Authority and Communication in the Laboratory*

Ernest K. Lai
Department of Economics
Lehigh University
kwl409@lehigh.edu

Wooyoung Lim
Department of Economics
The Hong Kong University of Science and Technology
wooyoung@ust.hk

June 28, 2010
Preliminary Draft

Abstract

We experimentally investigate delegation and communication as two alternative means of coordinations among individuals with misaligned interests. We implement in the laboratory two delegation-communication games in which a principal chooses whether to delegate her decision-making authority to an informed agent or to make the decision herself after a cheap-talk communication with the agent. In the game in which equilibrium predicts communication over delegation, we observe that decision-making authorities are almost always retained and communication opted for. In the communication, subjects coordinate over the separating equilibrium when pooling is also consistent with equilibrium. In the game in which equilibrium predicts delegation over communication, significantly more delegations than communications are observed, although incidences of off-equilibrium-path plays are higher than those in the other game. In the off-equilibrium-path communication, relative to the unique pooling equilibrium we observe, consistent with findings in the previous literature, over-transmission of information.

Keywords: Delegation; Communication; Cheap Talk

JEL classification: C72, C92, D82, D83

*We are grateful to Andreas Blume for his valuable suggestion and comments. We gratefully acknowledge financial supports from the Office of the Provost of the University of Pittsburgh and the Office for Research and Graduate Studies of Lehigh University.

1 Introduction

Different states of the world typically call for different decisions to be made. More often than not, however, the authority to make decisions and the access to information about the state of the world do not fall on the same entity. The final approval of hiring a faculty, for example, rests with the provost or the dean, but it is the search committee who has information about whether a candidate is ideal for the position. Decision-making in situations of this sort requires coordinations among parties who have access to different components of the decision process. Since separate parties are involved, unless interests are perfectly aligned among them the coordinations are bound to be plagued by incentive problems.

This paper experimentally investigates two common means of coordinations when decision-making authority and informational access are separated: *delegation* and *communication*. Delegation involves the surrender of decision-making authority by one party (the principal) to another party who has access to information (the agent). In communication, the principal retains the authority and receives information from the agent as an input for decisions. When interests are misaligned, the agent may have incentives to withhold or manipulate information, leading to suboptimal decisions being made by the principal. In delegation, by surrendering her control over decisions the principal put the agent's information into full use. But if preferences over decisions do not coincide among the parties, suboptimal decisions may again be made from the vantage point of the principal. Thus, delegation may be a better means for coordinations in some situations and communication in others. In practice, contracting and monetary transfers may sometimes be used as additional arrangements to alleviate the incentive problems.

We use experiment to demonstrate the tension between controls and information in delegation and communication. Subjects of our experiment participate, in a between-subject design, repetitions of two delegation-communication games, representing our two experimental treatments. The two games, Game I and Game II, share the same procedures. Each involves two players, a principal (she) and an agent (he). The principal is endowed with a decision-making authority, an authority to choose one of the three (Game I) or four (Game II) actions. The agent has access to some private information - his binary type each of which has a prior probability of one half. At the beginning of the game, the principal, without any interaction with the agent, decides whether to delegate her decision-making authority to the agent or to communicate with him. If she chooses delegation, the agent chooses the action. If she chooses communication, the agent sends a cheap-talk message to her, after which she chooses the action herself. Payoffs to the players are jointly determined by what action is taken and what the agent's type is. To expose in a simple environment the tension of interests, we abstract away any consideration of contracting or monetary transfers.

Game I and Game II differ by the incentives provided to the players. In Game I, one of the agent's types shares the same preferences with the principal over the three actions. But for the other type the principal's most preferred action is the agent's worst, while they share the same preferences over the remaining two actions. The mismatch between the principal's best and the agent's worst for one type and perfect alignment of interests for the other makes communication impossible: one type has an incentive to mimic the other type. This leaves the principal with the pooling action, which is her second best. In delegation, however, the principal receives her first best and second best, each with probability one half. Delegation is thus preferred. In Game II with four actions, for both types the agent's most preferred actions are the principal's worst, while they share the same preferences over the remaining actions. By not surrendering her control over actions, the principal can make sure that her worst outcomes will not be chosen. Given the alignment of preferences over the remaining three actions, the agent is willing to provide information in communication, allowing the principal to achieve her first best. Communication is thus preferred.[1]

The different incentives embedded in Game I and Game II are reflected in the observed plays. We conduct four experimental sessions for each game, involving in total 160 subjects. In Game I significantly more delegations than communications are observed, whereas in Game II the decision-making authorities are almost always retained and communication opted for. Higher incidences of off-equilibrium-path plays are observed in Game I. In the off-equilibrium-path communication subgame of Game I, in which there is a unique pooling equilibrium, we observe over-transmission of information. This results in the principal's observed payoffs in the communication subgame higher than the predicted ones. Even though in Game I we do not observe an equilibrium in the communication subgame, subjects' optimal choices of delegation are consistent with the equilibrium anticipation that there will be no informative communication. The tendency toward transmitting information is also observed in Game II; in the communication subgame on the equilibrium path, subjects coordinate over the separating equilibrium despite the existence of a pooling equilibrium.

Our experimental study builds on the existing literature on communication game experiments. We append a delegation decision to communication games similar to those in Blume et al. [3] and [4]. They study the evolution of meaning of messages and use *a priori* meaningless messages in their experiments. They document that meaningful communication emerges endogenously even with the meaningless messages. Since evolution of meaning is not part of our inquiry, in our experiment we use messages with literal meaning. Our findings in the communication subgames are, however, consistent with their another finding in which over-transmission

[1] Even though there always exists a pooling equilibrium in cheap-talk games of this sort (in which the pooling action is taken), we design the payoffs so that losing control over the action is so bad for the principal that communication is still preferred over delegation.

of information is observed. Another study that documents "overcommunication" is Cai and Wang [5]. They conduct an experiment which is closer in design to the cheap-talk model of Crawford and Sobel [8]. They use approaches of bounded rationality to analyze the observed "overcommunication."[2]

There are several studies that consider delegation in experiments. They are very different from ours both in motivations and in designs. Huck et al. [17] and Georgantzís et al. [15] consider delegation as a commitment device in Cournot duopolies, in which firm owners choose contracts for their managers who decide on their behalf the output quantities. Fershtman and Gneezy [12] introduce the uses of delegates into ultimatum games and examine how that may affect players' perceptions of the game. Bartling and Fischbacher [1] and Hamman et al. [16] consider delegation in dictator games, studying its role in avoiding responsibility or in eliciting punishment for selfish behavior. To the best of our knowledge, we are the first to experimentally study the role of delegation in resolving - in conjunction with communication - the principal-agent problem created under asymmetric information. On the theoretical front, Dessein [9] is one of the first to consider delegation in the cheap-talk framework of Crawford and Sobel [8]. He shows that, when the incentive conflict is not too large, the principal prefers delegation over communication. While our experiment does not constitute a test of his model, we share the same line of inquiry.

The rest of the paper is organized as follows. Section 2 lays out the details of Game I and Game II we use in the experiment, analyzing their equilibria and introducing our experimental hypotheses derived therefrom. Section 3 describes our experimental design. Section 4 reports our results from the experiment. Section 5 concludes.

2 Theory and Hypotheses

2.1 Delegation-Communication Games

We fill in the details of our two delegation-communication games, Game I and Game II. The games are played by an agent, who is privately informed about his type $t \in T = \{t_1, t_2\}$, and an uninformed principal, who is endowed with the authority to decide what action, $a \in A$, to take. The common prior beliefs are that t_1 and t_2 are equally likely.

Game I and Game II share the same rule of the game. At the beginning of the game, the

[2] Other experimental studies with communication as the major object of study or as additional condition for other games include, among others, Cooper et al. [6], Dickhaut et al. [10], and Duffy and Feltovich [11]. See also Crawford [7] for a survey.

principal, without any interaction with the agent, makes a delegation decision $d \in \{d_0, d_1\}$, where d_0 is the decision that the principal retains her authority to take action and d_1 is that she delegates such authority to the agent. If the principal chooses d_1, the agent chooses $a \in A$ in a subgame in which he is the only active player. If the principal chooses d_0, the players enter into a subgame in which the agent sends a cheap-talk message $m \in M$ to the principal after which she chooses $a \in A$.[3] The principal's choice of no delegation is thus a choice of communication. A strategy of the principal consists of a delegation decision $d \in \{d_0, d_1\}$ and an action rule under no delegation $\alpha_{d_0} : M \to \Delta A$. A strategy of the agent consists of an action rule under delegation $\alpha_{d_1} : T \to A$ and a message rule under no delegation $\mu_{d_0} : T \to \Delta M$.[4]

Payoffs are distributed after a is taken at which time the game ends. Payoffs to both players are functions of the pair (t, a). Game I and Game II differ by the profiles of payoffs and the action sets. Figure 1 presents the payoffs for the games.[5] In Game I, there are three elements in the action set: $A = \{a_1, a_2, a_3\}$. Game II is the same as Game I except that 1) Game II is appended with an additional column corresponding to the additional action, a_4, in the action set; and 2) the agent's payoff under the type-action pair (t_2, a_2) is different. As we shall see, these alterations offers a very different prediction about how the games will be played in equilibrium.

	a_1	a_2	a_3
t_1	800, 800	100, 100	500, 500
t_2	300, 100	100, 800	500, 500

(a) Game I

	a_1	a_2	a_3	a_4
t_1	800, 800	100, 100	500, 500	1000, 100
t_2	300, 100	800, 800	500, 500	1000, 100

(b) Game II

Figure 1: Delegation-Communication Games

2.2 Equilibrium Analysis

We first analyze the equilibria of the respective subgames after delegation and communication, starting with Game I.[6] If the principal in Game I chooses delegation d_1, to maximize his payoff

[3]Theoretically, there is no restriction on the message space except that its cardinality is not lower than that of the type space. Our experimental design, which will be detailed in the next section, uses a message space with three elements.

[4]As will become clear below, the payoff structures are such that the principal will not want to randomize in the delegation decision, and neither will the agent when he is delegated to take the action. We, however, consider randomization in the communication subgames.

[5]In each cell, the number on the left is the agent's payoff, whereas that on the right is the principal's.

[6]Game I is an extracted version of "Game 4" in Blume et al. [4]. Their game is in turn a modified version of that in Myerson [18] (p.284). Part of our analysis below is adopted from Myserson [18].

the agent will take action a_1 if his type is t_1 and a_3 if his type is t_2. Given the prior beliefs that t_1 and t_2 are equally likely, the principal's expected payoff from delegation is thus 650.

If the principal chooses not to delegate d_0, the game enters into a communication subgame. This subgame has a unique pooling equilibrium in which no information is transmitted; the principal's action is independent of what message she receives. For any message sent by the agent, there are seven possible responses that the principal can make. She can randomize among all three actions or among two of them, or she can take one of the actions for sure. The principal is indifferent between a_1 and a_2 only if she believes that t_1 and t_2 are equally likely - but with that beliefs she would strictly prefer a_3. Thus, she will not randomize with a_1 and a_2 in the support, and this rules out two of the responses as candidates for her best responses. For the agent, type t_1 strictly prefers a_1 to a_3 and a_3 to a_2; for any two responses of the principal from the remaining five, t_1 has a strict preference over one of them. Thus, if there are at least two messages sent with positive probability and the principal responds to them differently, t_1 will be willing to send only one of them. For such to be an equilibrium, the other message must be sent exclusively by t_2 in which case the principal responds with a_2, the worst outcome for t_2. Thus, neither will t_2 want to send that other message not preferred by t_1. This implies that in any equilibrium the principal must respond the same to every message the agent sends with positive probability. That response is a_3, the principal's optimum under the prior which gives her an expected payoff of 500.

Given the outcomes of the two subgames, the principal in Game I therefore prefers delegation over communication. We summarize the above analysis with the following proposition:

Proposition 1. *In the unique equilibrium of Game I, the principal delegates to the agent her authority over the action. In the communication subgame off the equilibrium path, there exists a unique pooling equilibrium in which the principal takes action a_3.*

If the principal in Game II delegates, the agent will take action a_4 regardless of his type. This is the worst outcome for the principal, giving her an expected payoff of 100. If the principal chooses communication and retains her authority over the action, she will ensure that a_4 will not be taken. The resulting communication subgame, stripped of action a_4, is effectively a game with common interests. There are two equilibria in this subgame, one separating and one pooling. For communication to be saliently a preferred choice in the experiment, the payoffs are chosen so that, regardless of which equilibrium prevails, the principal's expected payoff from communication (800 in the separating and 500 in the pooling) is higher than that from delegation. We summarize the above analysis with the following proposition:

Proposition 2. *In the equilibria of Game II, the principal does not delegate and chooses communication. In the communication subgame on the equilibrium path, there exist a) a separating* *equilibrium in which the principal takes action a_i after the agent truthfully reveals his type t_i, $i = 1, 2$, and b) a pooling equilibrium in which action a_3 is taken.*

2.3 Experimental Hypotheses

Our games append a delegation decision to communication games. While we are also interested in how the observed plays in our communication subgames compare with the findings in the existing literature, our main focus is on the delegation decision. Our main hypotheses thus surround the delegation component of the games, although in Section 4 we shall also analyze observations from the communication subgames.

Propositions 1 and 2 provide the basis for our experimental hypotheses. The equilibrium predictions are that with probability one delegation will be chosen in Game I and communication in Game II. A hypothesis stated in such a strong form with point prediction will, however, easily be refuted. We thus test a hypothesis in a weaker form; we take it as an evidence supporting our theoretical predictions if, in the choice between delegation and communication, more optimal choices than non-optimal are observed:

Hypothesis 1. *In Game I, the observed frequency of delegation is higher than that of communication. In Game II, the observed frequency of communication is higher than that of delegation.*

Hypothesis 1 involves comparisons within the games. But since delegation and communication are mutually exclusive, if we have the same numbers of observations from the two games, a corollary of Hypothesis 1 is the cross-game comparison that the observed frequency of delegation is higher in Game I than in Game II.

Our another hypothesis looks into the payoffs of the principals:

Hypothesis 2. *In Game I, the principals choosing delegation have a higher expected payoff than the principals choosing communication. In Game II, the principals choosing communication have a higher expected payoff than the principals choosing delegation.*

The principals' payoffs provide us with a window to examine the motivations behind the delegation/communication choices. Such decision is a forward-looking decision, based on the anticipation of what will happen in each of the subgames. Observations from a subgame could serve as an approximation for what would have happened when that subgame is not reached.

3 Experimental Design

Game I and Game II constitute the two treatments of our experiment. They share the same procedures, and the treatment variable pertains to the different incentives - different payoffs and action sets - embedded in them. We conduct four experimental sessions for each game. All the sessions are conducted at the Pittsburgh Experimental Economics Lab of the University of Pittsburgh. The experiment is programmed and conducted with the software z-Tree (Fischbacher [13]).

Subjects are recruited from the undergraduate population of the University of Pittsburgh, who have no prior experience in our experiment. Upon arrival at the lab, subjects are instructed to sit at separate computer terminals, and each receives a copy of the instructions for the experiment.[7] The instructions are then explained aloud. A series of questions related to the instructions follows. The questions are reviewed after the subjects are allowed time to answer. The respective payoff table in Figure 1 is also drawn on the blackboard. All these practices ensure that the information contained in the instructions is induced as common knowledge among the participants.

The following procedures are common to the two games. In each experimental session, 20 subjects participate in 40 repetitions or rounds of the respective delegation-communication game. Subjects form groups of two, one as principal (Type-A) and one as agent (Type-I).[8] At the beginning of each session, 10 subjects are randomly chosen to be principals and the other 10 as agents. Such role designations last for 20 rounds; to ensure equity among subjects, the roles are rotated starting from Round 21. Thus, if a subject plays as principal (agent) in Rounds $1-20$, he or she will play as agent (principal) in Rounds $21-40$. Principals and agents are paired anew in each round using a random matching protocol.

At the beginning of each round, each agent's type (the row in the reward profile), t_1 or t_2 (\$ or @), is drawn from a uniform distribution, which is then revealed on the agent's screen. The draws are independent across agents and across rounds. While the agents privately learn their types, the principals are asked to decide whether they want to delegate the right to choose action to their paired agents (Type-I partners). How the rest of the round in each group proceeds depends on the principal's delegation decision. If delegation is chosen in a group, the agent, after being informed of such decision of the principal (Type-A partner), chooses one of the three actions, a_1, a_2 or a_3 (%, # or $*$) in Game I, or, in Game II, one of the four, a_1, a_2, a_3 or a_4 (%, #, $*$, or

[7] Refer to the Appendix for a sample of the instructions (Game I).

[8] To ensure dominance, during the experiment we avoid references to non-neutral languages. In this Section, for each major terminology that appears the first time we shall state in parentheses the corresponding languages we adopt in the instructions. In this case, we use "Type-A" to refer to the principals (the type of subjects who has right over "A"ction) and "Type-I" to the agents (the type of subjects who has access to "I"nformation).

!).[9] The pair then learns the agent's type, the action taken and the respective payoffs received before the round comes to an end.

If the principal in a group decides not to delegate, the paired agent, after being informed of such decision, will be asked to input one of the messages, "t_1", "t_2" or "t_1 or t_2" ("$", "@", or "$ or @") into the computer.[10] The instructions state that such message is "regarding the row of rewards for the current round" but makes it clear that "regardless of which row the computer has chosen" the agent is "completely free in your choice of which message to send." The agent's message is revealed on the screen of the paired principal, who then chooses the action. Information about the agent's type, the action taken, the message sent and the respective payoffs received is shown to the couple, after which the round ends. At the end of each round, a summary on types, actions and payoffs from all previous rounds and current round is also provided. A group only receives information pertaining to that group but not the others.

A payoff of 100 translates into a real payment of $1. We randomly draw one round from Rounds $1-20$ and one from Rounds $21-40$ for payments. A subject is paid his or her sum of earnings from the two chosen rounds and a $5 dollar show-up fee. Subject are explained this payment arrangemen in the instructions.[11]

4 Results

The observed plays are strongly supportive of our hypotheses. Table 1 provides a summary statistics of the total frequencies of delegation and communication in the two games.[12] Using the relative frequencies of delegation as the measuring unit, Table 2 and Figure 2 further provide

[9]We use symbols for types and actions in the experiment to ensure no suggestion is made to the subjects that there is any *a priori* association between a type and an action.

[10]Since our focus is not on the evolution of meanings of messages (Blume et al. [3] and [4]) but the choice between delegation and communication, we use messages with literal meanings. Exogenously meaningful messages provide focal points in communication. We use this design to avoid complications that may arise from subjects' learning how to use and interpret messages. Also, we provide the third message, "t_1 or t_2", to allow the subjects a clear option for concealing their types if they so wish.

[11]Each experimental session lasts for about 90 minutes, and subjects' payments range from $11 to $23. To avoid an extra layer of complexity in subjects' understanding of the incentives, we do not use binary lotteries (Roth and Malouf [19] and Berg et al. [2]) in our payment arrangement to induce risk neutrality. We believe that this does not affect the integrity of our study. Indeed, with the "safe" pooling action in place, if the subjects are risk averse, such risk attitude will only run against confirming our hypotheses about Game I because the principals can always choose communication and then get 500 for sure. In Game II, risk aversions should not create any bias in confirming our main hypothesis on the choice between delegation and communication, although it may in communication favor the pooling equilibrium.

[12]In each game, there are 10 groups in each of the four sessions, and in a session the principal of each group makes 40 delegation/communication decisions. That makes a total of $1,600$ decisions per game. For Game II, however, we lost the data from Round 40 of one of the sessions. We thus have $1,590$ recorded decisions from Game II. In our reporting below, we shall use the data from Round 39 for Round 40.

a "breakdown" of these aggregate observations.[13] We begin reporting our results from Game I:

Table 1: Total Frequencies of Delegation and Communication

	Delegation	Communication	Total
Game I	1,051	549	1,600
Game II	28	1562	1,590

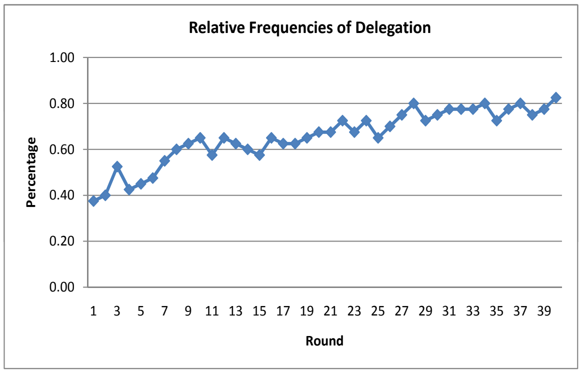
Result 1. *In Game I, more delegations than communications are observed. The relative frequency of delegation increases over rounds, from slightly more communications than delegations at the beginning to an average of 80% delegation toward the final rounds.*

Table 2: Relative Frequencies of Delegation

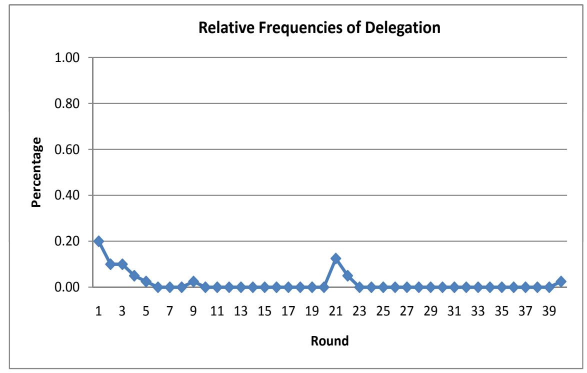
Round	1	10	20	30	40
			Game I		
Session 1	0.4	0.8	0.9	1	1
Session 2	0.2	0.7	0.7	0.5	0.6
Session 3	0.4	0.6	0.6	0.5	1
Session 4	0.5	0.5	0.5	0.8	0.7
Mean	0.38	0.65	0.68	0.75	0.83
			Game II		
Session 1	0.4	0	0	0	0
Session 2	0.2	0	0	0	0
Session 3	0.1	0	0	0	0.1
Session 4	0.1	0	0	0	0
Mean	0.2	0	0	0	0.03

Since delegation and communication is a binary choice, a relative frequency of delegation above 50% means that there are more delegations than communications. In total, a relative frequency of 66% $(1,051/1,600)$ is observed for delegation. In the first rounds of the four sessions, the relative frequencies range from 20% to 50% (Table 2), and in aggregate it exceeds 50% and never goes back below after Round 7 (Figure 2(a)). Using observations at the session level, the frequency of delegation is significantly higher than that of communication (the Wilcoxon

[13]Table 2 reports the relative frequencies of delegation in the selected rounds of each session. Figure 2 presents the relative frequencies in each round, aggregated over all four sessions in each game. Throughout the Section, we shall refer to both the total and relative frequencies. We shall be explicit when the frequencies in question are relative.



(a) Game I



(b) Game II

Figure 2: Relative Frequencies of Delegation

signed-rank test renders $p = 0.0625$, the lowest p-value possible with four observations).[14] The equilibrium point prediction is that the principal delegates with probability one. The observed plays suggest that subjects do not choose the equilibrium play instantaneously; they learn over time to delegate (the Spearman rank-order coefficient between aggregated relative frequencies and rounds is 0.94 with $p < 0.0001$).

The observed plays of Game II are much more consistent with the equilibrium point prediction of communication:

Result 2. *In Game II, exceedingly more communications than delegations are observed. An average of 20% delegation occurs at the beginning, and it converges over rounds to almost all communications. A temporary "restart effect" toward delegation is, however, observed when the subjects' roles rotate between principals and agents.*

In total, a relative frequency of only 2% (28/1,590) is observed for delegation, while the equilibrium point prediction is zero percent.[15] The data in Table 2 are also representative of other rounds not reported: there is only one round in a session in which the relative frequency is 40%; for the rest it never exceeds 20%, and the majority is no delegation at all.

Apart from the within-treatment comparisons, the above findings also imply that there is a significant "treatment effect" with respect to the different incentives embedded in Game I and Game II. Not surprisingly, the relative frequency of delegation is significantly higher in Game I

[14] All our statistical tests are using aggregated data from a session as an independent observation. We thus have four observations per game. While this has the disadvantage of reducing the power of the tests, it comes with the benefit of bypassing possible interdependence of plays within a session. All the p-values we report are from one-tailed tests.

[15] It should not be surprising that formal testing indicates that in Game II the frequency of communication is significantly higher than that of delegation; the Wilcoxon signed-rank test renders the lowest possible p-value of 0.0625.

than in Game II (the Mann-Whitney test renders $p = 0.01$). Perhaps more interestingly, there is also a significant difference in the relative frequencies of equilibrium plays (with respect to the choice between delegation and communication); while the observed plays in both Game I and Game II are consistent with our theoretical predictions, the relative frequencies of equilibrium plays is significantly higher in Game II (the Mann-Whitney test renders $p = 0.01$).

In Game II, there appears to be not much learning over rounds with respect to the equilibrium choice of communication; subjects in the role of principal figure out the optimal choice early in the sessions and adhere to it. However, in three sessions we observe in Round 21 a small but obvious "restart effect," when the subjects previously assuming the role of agents now play as principals. The relative frequencies of delegation increase from 0 in Round 20 in all sessions to $0.1 - 0.2$ in Round 21.[16] With one exception, all subjects in all rounds quickly go back again to choose communication starting from Round 23 (Figure 2(b)).

Turning to examining payoffs, we approximate expected payoffs by the average payoffs of all principal-subjects from all rounds in each session. They are reported in Table 3.[17] We obtain the following result, confirming our Hypothesis 2:

Result 3. *In Game I, the average payoffs of the principals choosing delegation are higher than those of the principals choosing communication. In Game II, the average payoffs of the principals choosing communication are higher than those of the principals choosing delegation.*

The principal-subjects in Game I choose delegation presumably because they anticipate a higher payoff from delegation than from communication. Similarly for Game II in which a higher payoff from communication should be anticipated. The observed plays off the equilibrium path provide an opportunity to compare such beliefs with "the reality." And our findings suggest that the forward-looking behavior of the subjects are grounded on "correct" anticipations; the respective directional differences of payoffs referred to in Result 3 are statistically significant (for both games, the Wilcoxon signed-rank test render $p = 0.0625$, the lowest p-value possible with four observations). In Game I, the observed payoffs from delegation are strikingly close to the equilibrium point prediction (an aggregated average of 650.47 vs. 650 predicted). For the

[16] No obvious "restart effect" is observed for Game I. In two sessions, the relative frequencies of delegation are the same in Rounds 20 and 21; in the other two, the differences across the two rounds, one positive and one negative, are 0.1.

[17] Since the average payoffs are calculated conditioned on the delegation decisions, the payoffs are averaged over different numbers of observations in each session. Except for delegation in Game II in which we have only 28 observations in the whole experiment (Table 1), we have large enough observations in the other cases to reasonably approximate the uniform distribution of types. In the four sessions in Game I, the distributions of t_1 and t_2 under delegation are $(0.48, 0.52)$, $(0.43, 0.57)$, $(0.55, 0.45)$ and $(0.52, 0.48)$, and those under communication are $(0.47, 0.53)$, $(0.56, 0.44)$, $(0.49, 0.51)$ and $(0.54, 0.46)$. In Game II under communication, the distributions are $(0.45, 0.55)$, $(0.5, 0.5)$, $(0.48, 0.52)$ and $(0.49, 0.51)$. Even for delegation in Game II, the equilibrium payoff is the same under t_1 and t_2; thus, any deviation from the predictions reflects deviations in behavior rather than from the uniform types.

Table 3: Average Payoffs of the Principals

	Delegation	Communication
	Game I	
Session 1	645.24	471.70
Session 2	630.45	607.70
Session 3	664.53	648.15
Session 4	661.64	645.86
Mean	650.47	593.37
	Game II	
Session 1	261.54	769.76
Session 2	100.00	789.90
Session 3	275.00	744.95
Session 4	400.00	787.79
Mean	259.13	773.10

off-equilibrium-path communication, however, except for one session, all the observed payoffs are higher than the point prediction (an aggregated average of 593.37 vs. 500 predicted).[18] Recall that in Game II there are two equilibria in the communication subgame, one separating and one pooling. The observed payoffs from communication are very close to the equilibrium point prediction of the separating equilibrium (an aggregated average of 773.1 vs. 800 predicted).[19]

These observations provide a preliminary evidence that the agent-subjects have a tendency to transmit information in communication: when equilibrium prescribes separating and pooling, they choose separating; when equilibrium prescribes only pooling, they deviate from the equilibrium. This leads us to examine the communication subgames. Table 4 provides a summary statistics of the relative frequencies of observed plays that are consistent with the equilibrium outcomes. Figure 3 displays the round-by-round variations aggregated across sessions.[20]

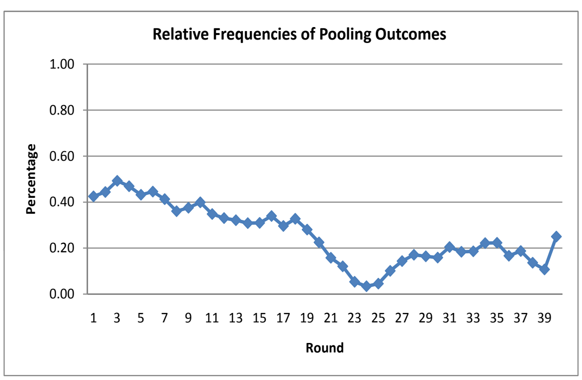
[18] Session 1 of Game I is exceptional from other sessions in the treatment on various fronts. Apart from the exceptionally high percentage of equilibrium delegation, we also observe lower payoffs from communication for the principals. As we shall see, exceptions are also noted in the communication subgames.

[19] In Game II, the observed payoffs off the equilibrium path when delegation is chosen are also, except for one session, higher than the prediction (an aggregated average of 259.13 vs. 100 predicted). With a closer look at the 28 observations, we find that the delegated agent-subjects choose either the payoff cell (800, 800) or (1,000, 100). Thus, in any deviations from the predicted (1,000, 100), subjects sacrifice some payoffs for equity. This echoes the findings from dictator games (e.g., Forsythe et al., [14]).

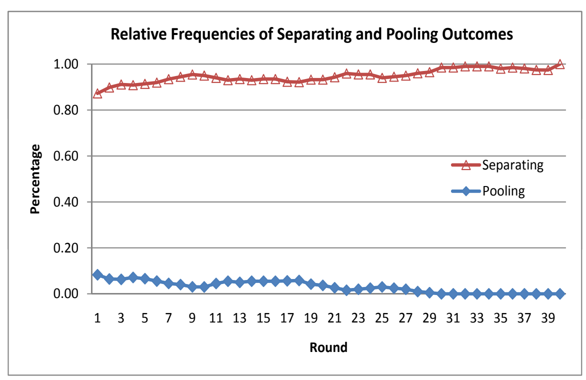
[20] For the pooling outcomes, we measure the relative frequencies of the pooling action, a_3. For the separating outcomes, we measure the relative frequencies of the type-action pairs (t_i, a_i), $i = 1, 2$. Since the numbers of observations from the communication subgames vary across rounds contingent on the delegation decisions, in Table 4 we report the relative frequencies in 10 rounds. For the same reason, in Figure 3 we report moving averages using five rounds as a unit, aggregated over four sessions (the moving averages of the last four rounds use the data from the remaining rounds ahead). We also want to note that in Section 1 of Game I which has an

Table 4: Relative Frequencies of Separating and Pooling Outcomes

Round		1-10	11-20	21-30	31-40
		Game I			
Session 1	Pooling	0.48	0.53	0.14	0.00
Session 2	Pooling	0.34	0.40	0.07	0.28
Session 3	Pooling	0.29	0.12	0.12	0.07
Session 4	Pooling	0.61	0.31	0.21	0.21
Mean		0.43	0.34	0.14	0.14
		Game II			
Session 1	Separating	0.90	0.88	0.92	0.99
	Pooling	0.08	0.12	0.05	0.00
Session 2	Separating	0.96	1.00	0.98	1.00
	Pooling	0.03	0.00	0.01	0.00
Session 3	Separating	0.84	0.88	0.90	0.96
	Pooling	0.08	0.08	0.03	0.00
Session 4	Separating	0.89	1.00	0.98	1.00
	Pooling	0.09	0.00	0.01	0.00
Mean	Separating	0.90	0.94	0.94	0.98
	Pooling	0.07	0.05	0.03	0.00



(a) Game I



(b) Game II

Figure 3: Relative Frequencies of Separating and Pooling Outcomes in the Communication Subgames

Since the equilibrium predictions for the communication subgames are nonstochastic, it is unlikely to obtain observations in the laboratory that are as sharp as the point predictions.

exceptionally high incidences of delegation, from Round 31 to 40 we only observe two cases of communication; the zero percentage of pooling in Table 4 is based on two observations only.

Following Blume et al. [3] and [4], we consider it an evidence in support of the equilibrium predictions when the relative frequency of an equilibrium outcome exceeds that predicted by chance alone. In Game I, among the six type-action pairs, two are consistent with the pooling outcomes. Thus, when types and actions are independent, the type-action pairs consistent with the pooling outcome has a relative frequency of 0.33. Similarly, in Game II, with eight type-action pairs and two each for separating outcomes and pooling outcomes, the relative frequency under independence are 0.25 for both separating and pooling. We are now ready to state our final set of results:

Result 4. *The following results pertain to the communication subgames.*

1. *In Game I, the relative frequency of the pooling outcomes decreases over rounds. Such frequency is not significantly higher than the relative frequency generated when types and actions are independent.*

2. *In Game II, the relative frequencies of the separating and pooling outcomes are stable over rounds. The relative frequency of the separating outcomes is significantly higher than the relative frequency generated when types and actions are independent. Such is not true for the pooling outcomes.*

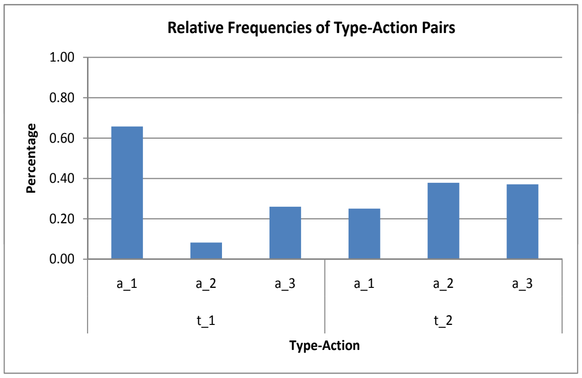
Using the relative frequencies of the pooling outcomes in all 40 rounds in each session as an independent observation, in Game I we cannot reject the null hypothesis of independence in favor of pooling (the Wilcoxon signed-rank test renders $p = 0.6875$).[21] Similarly, in Game II we cannot reject the null hypothesis in favor of pooling (the Wilcoxon signed-rank test renders an extreme $p = 1$). However, in Game II the null hypothesis of independence is rejected in favor of the separating outcomes (the Wilcoxon signed-rank test renders $p = 0.0625$, the lowest p-value possible with four observations).

We have a clear "equilibrium selection" in Game II in which the separating outcomes prevail. It is also notable that subjects start coordinating over the separating equilibrium early in the sessions. In Game I, overall not only does the pooling equilibrium fails to predict how the subgame is played, but the relative frequencies of the pooling outcomes also decrease over rounds (the Spearman rank-order coefficient between aggregated relative frequency moving averages and rounds is -0.79 with $p < 0.0001$).[22] It appears that we have learning against the equilibrium. To explore what patterns of plays emerge instead, for Game I we further look into the associations between types and messages, messages and actions, and types and actions. Figure 4 presents the relative frequencies of the combinations aggregated over all rounds and then all sessions.[23]

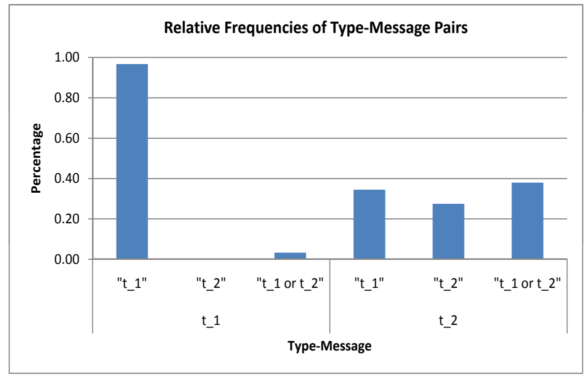
[21] The same conclusion is drawn if we look at pooling outcomes within each of the eight five-rounds.

[22] For data not in moving averages, the correlation coefficient is -0.67 with the same p value.

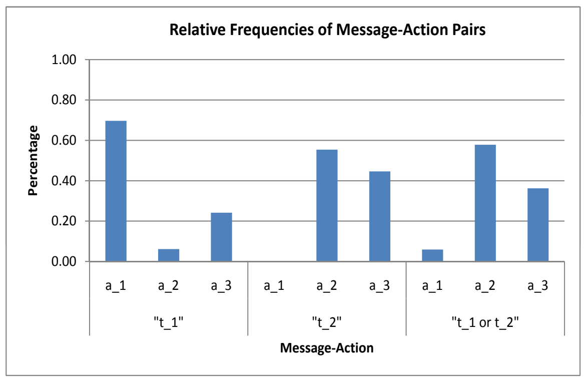
[23] As an illustration, for the relative frequencies of the pair (t_1, a_1), we first obtain the total frequency of the



(a) Type-Action



(b) Type-Message



(c) Message-Action

Figure 4: Relative Frequencies of Type-Action, Type-Message, and Message-Action Pairs in Game I

Over-transmission of information is documented in previous experimental studies of communication games (Blume et al. [3] and [4], and Cai and Wang [5]). The same phenomenon is observed in our Game I.[24] For the agents, types t_1 send "t_1" 97% of the time, while for types t_2 the uses of the three messages are quite even. Even with the clear incentive to mimic t_1, 66% of the time types t_2 choose not to use the message with the exact literal meaning that they are t_1. And they send "t_2" 28% of the time despite that when believed it would lead to their worst outcomes. The principals also appear to be credulous: 70% of the time they respond to "t_1" with a_1. For the other two messages, "t_2" and "t_1 or t_2", more a_2 than the pooling a_3 are observed, and there are almost no a_1. The principals manage to receive their best outcomes 66% of the time (by taking a_1) when the type is t_1. When the type is t_2, they still manage to receive their

pair observed in the communication subgames in all rounds of a session and divide it by the respective total frequency of t_1. We then average across sessions the relative frequencies obtained.

[24]In particular, observations from our Game I - an extracted version of "Game 4" in Blume et al. [4] - share a similar pattern with theirs.

best outcomes 33% of the time (by taking a_2). These are consistent with the findings that the principals' average payoffs are higher than the predicted.[25]

The transmission of information in communication makes delegation less attractive. In the extreme situation in which the agents truthfully reveal their types, delegation is an inferior choice compared to communication. In our findings, delegation is nevertheless chosen in the midst of over-transmission of information in the communication subgames. While the relative frequency of the pooling outcomes decreases over round, the relative frequency of delegation increases over round. Our results in Game I thus suggest that, despite the non-equilibrium plays in communication that may be motivated by factors other than pure rational considerations, the delegation decisions are made in accordance with rational expectation consistent with equilibrium.

5 Concluding Remarks

This paper investigates two delegation-communication games, which provide different incentives favoring delegation in one case and communication in another. Our experimental data indicate that subjects' choices between delegation and communication are highly consistent with the equilibrium predictions. In the communication subgames, while we observe the separating equilibrium in the game with common interests, we observe over-transmission of information in another game in which the unique prediction is a pooling equilibrium.

[25]We again observe exceptions in Session 1 of Game I in which subjects appear to be better abided by equilibrium. While types t_1 send "t_1" 96% of the time, we observe more uses of "t_1" by types t_2 (54%), and the uses of "t_2" drop to 18%. The principals are also less credulous: only 31% of the time they respond to "t_1" with a_1. Furthermore, only 20% of the time the principals are able to receive the best outcome when the type is t_1 and 36% when the type is t_2. These are consistent with the lower observed payoffs of the principals among other sessions in the treatment (Table 3).

Appendix - Instruction for Game I

INSTRUCTION

Welcome to the experiment. This experiment studies decision-making between two individuals. In the following two hours or less, you will participate in 40 rounds of decision-making. Please read carefully the instructions below; the cash payment you will receive at the end of the experiment depends on how well you make your decision in accordance with the rules described in these instructions.

Your Role and Reward

In each of the 40 rounds in the experiment, you will be randomly paired with another participant in this room to form a group of two. The two members of a group each takes a different role, and the roles are designated as **Type-I** and **Type-A**. If you are Type-I, your partner in the group will be Type-A, and vice versa. If you are assigned to be Type-I at the beginning of the experiment, you will be reassigned to be Type-A starting from the 21st round. Similarly, if you play the role of Type-A in the first 20 rounds, you will play the role of Type-I in the last 20 rounds.

The experimenter (computer) will provide the Type-I member in each group with some INFORMATION (hence "I"). The Type-A member will *not* be provided with such information but will be given a right to choose an ACTION (hence "A"). Your reward in each round depends on what the information is and what action is taken. The following provides the details.

Refer to Figure 1 on p.4 for your potential reward in each round. If you are, say, Type-A, your reward from each round will be *one of* the numbers in the six triangles marked with "A"; similarly for Type-I ("I"). At the beginning of each round, the computer determines - with 50-50 chance - which row of rewards, $ or @, will be applicable to the current round. Such information is revealed to Type-I but *not* to Type-A. Further depending on which action, %, #, or $*$, is taken, your reward from that round will be determined. Here are some examples:

1. If row $ is chosen by the computer and action % is taken, both the rewards of Type-I and Type-A in that round will be 800.
2. If row @ is chosen by the computer and action % is taken, Type-I's reward in that round will be 300 and Type-A's reward will be 100.
3. If row @ is chosen by the computer and action # is taken, Type-I's reward in that round will be 100 and Type-A's reward will be 800.

Your Task in Each Round

Type-A

If you are the Type-A in your group, you will have to make an initial decision. Depending on what your initial decision is, you may or may not have to make a second decision.

First, you decide whether you want to delegate to your Type-I partner the right to choose an action. If yes, your partner will take one of the three actions: %, #, or ∗. Once you decided to delegate your right, you would have no influence at all on what action your partner will take. Your participation in that round will end, and the action in that round (and thus the determination of your reward in that round) will be decided solely by your Type-I partner.

If you decide not to delegate and keep the action-right to yourself, your Type-I partner will be asked to send you through the computer one of the messages, {$}, {@}, or {$ or @}, providing you with information about the row of rewards for the current round. After seeing the message on the computer, you will be given an opportunity to choose your action. You should note that there is no requirement that your Type-I partner has to tell you the truth. Indeed, with the message {$ or @} available, he/she has the option of telling you that the row chosen by the computer is "either $ or @".

Type-I

If you are the Type-I in your group, you will have *one of* the following two decisions to make, depending on the delegation decision of your Type-A partner.

If your Type-A partner decides to delegate, you will be rendered the right to choose one of the three actions: %, #, or ∗.

If your partner decides to keep the action-right to himself/herself, you will be asked to send him/her a message regarding the row of rewards for the current round. You can choose among the following three messages: {$}, {@}, or {$ or @}. After seeing your message, your Type-A partner will take one of the three actions: %, #, or ∗. You should note that, regardless of which row the computer has chosen, you are completely free in your choice of which message to send.

The Rundown of the Experiment

1. At the beginning of each round, the computer will randomly pair you with another participant of the opposite role to form a group of two. That person becomes your partner in the current round. (The random pairing does not rule out repeating partners; it is possible that in certain rounds you will form a group with a participant that you have "met" in previous rounds.)

2. In each group, the Type-I is informed privately about the row of rewards for the current round, randomly chosen by the computer; the Type-A decides whether to delegate to the Type-I the right to take an action.

3.a. If the Type-A decides to delegate, the Type-I will be asked to take an action. Once the action is taken, the round is over.

3.b.1. If the Type-A decides not to delegate, the Type-I will be asked to input a message into the computer.

3.b.2. The message is revealed to the Type-A. The Type-A takes an action, and the round is over.

In all but the final (40th) round, the above steps will be repeated once the round is over. Your role - Type-I or Type-A - will be reassigned again after the 20th round. The completion of the 40th round entails the end of the experiment. The computer randomly selects two rounds for your payment, one from the first 20 rounds and one from the last 20 rounds. Your total payment will be the sum of the rewards you received in the selected rounds divided by 100 plus the 5 dollars show-up fee.

Remember that you have to make your decisions entirely on your own; *please do not discuss your decisions with any other participants.*

Adminstration

You input your decisions with the mouse in front of you. Your decisions as well as your monetary payment will be kept confidential. Upon finishing the experiment, you will receive your payment. You will be asked to sign your name to acknowledge your receipt of the payment (which will not be used for tax purposes). You are then free to leave. You may start now. Good luck!

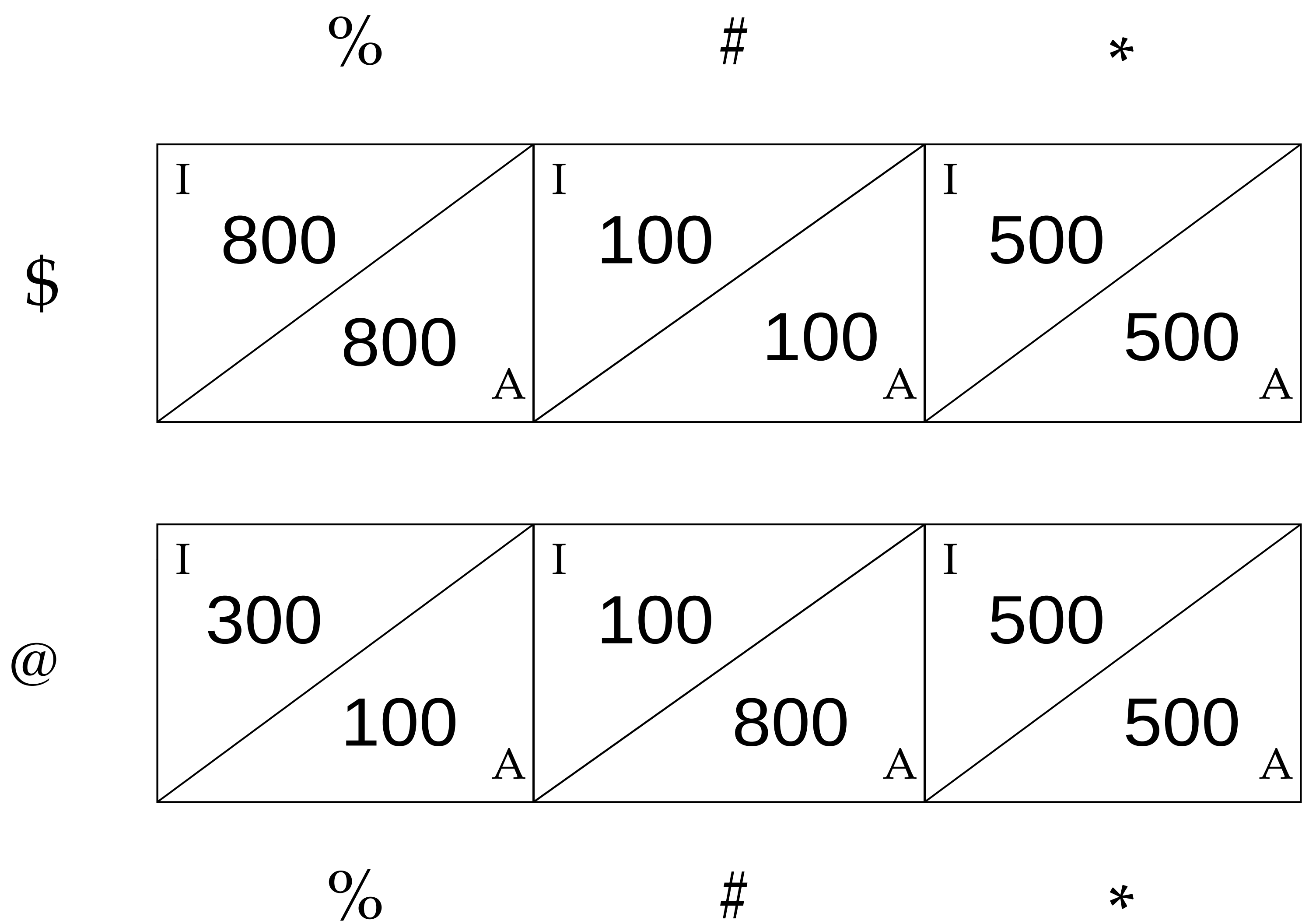


Figure 1: Reward Profile

References

[1] Bartling, Björn, and Urs Fischbacher. 2008. "Shifting the Blame: On Delegation and Responsibility." Institute for Empirical Research in Economics, University of Zurich, Working Paper 380.

[2] Berg, J. E., L. Daley, J. Dickhaut, and J. O'Brien. 1986. "Controlling Preferences for Lotteries on Units of Experimental Exchange." *Quarterly Journal of Economics*, 101: 281-306.

[3] Blume, Andreas, Douglas V. Dejong, Yong-Gwan Kim, and Geoffrey B. Sprinkle. 1998. "Experimental Evidence on the Evolution of the MEaning of Messages in Sender-Recevier Games." *American Economic Review*, 88: 1323-1340.

[4] Blume, Andreas, Douglas V. Dejong, Yong-Gwan Kim, and Geoffrey B. Sprinkle. 2001. "Evolution of Communication with Partial Common Interest." *Games and Economic Behavior*, 37: 79-120.

[5] Cai, Hongbin, and Joseph Tao-Yi Wang. 2006. "Overcommunication in Stragegic Information Transmission Games." *Games and Economic Behavior*, 56: 7-36.

[6] Cooper, R., D. DeJong, R. Forsythe, and T. Ross. 1989. "Communication in the Battle of the Sexes Game: Some Experimental Results." *Rand Journal of Economics*, 20: 568-587.

[7] Crawford, Vincent. 1998. "A Survey of Experiments on Communication via Cheap Talk." *Journal of Economic Theory*, 78: 286-298.

[8] Crawford, Vincent P., and Joel Sobel. 1982. "Strategic Information Transmission." *Econometrica*, 50(6): 1431-1451.

[9] Dessein, Wouter. 2002. "Authority and Communication in Organizations." *Review of Economic Studies*, 69: 811-838.

[10] Dickhaut, John W., Kevin A. McCabe, and Arijit Mukherji. 1995. "An Experimental Study of Strategic Information Transmission." *Economic Theory*, 6: 389-403.

[11] Duffy, John, and Nick Feltovich. 2002. "Do Actions Speak Louder Than Words? An Experimental Comparison of Observation and Cheap Talk." *Games and Economic Behavior*, 39: 1-27.

[12] Fershtman, Chaim, and Uri Gneezy. 2001. "Strategic Delegation: An Experiment." *Rand Journal of Economics*, 32(2): 352-368.

[13] Fischbacher, Urs. 2007. "z-Tree: Zurich Toolbox for Ready-made Economic Experiments." *Experimental Economics*, 10(2), 171-178.

[14] Forsythe, Robert, Joel L. Horowitz, N. E. Savin, and Martin Sefton. 1994. "Fairness in Simple Bargaining Experiments." *Games and Economic Behavior*, 6: 347-369.

[15] Georgantzís, Nikolaos, Constantine Manasakis, Evangelos Mitrokostas, and Emmanuel Petrakis. 2008. "Strategic Delegation in Experimental Duopolies with Endogenous Incentive Contracts.." University of Crete, BE.NE.TeC. Working Paper 2008-09.

[16] Hamman, John R., George Lowenstein, and Roberto A. Weber. Forthcoming. "Self-Interest through Delegation: An Additional Rationale for the Principal-Agent Relationship," *American Economic Review*.

[17] Huck, Steffen, Wieland Müller, and Hans-Theo Normann. 2004. "Strategic Delegation in Experimental Markets." *International Journal of Industrial Organization*, 22: 561-574.

[18] Myerson, Roger B. 1991. "Game Theory: Analysis of Conflict." Harvard University Press.

[19] Roth, Alvin, and M. Malouf. 2007. "Game-Theoretic Models and the Role of Bargaining." *Psychological Review*, 86, 574-594.