	(0.08)	(0.05)	(0.03)
Period	-0.04	-0.03	0.03^{*}
	(0.01)	(0.03)	(0.01)
Present bias	0.87	-2.86^{***}	0.24
	(0.42)	(0.42)	(0.24)
Risk preference	0.31	-0.16	0.06
	(0.13)	(0.30)	(0.12)
Constant	12.51^{***}	18.11^{***}	16.19^{***}
	(1.36)	(0.62)	(0.41)
Fixed effects?	Yes	Yes	Yes
Observations	315	552	330
R^2	0.28	0.24	0.26
Adjusted R^2	0.26	0.23	0.24
Residual Std. Error	2.91	3.29	1.02

Note: $^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$; Numbers in parenthesis are robust standard errors clustered at the group level.

Table 12: Determinants of player contribution(for losing group)

	Dependent variable: Player contribution		
	HH Contest	HL Contest	LL Contest
	(1)	(2)	(3)
Rank(= 2)	−0.42	1.87**	0.78
	(0.99)	(0.80)	(1.03)
Cheap Talk(= 1)	−0.73	−4.11**	1.46
	(2.38)	(1.67)	(2.44)
Belief	0.53***	0.08	0.37***
	(0.09)	(0.08)	(0.09)
Cheap Talk:Belief	0.08	0.20*	0.10
	(0.14)	(0.10)	(0.14)
Period	−0.12*	−0.28***	−0.52***
	(0.08)	(0.07)	(0.08)
Present bias	0.22	2.57***	3.62***
	(1.05)	(0.94)	(1.16)
Risk preference	−0.68	−2.08***	−2.22***
	(0.79)	(0.65)	(0.72)
Constant	7.69***	12.76***	11.31***
	(1.73)	(1.56)	(1.93)
Fixed effects?	Yes	Yes	Yes
Observations	315	543	330
R^2	0.27	0.10	0.24
Adjusted R^2	0.26	0.09	0.22
Residual Std. Error	5.09	7.41	6.04

Note: $^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$; Numbers in parenthesis are robust standard errors clustered at the group level.

8 Discussion:

This study provides important new understandings of the behavior of bidders and the results of asymmetric Tullock contests, in which participants have varying skill levels and communicate with cheap talk. The results highlight the complex interactions that shape bidding tactics and contest dynamics, including ability asymmetry, risk preferences, attitudes, communication, and prior performance. In this chapter, we conduct a theoretical analysis to elucidate the effect of incomplete information asymmetry on individual effort provision and employ experimental methods to examine the impact of cheap talk communication between players on the pattern of effort provision. We compare the effect of communication in three distinct cases: (i) when both players are cognizant of their High type designation, (ii) when both players are cognizant of their Low type designation, and (iii) when one player is of High type, while the opponent player is of Low type. In each case, players exhibit differential abilities, and consequently, they possess varying unit effort costs. For contests involving two players, we discern significant differences in the distribution of effort levels across all treatments for all three cases. Furthermore, we find that communication exerts a heterogeneous effect on effort provision, contingent upon the nature of the contestant types.

The findings highlight the complex interplay between ability asymmetry, risk preferences, beliefs, communication, and past performance in shaping strategies and contest dynamics. Bid density varies across contest types and communication treatments, with cheap talk impacting individual bidding levels differently depending on ability asymmetry. Risk preference significantly increases overbidding in high-high-ability contests, particularly for lower ranks, while beliefs about winning mitigate overbidding. Communication increases overbidding in high-low contests but decreases it in low-low contests compared to no communication. Higher contributions increase winning probability across contests, but communication provides an advantage to low-ability players in high-low contests while reducing winning probability in low-low contests. Ability asymmetry impacts bidding, with lower effort costs leading to higher bids and the highest bids observed when low-ability players face each other. Players' beliefs about opponents' bids play a crucial role, with high-ability players holding significantly higher beliefs irrespective of outcomes. In comparison to the equilibrium predictions in the absence of communication between players, we observe a significant amount of overbidding. This finding is consistent with earlier research on Tullock contests, all-pay auctions, tournaments, and other contest forms (Schotter and Weigelt ((1992)), Millner and Pratt ((1989)), Fonseca ((2009)), Sheremeta ((2018))). We find that a substantial percentage of respondents submit nonzero bids, which aligns with previous studies. This bidding behavior, which serves as a reliable predictor of bidding in the conventional contest, automatically accounts for a considerable portion of the observed overbidding.

Our main findings are related to the effect of communication treatment. We find a significant impact of cheap talk communication protocol on the individual bidding level. In the case of two competing players of two different types, allowing communication between them significantly reduces the average bidding level, reducing resource wastage and thus promoting efficiency. From the policy perspective, this opens a new mechanism design perspective for contest organizers. Since the literature on the communication effect in incomplete information contests is not rich enough, our findings may lead to several inquiries in this dimension. Given constraints, this study also has some limitations. When we are considering two contestants of the same type (High or Low type), we rely on the perceived notion of ability with cost differential between them. One possible further extension of this study can be done if no cost differential is considered between the same type of players. Studying this aspect may give a more robust check of our findings.

The experimental results provide important new understandings of bidding behavior and performance in one-sided asymmetric Tullock contests with different communication channels and ability levels. The findings highlight how crucial it is to take into account variables, including ability asymmetry, risk preferences, attitudes, communication, and previous results, when developing and evaluating contest mechanisms.

These results add to the growing body of knowledge on the experimental study of Tullock contests and have practical applications in lobbying, rent-seeking, and competitive procurement, among other real-world contexts. Since the ability disparity between participants might affect the influence of risk preferences and the effectiveness of communication channels, the study emphasizes the necessity for customized tactics to reduce overbidding and increase efficiency. Furthermore, the results indicate that cheap talk communication may affect individual bidding levels and contest outcomes depending on the ability asymmetry between participants. The possible effects of communication channels should be carefully considered by policymakers and contest designers, who should then customize their implementation according to the particular contest context and participant ability distribution.

Future research could further explore the robustness of these findings under different contest structures, information environments, and communication protocols. It could also investigate the potential for behavioral interventions to mitigate overbidding and enhance the efficiency of contest mechanisms. Additionally, incorporating insights from psychology could provide a deeper understanding of contestants' underlying decision-making processes and motivations in asymmetric contests.

A Proofs of Propositions:

A.A Proof of Proposition 4.1:

Now putting $V_1 = V$ and $e_2 = \frac{l}{h}.e_1$ into equation ((3.10)), we get:

$$\begin{aligned}
V.\frac{r.e_1^{r-1}.\frac{l^r}{h^r}.e_1^r}{(e_1^r + \frac{l^r}{h^r}.e_1^r)^2} &= \frac{1}{h} \\
\implies V.\frac{r.e_1^{-1}.l^r.h^r}{(h^r + l^r)^2} &= \frac{1}{h} \\
\implies V.\frac{r.l^r.h^r}{(h^r + l^r)^2} &= \frac{1}{h} \\
\implies V.\frac{r.l^r.h^{r+1}}{(h^r + l^r)^2} &= e_1
\end{aligned} \tag{A.1}$$

Since contestant 1 is of type 'h' and plays against contestant 2 of type 'l,' we call e_1 as e_{hl}. Thus,

$$e_{hl} = V.\frac{r.l^r.h^{r+1}}{(h^r + l^r)^2} \tag{A.2}$$

Similarly for contestant 2, we call $e2$ as e_{lh} and its value is given by:

$$e_{lh} = V.\frac{r.h^r.l^{r+1}}{(h^r + l^r)^2} \tag{A.3}$$

Now for a constant rate of return, i.e., for value $r = 1$ and unit valuation of the prize, i.e., $V = 1$, we get the following set of equilibrium outcomes depending on the nature of the contest:

$$\begin{aligned}
e_{hh} &= \frac{h}{4} \\
e_{hl} &= \frac{h^2}{(h+l)^2} \\
e_{lh} &= \frac{l^2}{(h+l)^2} \\
e_{ll} &= \frac{l}{4}
\end{aligned} \tag{A.4}$$

Where $e_{\theta_i \theta_j}$ represents the equilibrium effort of type θ_i contesting against a rival of type θ_j.

It is to be noted that $e_{hh} < e_{hl}$ and $e_{ll} < e_{lh}$ as players exert more effort in even contests than in uneven contests as we have assumed $l > h > 0$.

A.B Proof of Proposition 4.2:

Let's assume $m = \frac{h}{l}$; $h, l > 0, l > h, 0 < m < 1$.
We know, $e_1 = V.\frac{rl^r h^{r+1}}{(h^r+l^r)^2}$

For, $r = 1$, we get:

$$\begin{aligned}
e_1 &= V.\frac{lh^2}{(h+l)^2} = V.\frac{lh^2}{l^2(\frac{h}{l}+1)^2} \\
&= V.\frac{h}{l(\frac{h}{l}+1)^2} = \frac{hmV}{(1+m)^2} \\
\implies \frac{e_1}{h} &= \frac{mV}{(1+m)^2} \\
\text{similarly,} \implies \frac{e_2}{l} &= \frac{mV}{(1+m)^2}
\end{aligned} \tag{A.5}$$

Now,

$$\begin{aligned}
\frac{\partial(\frac{e_1}{h})}{m} &= V.\frac{(1+m)^2 - 2m(1+m)}{(1+m)^3} > 0 \\
&= V.\frac{(1-m)^2}{(1+m)^2} > 0 \\
\implies \frac{\partial(\frac{e_1}{h})}{m} &> 0 \\
\text{,and similarly,} \implies \frac{\partial(\frac{e_2}{l})}{m} &> 0
\end{aligned} \tag{A.6}$$

This establishes the proof.

A.C Proof of Proposition 4.3:

In our case, the prize value is positive, so any pure strategy Nash Equilibrium will require players to exert positive effort in equilibrium. Through equation ((A.2)) and equation ((A.3)), we have shown that efforts at equilibrium are positive. We have also shown that there exists a unique solution (e_{hl}, e_{lh}) to the first-order condition. Moreover, the expected profit for both types of players is positive (shown in equation ((3.26)) & ((3.27))). Now, when we evaluate the second-order sufficiency condition for player 1 (type h), we have shown that $\frac{\partial^2 \pi_{hl}{}^*}{\partial e_{hl}{}^2} < 0$ (see equation ((3.19))). Therefore, player 1 (h type) is maximizing profit against player 2 (l type), and a similar argument holds for player 2 as well.
Thus, this sufficiency condition here implies there exists a PSNE.

B Additional Tables and figures:

Table 13: Description of data

Variable Name	Description	Mean	S.D.
Dependent variables:			
Player contribution	Total points contributed by player	15.87	6.14
Overbidding rate	$\frac{playercontribution - expectedbid}{expectedbid}$	13.96	12.46
Winning probability	Calculated as a function of own and opponent player's effort(contribution), using equation (3.1)	0.50	0.20
Experimental treatment variables:			
Cheap Talk	= 1 for communication treatment ; 0 otherwise		
Rank	= 1 for ranked 1 in task coding; 2 otherwise		
Belief	The player's intended amount of bid by his/her opponent in the contest	15.36	5.49
Win	= 1 for winning in round t ; 0 otherwise	0.50	0.50
Win$_{(t-1)}$	= 1 for winning in round $(t-1)$; 0 otherwise	0.49	0.50
Additional control variable			
Period	Decision round in the experiment, from 1 to 15	8.00	4.32
Risk preference	= 1 for risk takers ; 0 otherwise		
Present bias	= 1 for present bias ; 0 otherwise		

Table 14: Determinants of Over-bidding rate

	Dependent variable: Over-bidding rate		
	HH Contest	HL Contest	LL Contest
	(1)	(2)	(3)
Risk preference(= 2)	6.08^{***}	1.52	0.69
	(1.90)	(1.31)	(1.38)
Rank(= 2)	1.81	1.95^{***}	2.82
	(1.80)	(0.87)	(1.85)
Belief	-0.33^{**}	-0.14^{**}	-0.46^{***}
	(0.13)	(0.07)	(0.10)
Period	-0.13	0.22^{**}	0.25^{**}
	(0.15)	(0.10)	(0.12)
Cheap Talk(= 1)	0.50	2.77^{**}	-3.46^{**}
	(0.95)	(1.14)	(1.37)
Win	-2.16	-4.00^{***}	-3.72^{***}
	(1.35)	(1.21)	(1.40)
$\text{Win}_{i_{(t-1)}}$	-0.24	3.05^{*}	0.71
	(2.06)	(1.60)	(1.39)
Risk preference : Rank	-6.12^{***}	0.22	-1.59
	(2.27)	(2.10)	(2.47)
Constant	-9.44^{***}	-15.76^{***}	-7.14^{***}
	(3.18)	(2.21)	(2.32)
Clustered?	Yes	Yes	Yes
Observations	609	1,059	638
R^2	0.07	0.13	0.12
Adjusted R^2	0.06	0.12	0.10
Residual Std. Error	11.40	11.87	12.07

Note: $^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$; Numbers in parenthesis are robust standard errors clustered at the group level.

Table 15: Winning probability model estimates: Tobit maximum likelihood estimate

	Dependent variable: Winning probability		
	HH Contest	HL Contest	LL Contest
	(1)	(2)	(3)
Player Contribution	0.02^{***}	0.02^{***}	0.03^{***}
	(0.001)	(0.001)	(0.001)
Cheap Talk(= 1)	-0.002	0.001	-0.04^{***}
	(0.01)	(0.01)	(0.01)
Risk preference(= 2)	-0.05^{***}	0.04^{***}	-0.02^{*}
	(0.01)	(0.02)	(0.01)
Rank(= 2)	-0.05^{***}	-0.08^{***}	-0.09^{***}
	(0.02)	(0.02)	(0.02)
Present bias(= 2)	0.001	0.04^{**}	-0.01
	(0.01)	(0.02)	(0.02)
Belief	-0.004^{***}	-0.01^{***}	-0.005^{***}
	(0.001)	(0.001)	(0.001)
Period	0.001	0.003^{**}	0.01^{***}
	(0.001)	(0.001)	(0.001)
Risk preference : Rank	0.03^{*}	-0.06^{***}	-0.01
	(0.02)	(0.02)	(0.02)
Cheap Talk : Rank	-0.002	0.04^{*}	0.06^{***}
	(0.02)	(0.02)	(0.02)
Constant	0.32^{***}	0.23^{***}	0.14^{***}
	(0.02)	(0.02)	(0.03)
Observations	630	1,095	660
Log Likelihood	493.67	334.87	428.29
Wald Test	426.68^{***}	$1,200.17^{***}$	$1,017.89^{***}$

Note: Clustered standard errors are in parentheses. $***$ Denotes significantly different from zero at 1%. $**$ Denotes significantly different from zero at 5%. $*$ Denotes significantly different from zero at 10%.

Table 16: Relative frequency of effort

Contribution Range	**CONTEST TYPE**								
	HH	**HH WITHOUT CHAT**	**HH WITH CHAT**	**HL**	**HL WITHOUT CHAT**	**HL WITH CHAT**	**LL**	**LL WITHOUT CHAT**	**LL WITH CHAT**
(0,1]	4	3	1	54	30	29	19	4	15
(1,2]	7	2	5	23	12	11	9	3	6
(2,3]	8	4	4	15	7	8	2	1	1
(3,4]	10	4	6	9	7	2	1	1	0
(4,5]	9	5	4	23	16	7	11	9	2
(5,6]	13	6	7	13	8	5	2	1	1
(6,7]	17	8	9	12	11	1	4	4	0
(7,8]	2	11	11	13	9	4	3	0	3
(8,9]	5	2	3	14	6	8	4	2	2
(9,10]	21	9	12	36	20	16	13	4	9
(10,11]	8	3	5	14	9	5	3	2	1
(11,12]	20	11	9	23	14	9	3	0	3
(12,13]	17	10	7	8	5	3	8	5	3
(13,14]	17	5	12	14	7	7	6	2	4
(14,15]	32	16	16	49	19	30	20	15	5
(15,16]	33	23	10	22	14	8	18	8	10
(16,17]	36	19	17	21	10	11	19	11	8
(17,18]	45	19	26	43	25	18	54	39	15
(18,19]	70	29	41	112	55	57	68	46	22
(19,20]	233	123	110	540	243	297	377	171	206

Table 17: Relative contribution of effort in percentage

Round number	HH contest						HL contest						LL contest					
	TOTAL		WITH CHAT		WITHOUT CHAT		TOTAL		WITH CHAT		WITHOUT CHAT		TOTAL		WITH CHAT		WITHOUT CHAT	
	Higher	Lower	Higher	Lower	Higher	Lower	Higher	Lower	Higher	Lower	Higher	Lower	Higher	Lower	Higher	Lower	Higher	Lower
1	6.01%	7.32%	8.12%	4.55%	3.85%	10.00%	7.23%	6.10%	6.74%	6.27%	7.69%	5.93%	8.04%	5.61%	8.84%	4.92%	7.19%	6.28%
2	7.91%	5.41%	6.25%	7.79%	9.62%	3.12%	7.23%	6.10%	6.74%	6.97%	7.69%	5.19%	8.04%	5.61%	8.84%	4.92%	7.19%	6.28%
3	7.28%	6.05%	8.75%	3.90%	5.77%	8.12%	8.50%	4.85%	9.74%	3.48%	7.34%	6.30%	9.09%	4.81%	9.52%	4.37%	8.63%	5.24%
4	5.70%	7.64%	4.38%	9.74%	7.05%	5.62%	7.78%	5.57%	8.61%	5.23%	6.99%	5.93%	6.64%	6.68%	6.80%	6.56%	6.47%	6.81%
5	6.96%	6.37%	6.88%	5.84%	7.05%	6.88%	6.69%	6.64%	6.74%	6.27%	6.64%	7.04%	8.39%	5.35%	8.84%	4.92%	7.91%	5.76%
6	6.01%	7.32%	6.25%	7.79%	5.77%	6.88%	6.33%	7.00%	5.62%	8.01%	6.99%	5.93%	8.04%	5.61%	7.48%	6.01%	8.63%	5.24%
7	7.28%	6.05%	7.50%	5.19%	7.05%	6.88%	6.51%	6.82%	7.49%	5.57%	5.59%	8.15%	8.04%	5.61%	6.12%	7.10%	10.07%	4.19%
8	6.33%	7.01%	5.00%	9.09%	7.69%	5.00%	6.69%	6.64%	5.99%	7.67%	7.34%	5.56%	6.29%	6.95%	6.80%	6.56%	5.76%	7.33%
9	6.65%	6.69%	5.62%	7.14%	7.69%	6.25%	5.42%	7.90%	5.99%	6.97%	4.90%	8.89%	6.29%	6.95%	7.48%	6.01%	5.04%	7.85%
10	5.70%	7.64%	5.00%	9.09%	6.41%	6.25%	5.97%	7.36%	5.62%	8.01%	6.29%	6.67%	6.99%	6.42%	6.80%	6.56%	7.19%	6.28%
11	7.28%	6.05%	8.12%	4.55%	6.41%	7.50%	6.69%	6.64%	7.49%	5.57%	5.94%	7.78%	5.59%	7.49%	6.12%	7.10%	5.04%	7.85%
12	6.65%	6.69%	6.25%	7.79%	7.05%	5.62%	5.61%	7.72%	5.24%	8.36%	5.94%	7.04%	3.85%	8.82%	2.72%	9.84%	5.04%	7.85%
13	6.01%	7.32%	6.25%	6.49%	5.77%	8.12%	6.69%	6.64%	5.99%	6.97%	7.34%	6.30%	5.94%	7.22%	5.44%	7.65%	6.47%	6.81%
14	7.91%	5.41%	8.12%	5.84%	7.69%	5.00%	6.15%	7.18%	5.99%	7.67%	6.29%	6.67%	5.24%	7.75%	5.44%	7.65%	5.04%	7.85%
15	6.33%	7.01%	7.50%	5.19%	5.13%	8.75%	6.51%	6.82%	5.99%	6.97%	6.99%	6.67%	3.50%	9.09%	2.72%	9.84%	4.32%	8.38%

Note: We define relative contribution is Higher if player's contribution > player's belief amount

C Experimental instructions and pages:


WELCOME NOTE

Thank you for your participation in this experimental activity today. you have earned 30 rupees. This amount will be added to your final earnings today in this activity.

In this activity,you will be able to earn points according to your decision and the decisions of other participants. Each point you earn will be paid at 0.75 rupees per point.

When you start the activity by selecting the :next" button, you agree that the data about your decisions will be used for research purposes only. this information will be anonymous i.e. it will not be possible to link your decision data with any information that would allow you to be identified. Additionally, we request you to carefully read and fill out the informed consent form given to you.

Participation in this research will require a maximum of one hour of your time, in which it is not allowed to carry out other simultaneous activities or receive help from other people.

The study is anonymous, and no one will be able to link your answers back to you. Please do not include your name or other information that could be used to identify you in the survey responses.

Being in this study is voluntary. Please exit this webpage if you do not want to participate.
If you consent to take part to the study, click the "next" button below.

আজকের এই পরীক্ষামূলক কার্যকলাপে আপনার অংশগ্রহণের জন্য আপনাকে ধন্যবাদ। আপনি 30 টাকা উপার্জন করেছেন। এই অ্যাক্টিভিটিটিতে আজকের আপনার চূড়ান্ত উপার্জনে এই পরিমাণ যোগ করা হবে।

এই কার্যকলাপে, আপনি আপনার সিদ্ধান্ত এবং অন্যান্য অংশগ্রহণকারীদের সিদ্ধান্ত অনুযায়ী পয়েন্ট অর্জন করতে সক্ষম হবেন।
আপনার উপার্জন করা প্রতিটি পয়েন্ট প্রতি পয়েন্টে 0.75 টাকা প্রদান করা হবে।

আপনি যখন পরবর্তী" বোতামটি নির্বাচন করে কার্যকলাপ শুরু করেন, তখন আপনি সম্মত হন যে আপনার সিদ্ধান্তগুলির ডেটা শুধুমাত্র গবেষণার উদ্দেশ্যে ব্যবহার করা হবে। এই তথ্যটি বেনামী হবে অর্থাৎ আপনার সিদ্ধান্তের ডেটাকে এমন কোনো তথ্যের সাথে লিঙ্ক করা সম্ভব হবে না যা আপনাকে সনাক্ত করার অনুমতি দেবে। উপরন্তু, আমরা আপনাকে প্রদত্ত অবহিত সম্মতি ফর্মটি মনোযোগ সহকারে পড়ার এবং পূরণ করার অনুরোধ করছি।

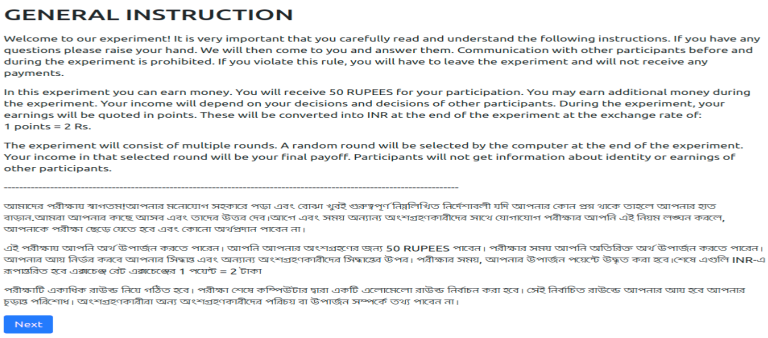
এই গবেষণায় অংশগ্রহণের জন্য আপনার সময়ের সর্বোচ্চ এক ঘণ্টার প্রয়োজন হবে, যেখানে এটি অন্যান্য যুগপত ক্রিয়াকলাপগুলি চালানো বা অন্য লোকেদের কাছ থেকে সাহায্য নেওয়ার অনুমতি নেই।

অধ্যয়নটি বেনামী, এবং কেউ আপনার উত্তরগুলিকে আপনার সাথে লিঙ্ক করতে সক্ষম হবে না। অনুগ্রহ করে আপনার নাম বা অন্যান্য তথ্য অন্তর্ভুক্ত করবেন না যা সমীক্ষার প্রতিক্রিয়াগুলিতে আপনাকে সনাক্ত করতে ব্যবহার করা যেতে পারে।

এই গবেষণায় থাকা স্বেচ্ছাসেবী। আপনি অংশগ্রহণ করতে না চাইলে এই ওয়েবপৃষ্ঠা থেকে প্রস্থান করুন ।
আপনি যদি অধ্যয়নে অংশ নিতে সম্মত হন তবে নীচের "next" ("পরবর্তী") বোতামে ক্লিক করুন।

Next

Figure 20: Welcome note for players


GENERAL INSTRUCTION

Welcome to our experiment! It is very important that you carefully read and understand the following instructions. If you have any questions please raise your hand. We will then come to you and answer them. Communication with other participants before and during the experiment is prohibited. If you violate this rule, you will have to leave the experiment and will not receive any payments.

In this experiment you can earn money. You will receive 50 RUPEES for your participation. You may earn additional money during the experiment. Your income will depend on your decisions and decisions of other participants. During the experiment, your earnings will be quoted in points. These will be converted into INR at the end of the experiment at the exchange rate of:
1 points = 2 Rs.

The experiment will consist of multiple rounds. A random round will be selected by the computer at the end of the experiment. Your income in that selected round will be your final payoff. Participants will not get information about identity or earnings of other participants.

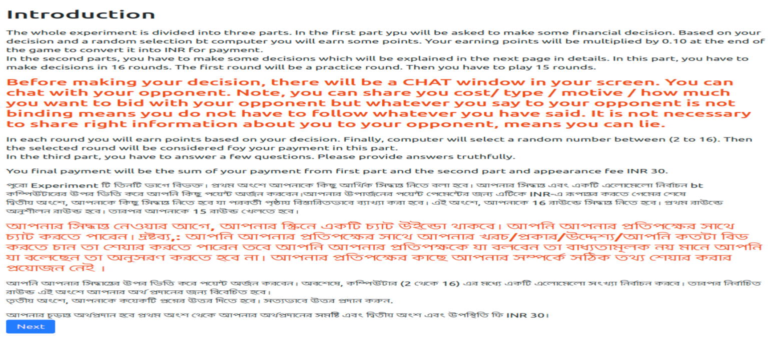
আমাদের পরীক্ষায় স্বাগতম!আপনার মনোযোগ সহকারে পড়া এবং বোঝা খুবই গুরুত্বপূর্ণ নিম্নলিখিত নির্দেশাবলী যদি আপনার কোন প্রশ্ন থাকে তাহলে আপনার হাত বাড়ান.আমরা আপনার কাছে আসব এবং তাদের উত্তর দেব।আগে এবং সময় অন্যান্য অংশগ্রহণকারীদের সাথে যোগাযোগ পরীক্ষার আপনি এই নিয়ম লঙ্ঘন করলে, আপনাকে পরীক্ষা ছেড়ে যেতে হবে এবং কোনো অর্থপ্রদান পাবেন না।

এই পরীক্ষায় আপনি অর্থ উপার্জন করতে পারেন। আপনি আপনার অংশগ্রহণের জন্য 50 RUPEES পাবেন। পরীক্ষার সময় আপনি অতিরিক্ত অর্থ উপার্জন করতে পারেন। আপনার আয় নির্ভর করবে আপনার সিদ্ধান্ত এবং অন্যান্য অংশগ্রহণকারীদের সিদ্ধান্তের উপর। পরীক্ষার সময়, আপনার উপার্জন পয়েন্টে উদ্ধৃত করা হবে।শেষে এগুলি INR-এ রূপান্তরিত হবে এক্সচেঞ্জ রেট এক্সচেঞ্জের 1 পয়েন্ট = 2 টাকা

পরীক্ষাটি একাধিক রাউন্ড নিয়ে গঠিত হবে। পরীক্ষা শেষে কম্পিউটার দ্বারা একটি এলোমেলো রাউন্ড নির্বাচন করা হবে। সেই নির্বাচিত রাউন্ডে আপনার আয় হবে আপনার চূড়ান্ত পরিশোধ। অংশগ্রহণকারীরা অন্য অংশগ্রহণকারীদের পরিচয় বা উপার্জন সম্পর্কে তথ্য পাবেন না।

Next

Figure 21: General instruction for players


Introduction

The whole experiment is divided into three parts. In the first part ypu will be asked to make some financial decision. Based on your decision and a random selection bt computer you will earn some points. Your earning points will be multiplied by 0.10 at the end of the game to convert it into INR for payment.
In the second parts, you have to make some decisions which will be explained in the next page in details. In this part, you have to make decisions in 16 rounds. The first round will be a practice round. Then you have to play 15 rounds.

Before making your decision, there will be a CHAT window in your screen. You can chat with your opponent. Note, you can share you cost/ type / motive / how much you want to bid with your opponent but whatever you say to your opponent is not binding means you do not have to follow whatever you have said. It is not necessary to share right information about you to your opponent, means you can lie.

In each round you will earn points based on your decision. Finally, computer will select a random number between (2 to 16). Then the selected round will be considered foy your payment in this part.
In the third part, you have to answer a few questions. Please provide answers truthfully.

You final payment will be the sum of your payment from first part and the second part and appearance fee INR 30.

পুরো Experiment টি তিনটি ভাগে বিভক্ত। প্রথম অংশে আপনাকে কিছু আর্থিক সিদ্ধান্ত নিতে বলা হবে। আপনার সিদ্ধান্ত এবং একটি এলোমেলো নির্বাচন bt কম্পিউটারের উপর ভিত্তি করে আপনি কিছু পয়েন্ট অর্জন করবেন।আপনার উপার্জনের পয়েন্ট পেমেন্টের জন্য এটিকে INR-এ রূপান্তর করতে গেমের শেষে
দ্বিতীয় অংশে, আপনাকে কিছু সিদ্ধান্ত নিতে হবে যা পরবর্তী পৃষ্ঠায় বিস্তারিতভাবে ব্যাখ্যা করা হবে। এই অংশে, আপনাকে 16 রাউন্ডে সিদ্ধান্ত নিতে হবে। প্রথম রাউন্ডে অনুশীলন রাউন্ড হবে। তারপর আপনাকে 15 রাউন্ড খেলতে হবে।

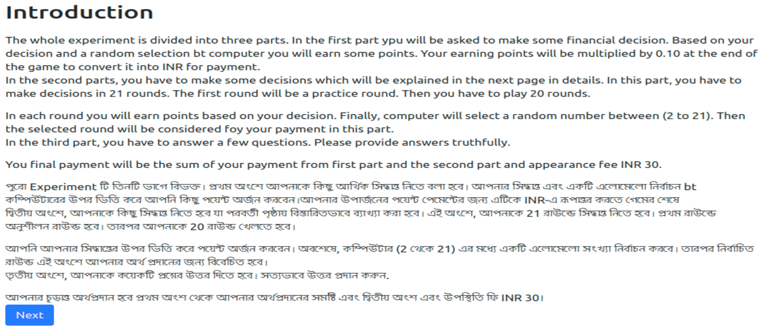
আপনার সিদ্ধান্ত নেওয়ার আগে, আপনার স্ক্রিনে একটি চ্যাট উইন্ডো থাকবে। আপনি আপনার প্রতিপক্ষের সাথে চ্যাট করতে পারেন। দ্রষ্টব্য,: আপনি আপনার প্রতিপক্ষের সাথে আপনার খরচ/প্রকার/উদ্দেশ্য/আপনি কতটা বিড করতে চান তা শেয়ার করতে পারেন তবে আপনি আপনার প্রতিপক্ষকে যা বলবেন তা বাধ্যতামূলক নয় মানে আপনি যা বলেছেন তা অনুসরণ করতে হবে না। আপনার প্রতিপক্ষের কাছে আপনার সম্পর্কে সঠিক তথ্য শেয়ার করার প্রয়োজন নেই ।

আপনি আপনার সিদ্ধান্তের উপর ভিত্তি করে পয়েন্ট অর্জন করবেন। অবশেষে, কম্পিউটার (2 থেকে 16) এর মধ্যে একটি এলোমেলো সংখ্যা নির্বাচন করবে। তারপর নির্বাচিত রাউন্ড এই অংশে আপনার অর্থ প্রদানের জন্য বিবেচিত হবে।
তৃতীয় অংশে, আপনাকে কয়েকটি প্রশ্নের উত্তর দিতে হবে। সত্যভাবে উত্তর প্রদান করুন.

আপনার চূড়ান্ত অর্থপ্রদান হবে প্রথম অংশ থেকে আপনার অর্থপ্রদানের সমষ্টি এবং দ্বিতীয় অংশ এবং উপস্থিতি ফি INR 30।

Next

Figure 22: Instructions to players (communication treatment)



Introduction

The whole experiment is divided into three parts. In the first part ypu will be asked to make some financial decision. Based on your decision and a random selection bt computer you will earn some points. Your earning points will be multiplied by 0.10 at the end of the game to convert it into INR for payment.
In the second parts, you have to make some decisions which will be explained in the next page in details. In this part, you have to make decisions in 21 rounds. The first round will be a practice round. Then you have to play 20 rounds.

In each round you will earn points based on your decision. Finally, computer will select a random number between (2 to 21). Then the selected round will be considered foy your payment in this part.
In the third part, you have to answer a few questions. Please provide answers truthfully.

You final payment will be the sum of your payment from first part and the second part and appearance fee INR 30.

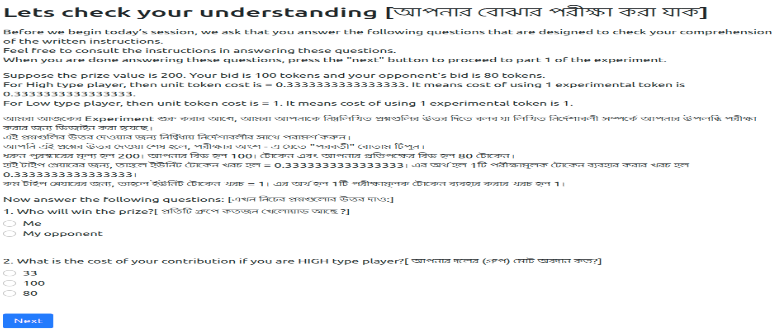
পুরো Experiment টি তিনটি ভাগে বিভক্ত। প্রথম অংশে আপনাকে কিছু আর্থিক সিদ্ধান্ত নিতে বলা হবে। আপনার সিদ্ধান্ত এবং একটি এলোমেলো নির্বাচন bt কম্পিউটারের উপর ভিত্তি করে আপনি কিছু পয়েন্ট অর্জন করবেন।আপনার উপার্জনের পয়েন্ট পেমেন্টের জন্য এটিকে INR-এ রূপান্তর করতে গেমের শেষে
দ্বিতীয় অংশে, আপনাকে কিছু সিদ্ধান্ত নিতে হবে যা পরবর্তী পৃষ্ঠায় বিস্তারিতভাবে ব্যাখ্যা করা হবে। এই অংশে, আপনাকে 21 রাউন্ডে সিদ্ধান্ত নিতে হবে। প্রথম রাউন্ডে অনুশীলন রাউন্ড হবে। তারপর আপনাকে 20 রাউন্ড খেলতে হবে।

আপনি আপনার সিদ্ধান্তের উপর ভিত্তি করে পয়েন্ট অর্জন করবেন। অবশেষে, কম্পিউটার (2 থেকে 21) এর মধ্যে একটি এলোমেলো সংখ্যা নির্বাচন করবে। তারপর নির্বাচিত রাউন্ড এই অংশে আপনার অর্থ প্রদানের জন্য বিবেচিত হবে।
তৃতীয় অংশে, আপনাকে কয়েকটি প্রশ্নের উত্তর দিতে হবে। সত্যভাবে উত্তর প্রদান করুন.

আপনার চূড়ান্ত অর্থপ্রদান হবে প্রথম অংশ থেকে আপনার অর্থপ্রদানের সমষ্টি এবং দ্বিতীয় অংশ এবং উপস্থিতি ফি INR 30।

Next

Figure 23: Instructions to players (without communication treatment)



Lets check your understanding [আপনার বোঝার পরীক্ষা করা যাক]

Before we begin today’s session, we ask that you answer the following questions that are designed to check your comprehension of the written instructions.
Feel free to consult the instructions in answering these questions.
When you are done answering these questions, press the "next" button to proceed to part 1 of the experiment.

Suppose the prize value is 200. Your bid is 100 tokens and your opponent's bid is 80 tokens.
For High type player, then unit token cost is = 0.3333333333333333. It means cost of using 1 experimental token is 0.3333333333333333.
For Low type player, then unit token cost is = 1. It means cost of using 1 experimental token is 1.

আমরা আজকের Experiment শুরু করার আগে, আমরা আপনাকে নিম্নলিখিত প্রশ্নগুলির উত্তর দিতে বলব যা লিখিত নির্দেশাবলী সম্পর্কে আপনার উপলব্ধি পরীক্ষা করার জন্য ডিজাইন করা হয়েছে।
এই প্রশ্নগুলির উত্তর দেওয়ার জন্য নির্দ্বিধায় নির্দেশাবলীর সাথে পরামর্শ করুন।
আপনি এই প্রশ্নের উত্তর দেওয়া শেষ হলে, পরীক্ষার অংশ - এ যেতে "পরবর্তী" বোতাম টিপুন।
ধরুন পুরস্কারের মূল্য হল 200। আপনার বিড হল 100। টোকেন এবং আপনার প্রতিপক্ষের বিড হল 80 টোকেন।
হাই টাইপ প্লেয়ারের জন্য, তাহলে ইউনিট টোকেন খরচ হল = 0.3333333333333333। এর অর্থ হল 1টি পরীক্ষামূলক টোকেন ব্যবহার করার খরচ হল 0.3333333333333333।
কম টাইপ প্লেয়ারের জন্য, তাহলে ইউনিট টোকেন খরচ = 1। এর অর্থ হল 1টি পরীক্ষামূলক টোকেন ব্যবহার করার খরচ হল 1।

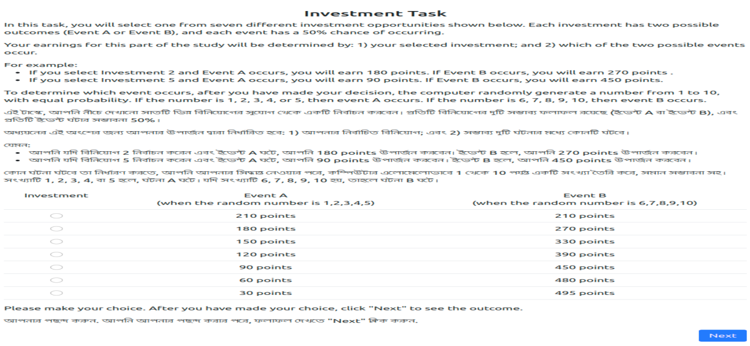
Now answer the following questions: [এখন নিচের প্রশ্নগুলোর উত্তর দাও:]

1. Who will win the prize?[প্রতিটি গ্রুপে কতজন খেলোয়াড় আছে ?]
- Me
- My opponent

2. What is the cost of your contribution if you are HIGH type player?[আপনার দলের (গ্রুপ) মোট অবদান কত?]
- 33
- 100
- 80

Next

Figure 24: Attention check page



Investment Task

In this task, you will select one from seven different investment opportunities shown below. Each investment has two possible outcomes (Event A or Event B), and each event has a 50% chance of occurring.

Your earnings for this part of the study will be determined by: 1) your selected investment; and 2) which of the two possible events occur.

For example:
- If you select Investment 2 and Event A occurs, you will earn 180 points. If Event B occurs, you will earn 270 points .
- If you select Investment 5 and Event A occurs, you will earn 90 points. If Event B occurs, you will earn 450 points.

To determine which event occurs, after you have made your decision, the computer randomly generate a number from 1 to 10, with equal probability. If the number is 1, 2, 3, 4, or 5, then event A occurs. If the number is 6, 7, 8, 9, 10, then event B occurs.

Investment	Event A (when the random number is 1,2,3,4,5)	Event B (when the random number is 6,7,8,9,10)
○	210 points	210 points
○	180 points	270 points
○	150 points	330 points
○	120 points	390 points
○	90 points	450 points
○	60 points	480 points
○	30 points	495 points

Please make your choice. After you have made your choice, click "Next" to see the outcome.

Next

Figure 25: Investment task page

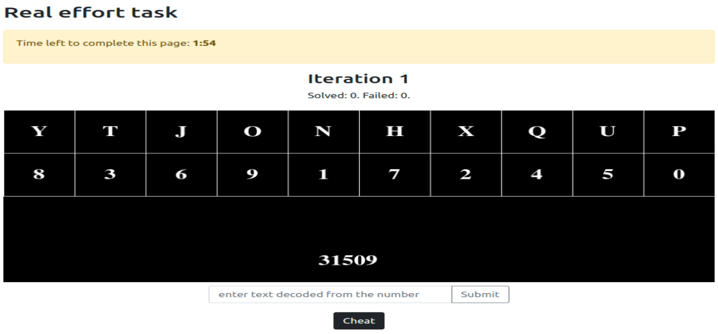
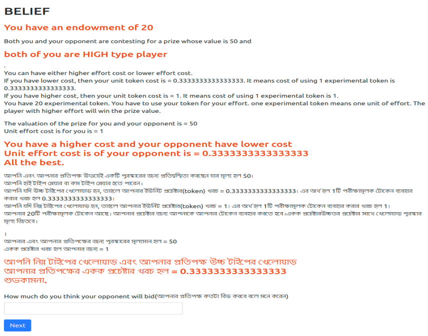
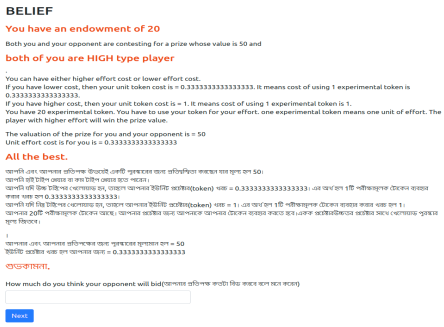


Figure 26: Real effort task page



(a) For players with chat



(b) For players without chat

Figure 27: Belief page

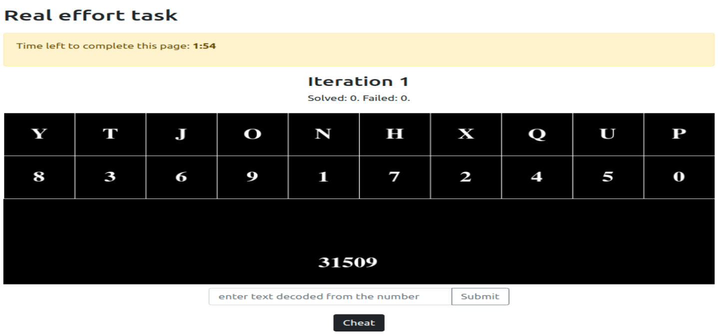
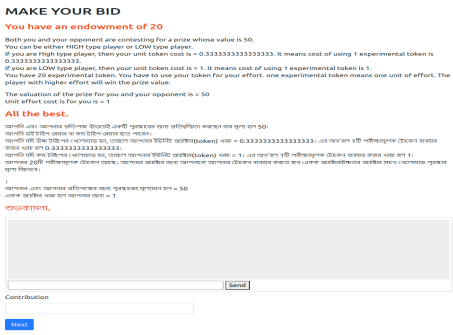
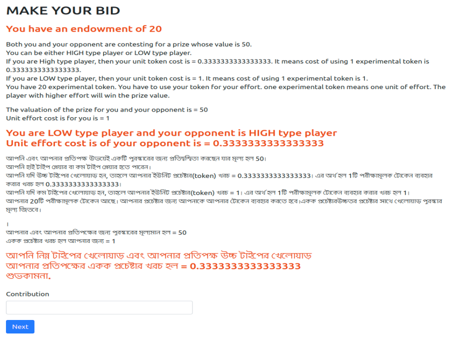


Figure 28: Real effort task page

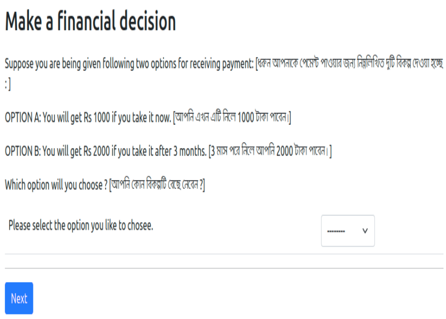


(a) For players with chat

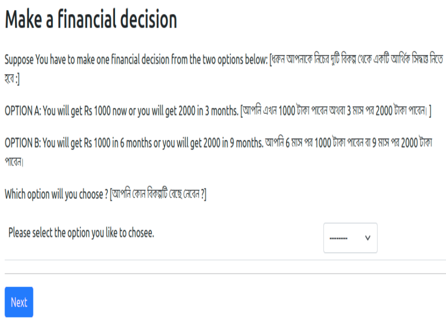


(b) For players without chat

Figure 29: Contribution page when both players are of different type



(a) Present bias



(b) Hyperbolic bias

Figure 30: Additional task page

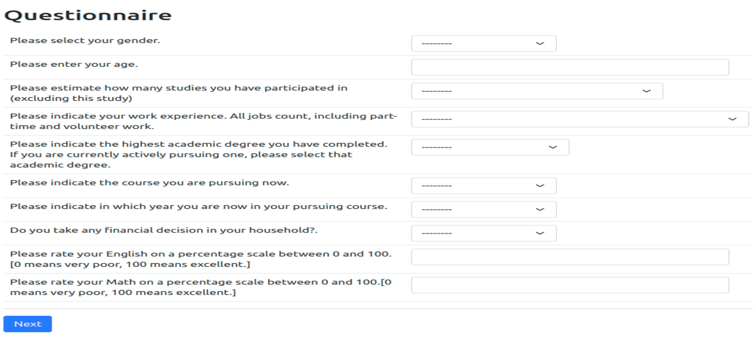


Figure 31: Survey questions page

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