Delegation as a Signal to Sustain Coordination: An Experimental Study

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Version: September 15, 2017

Within organizations, we often observe decision rights being delegated. In this paper, I explore a potentially important role of delegation: as a signal of trust that is reciprocated by more cooperation. I consider a static principal-agent model with two tasks, one of which requires cooperation between the principal and the agent. If there is asymmetric information about the agent's type, the principal with a private belief that the agent is a good type can delegate the first task in order to signal the agent about his 'trust'. Using a forward induction argument, I show theoretically that there is an equilibrium where delegation used as a signal can facilitate cooperation in the second task. I conduct laboratory experiments to test these theoretical predictions and to examine the role of information in equilibrium selection. From the experiment data I find that delegation is used only sometimes to facilitate cooperation. However, when the subjects have information about past sessions, there is a statistically significant increase in the use of delegation as a signaling device. This evidence suggests that experience matters in equilibrium selection in Bayesian games and illustrates that experience with delegation can bring about cooperation, thus enhancing the value of inter-organizational partnerships.

Keywords: delegation, experiment, principal-agent, forward induction, Bayesian games
JEL Classification: C92, D23, D86, D82.

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1. INTRODUCTION

Inter-organizational delegation is an important issue in economics. In an organizational relationship between a principal and an agent, we often observe decisions being delegated. Existing literature proposes a number of explanations for why decisions are delegated. Some of the common explanations include: the delegate might have lower opportunity costs, be better informed or equipped with more adequate skills. In this paper we explore another potentially important role of delegation: as a signalling device to facilitate cooperation.

In a theoretical model, I show that even if the agent does not have superior skill or information about the project, the principal may choose to delegate a task to him, in order to facilitate cooperation at a later stage. Delegation of a task here acts like a signal, which the principal uses to achieve cooperation with a trustworthy agent. The central idea is as follows: consider an inter-organizational relationship between an agent and a principal, where there are two separate tasks to perform. An example of such a relationship is the relation between a doctor (principal) and a nurse (agent). The first task (in the example, routine check-up of the patient) is a simple one and any one of the doctor and the nurse can do it, while the second task, the surgery, requires cooperation from both of them. The nurse may be trustworthy or not, but the doctor does not know his true type, she only has access to a private signal about the nurse's type. During the second task which has to be performed together, the doctor would benefit from cooperating with a trustworthy nurse but not an untrustworthy nurse. A trustworthy nurse would like to help the doctor but only if she believes that the doctor will also help the nurse, but an untrustworthy nurse would shirk. If the doctor can delegate the first task (*i.e.* , let the nurse go through the check up routine) , this Bayesian game has two equilibria which can be Pareto-ranked. In one of the equilibria, delegation can be used to signal the doctor's belief. If the doctor believes the nurse to be trustworthy, she can delegate a task to the nurse to signal her trust. Observing this signal, the trustworthy nurse will infer that the doctor must have a higher belief about her trustworthiness, and is likely to cooperate in the next task. In this equilibrium, delegation can bring about cooperation in the second task. The forward induction argument predicts that this equilibrium with delegation as a signaling device will be chosen. However, because of the presence of multiple equilibria in this game, whether this equilibrium is actually chosen by decision makers is an empirical question.

Therefore I take the next step: in a controlled laboratory experiment I simulate the exact environment postulated in the theoretical model. From the experimental data we can test the theoretical predictions and also get insights about how the subjects select equilibrium. This experimental study explores the possibility of using delegation as a signaling device, and at the same time, it helps us identify the factors behind equilibrium selection in this scenario.

From the experimental data I find that the subjects do not choose to delegate very often; the Pareto inferior Pooling equilibrium where the principal never delegates is chosen most of the times. However, in one of the treatments, in each session I publicly announce some information about the observed behavior in the past sessions, and the results from this treatment are significantly different that the benchmark treatment with no historical information being given. In this treatment with history, the principals with higher belief about the agents' trustworthiness delegate significantly more often, and is able to sustain coordination.

Apart from providing an explanation of the observed phenomenon of inter-organizational delegation using a theoretical prediction as well as empirical data, this study also adds to the relatively new area of experimental studies that deal with the principal-agent relationship.

This experimental study also complements another strand of literature. In Bayesian games characterized by some uncertainty about an agent's type, theoretical models suffer from the phenomenon of multiplicity of equilibria. It is important to know how economic agents choose between these equilibria to obtain unique theoretical prediction. This paper studies a Bayesian game with two equilibria which can be Pareto-ranked. So, the data on participants' choices in this game can add to the literature of equilibrium selection. Also, the standard theories of Bayesian games define equilibria consistent with different beliefs, but do not explain how economic agents actually form their beliefs. The results from the sessions with historical information indicate that the formation of first and second order belief depends on information. Thus, this study not only sheds light on the issue of equilibrium selection, but also seeks to identify the role of information in equilibrium selection. The results provide fresh insight and can be used in future to formulate behavioral models to show how belief formation in Bayesian games depends on the information environment.

This paper is organized as follows. First, I describe how the paper is related to the existing literature. In section 3, I develop the formal theoretical model and state the theoretical predictions. In section 4, I describe in detail the experimental design, along with the description of the sessions. Sections 5 contains the analysis of the results. In section 6 I discuss the significance of the results and suggest possible explanations of the observed behavior. Section 7 contains some concluding remarks.

2. LITERATURE REVIEW

There are two streams of research that relate to the present study.

Firstly, a large body of research, employing the standard principal-agent framework, explains delegation as emerging from either differences in information, cost, ability, or from credibility and commitment power due to handing of the decision-making authority (Bolton and Dewatripont, 2005 [5] includes an extensive survey). Schelling, 1980 [38] showed that delegation can also act as a commitment device. Delegation of control rights is often discussed as an important tool to provide incentives in the incomplete contract framework (Aghion and Tirole, 1997 [1]). Fershtman, Judd, and Kalai, 1991 [25] show that delegation can be used to gain credibility.

More recently, many experimental studies have also documented the use of delegation to serve other strategic purposes apart from efficiency. For example, Bartling and Fischbacher, 2011 [4], Oexl and Grossman, 2013 [36] find that delegation may happen because of the principal's desire to shift the responsibility to the delegate. They find that delegates are often punished less severely. Similarly, Hamman et.al., 2010 [31] show that a principal may hire an agent to take self-interested or immoral actions that the principal would be reluctant to take more directly. Delegated deception is also a common phenomenon observed in experiments (Erat, 2013 [22]). In gift exchange games, Charnes et.al., 2012 [10] show that Pareto improvement is possible using delegation. Similarly, in political economy contexts, Vetter, 2013 [42] shows how in a political scenario delegation for anticipated rewards can be used as an alternative to corruption. Drugov et.al., 2014 [21] also find that intermediaries can be used to lower the moral costs of citizens and officials and, thus, increase corruption. Schotter et.al., 2000 [39] study delegated bargaining and find efficieny loss due to this delegation.

While these studies examine different aspects of delegation decision, the theoretical model developed in this paper proposes an alternative explanation of delegation, where delegation can be used as a signal to facilitate cooperation at a later stage. Here, I do not assume that the agent has superior skills or information about the task. The experimental design makes it possible to isolate all other factors, and examines if subjects use delegation in order to achieve cooperation. This present paper is thus aimed at complementing the existing literature on delegation.

In a broader way, this experimental study is part of the growing experimental literature on equilibrium selection in signalling games. Bayesian games generally suffer from multiplicity of equilibria. To obtain predictive power, different refinements have been suggested theoretically. Mainly following Kohlberg and Mertens' (Kohlberg and Mertens, 1986 [35]) concept of stability, these refinements pick equilibria from the set of Perfect Bayesian Equilibria which satisfy the stability criteria; hence they are more likely to be chosen by a decision maker. In this paper, the theoretical prediction of the use of delegation as a signal is consistent with a forward induction argument.

These refinements of Nash equilibria refine the beliefs of players about the strategies selected by their opponents. However, since beliefs are inherently unobservable, we need to validate these solution concepts using the observed play of decision makers in a laboratory experimental environment. The laboratory results can provide important insights to complement the theoretical debate about which refinement is the most appropriate one. Since the early days of experimental economics, various studies have presented mixed evidence on the predictive power of the refinements (for an exhaustive review of these works, refer to Crawford, 1997 [19] and Friedman and Sunder, 1994 [28]). Brandts and Holt, 1989 [6] find that in a signaling game with multiple equilibria, the Pareto dominant Nash equilibrium is often chosen, which supports the Intuitive Criterion; however, after gaining experience with different partners in a series of these signaling games, behavior closer to the unintuitive equilibrium outcome is observed. Such mixed predictions require us to further investigate the out-of-equilibrium adjustment process. Cooper et.al., 1990 [12] find evidence supporting forward induction argument in coordination games, but only when the equilibrium chosen by the forward induction refinement coincides with the Pareto dominant equilibrium. In the battle of sexes game, forward induction is shown to be effective along with a focal point argument (Cooper et. al., 1993 [16]). Another study by Cooper et. al., 1994 [15] show that preplay communication can increase the predictive power of forward induction and solve the coordination failure problem. In general, it is found that the outcomes are often game-specific (see Banks et. al., 1994 [2], Brandts and Holt, 1992 [**?**]) and a small change in the parameter value can change the outcome even when the play followed equilibrium prediction before (Goeree and Holt, 2009 [29]) and even a small payoff asymmetry may lead to coordination failure (Crawford et. al., 2008 [18], Samuelson, 2005 [37]).

This paper adds to this body of literature by investigating the predictive power of forward induction and suggesting how informational environment can play a role in the formation of the out-of-equilibrium path beliefs. I find that the majority of the subjects choose the Pareto dominated equilibrium rather than the Pareto superior one supported by the forward induction argument. However, this refinement performs better if the subjects are publicly informed about the observed data in the past sessions. Thus, this paper sheds light on the issue of equilibrium selection in signalling games.

3. THEORETICAL MODEL

Consider a principal agent relationship: a principal (he) and an agent (she) are engaged in a project that involves two separate tasks where monetary transfers are not allowed. The first task requires effort from only one of the players, the principal can do it himself or delegate it to the agent, while the second task involves simultaneous choice of effort by both the principal and the agent where efforts are complementary in nature (coordination game). This second task is represented by a coordination game with two Nash equilibria: one of which Pareto dominates the other. If the players coordinate on the Pareto dominant equilibrium, we call it "cooperation" in this context.

In this model, the agent does not have any superior skill or knowledge relevant to the first task compared to the principal. The only information asymmetry is about the agent's "type": she is either "Biased" (B) or "Unbiased" (U), which is privately observed by the agent. A biased, or, untrustworthy agent does not care about the project's success whereas the unbiased or trustworthy agent has preferences completely aligned with the principal. The proportion of unbiased agents in the economy is known to be $\mu \in (0,1)$. Let us describe the timeline of the game:

- At the beginning, Nature moves and chooses the agent's type $\theta \in \{U, B\}$. The principal can not observe the true type, he gets a private binary signal $s \in \{H, L\}$ about θ. The signal structure is given by:

$$\begin{aligned} \Pr(s &= H|\theta = U) = p_U \\ \Pr(s &= H|\theta = B) = p_B \end{aligned}$$

- *Assumption 1:* The signal structure satisfies Monotone Likelihood Ratio Property (MLRP), i.e., $p_U > p_B$

  Thus the posterior belief about the true type becomes

$$\begin{aligned}\mu_H &= \Pr(\theta = U|s = H) = \frac{\mu p_U}{\mu p_U + (1-\mu)p_B} \\ \mu_L &= \Pr(\theta = U|s = L) = \frac{\mu(1-p_U)}{\mu(1-p_U) + (1-\mu)(1-p_B)}; \\ &\Rightarrow \mu_H > \mu > \mu_L\end{aligned}$$

  For conducting the experiments, I use a set of parameters to simulate the signal structure and the tasks. Here I state the theoretical results in terms of these parameters.

  The following parameters define the signal structure:

$$\begin{aligned}\mu = \frac{1}{2}, \mu_H = \frac{3}{5}, \mu_L = \frac{3}{7}; \\ p_U = \frac{1}{2}, p_B = \frac{1}{3}\end{aligned}$$

- *Task 1:* The principal can either perform Task 1 herself or delegate it to the agent. Formally, in this task the active player chooses effort $e_1 \in \{0, 1\}$. The payoffs of the players from this task are:

$$\begin{aligned}&u_{P,1}(e_1 = 1) = 2 = u_{U,1}(e_1 = 1); \\ &u_{B,1}(e_1 = 1) = 0 \\ &u_{P,1}(e_1 = 0) = 1 = u_{U,1}(e_1 = 0) \\ &u_{B,1}(e_1 = 0) = 1\end{aligned}$$

  Thus, the unbiased agent's preferences are closely aligned with the principal's, unlike the biased agent. Given a choice, the principal and the Unbiased agent would choose $e_1 = 1$ but the Biased agent would choose $e_1 = 0$.

  The effort choice in this task is not observable before the completion of task 2.

- *Task 2:* After task 1, both the principal and the agent have to choose efforts simultaneously to complete task 2, where efforts are complementary in nature. Task 2 involves simultaneous choice of effort $e_{2P}, e_{2A} \in \{0, 1\}$, which yields payoff according to the following 2x2 matrix.

  If the agent is Unbiased, the game becomes a coordination game:

P\AU	1	0
1	$(9, 9)$	$(1, 5)$
0	$(5, 1)$	$(5, 5)$

  If, however, the agent is biased, the game becomes:

P\AB	1	0
1	$(9, 1)$	$(1, 5)$
0	$(5, 1)$	$(5, 5)$

Thus, a Biased agent always has a dominant action in Task 2: to choose $e_{2A}^B = 0$, whereas if the Unbiased agent and principal chose with complete information, the coordination game will have two pure strategy Nash Equilibria: $(e_{2P}, e_{2A}^U) = (1, 1)$ and $(e_{2P}, e_{2A}^U) = (0, 0)$, with the former Pareto dominating the latter.

Total payoff of a player is the sum of his/ her payoffs obtained from both the tasks.

Note that, in the second task, the complementarity of effort choices implies that if the agent is unbiased then the principal would want him to choose higher effort in task 2. The unbiased agent's effort choice in task 2 in turn depends on his belief about the principal's "trust" in him (formally, belief about the principal's posterior after receiving the private signal). Thus, if delegating the first task can serve as a signalling device, then the principal with a more favorable signal could use it to induce higher effort from the unbiased agent in task 2. I look for Perfect Bayesian Equilibria that in this context.

Definition 1 (Perfect Bayesian Equilibrium). Consider a strategy profile for all players: the principal, the *Biased* and the *Unbiased* agent; as well as beliefs about the other players' types at all information sets (after observing Delegation and after observing No Delegation). This strategy profile and belief system form a *PBE (Perfect Bayesian Equilibrium)* if:

(1) *sequential rationality*—at each information set, each player's strategy specifies optimal actions, given her beliefs and the strategies of the other players, and

(2) *consistent beliefs*—given the strategy profile, the beliefs are consistent with Bayes' rule whenever possible.

Definition 2 (Forward Induction (van Damme, 1988 [41])). A Perfect Bayesian Equilibrium satisfies Forward Induction if the following property is satisfied. In a generic 2 player game in which player i chooses between an outside option or to play a game G of which a unique and viable equilibrium e^* yields the player more than the outside option, only the outcome in which player i plays G and then e^* is played is plausible[2].

Then, in the signaling game described above, the pure strategy Perfect Bayesian Equilibrium are:

Proposition 1. *If the prior belief is such that*

$$p_U < \frac{5}{9}, \mu_H > \frac{5}{9} > \mu_L$$

then there exist two pure strategy Perfect Bayesian Equilibria:

[2] See also Govindan and Wilson, 2009b [30]

(A) a separating equilibrium: *principal with a high private signal chooses to delegate Task 1, and then chooses high effort in the coordination game, and the principal with low signal does not delegate the task 1 and chooses low effort in the coordination game; Unbiased agent chooses High effort in Task 2 whenever he is delegated Task 1 and chooses low effort in Task 2 whenever not delegated; Biased agent always chooses low effort in Task 2.*

(B) a pooling equilibrium: *Both high and low signal principals choose not to delegate; subsequently in Task 2, both the principal and the agent always choose low effort, so cooperation fails to occur.*

Under the parametric restriction, the separating equilibrium is the unique Perfect Bayesian Equilibrium satisfying the forward induction refinement.

Proof. Let us define the Unbiased Agent's belief as:

$$\alpha_i^U = \Pr(P \text{ got a High Signal}|\ \theta = U,\ P \text{ chose } i);$$
$$i = \{Delegate, No\ Delegate\}$$

The strategies are:

$$\begin{aligned} &for \text{ Principal:} \\ &\qquad \sigma_{2j} = \Pr(P \text{ chooses Task 2 effort=1}|\text{Signal= } j) \\ &\qquad \sigma_{Dj} = \Pr(P \text{ chooses to Delegate}|\text{Signal= } j) \\ &\qquad j = \{High, Low\} \\ &for \text{ Unbiased Agent:} \\ &\qquad \sigma_U^i = \Pr(A \text{ chooses Task 2 effort=1}|P \text{ chose } i) \\ &\qquad i = \{Delegate, No\ Delegate\} \end{aligned}$$

Then, a pooling Perfect Bayesian Equilibrium is given by:

$$\begin{aligned} &for \text{ P:} \\ &\qquad (\sigma_{2H} = \sigma_{2L} = 0; \sigma_{DH} = \sigma_{DL} = 0) \\ &for \text{ Unbiased A:} \\ &\qquad (\alpha_D^U < p_U, \alpha_{ND}^U = p_U; \sigma_U^{ND} = \sigma_U^D = 0) \end{aligned}$$

For all parameter range, such a Perfect Bayesian Equilibrium exists. A separating equilibrium is given by:

$$\begin{aligned} &for \text{ P:} \\ &\qquad (\sigma_{2H} = 1, \sigma_{2L} = 0; \sigma_{DH} = 1, \sigma_{DL} = 0) \\ &for \text{ Unbiased A:} \\ &\qquad (\alpha_D^U = 1, \alpha_{ND}^U = 0; \sigma_U^{ND} = 0, \sigma_U^D = 1) \end{aligned}$$

Given $(\alpha_D^U = 1, \alpha_{ND}^U = 0; \sigma_{2H} = 1, \sigma_{2L} = 0)$, the ex-ante expected value of P with a private signal $j \in \{H, L\}$ is $V_j(D)$ and $V_j(ND)$ if P Delegates or doesn't Delegate, respectively. Then,

$$V_j(D) \gtreqless V_j(ND)$$
$$\Leftrightarrow \mu_j \gtreqless \frac{5}{9}$$

For $\mu_H \geq \frac{5}{9} > \mu_L$, $\sigma_{DH} = 1$ and $\sigma_{DL} = 0$. So, the only off the equilibrium belief consistent with the forward induction argument is:

$$\alpha_D^U = 1, \alpha_{ND}^U = 0$$

Thus, this separating equilibrium satisfies Forward Induction refinement. It is easy to see that the off equilibrium belief $\alpha_D^U < p_U$ is never consistent with Forward Induction refinement, so the pooling Perfect Bayesian Equilibrium does not satisfy this refinement. ∎

The experiment is intended to test Proposition 1, and reveal if the decision to delegate can be considered as a signalling device to facilitate cooperation, and how the decision to delegate depends on information.

4. EXPERIMENTAL DESIGN

I have conducted nine experimental sessions in the Computer Laboratory in the Economics Department at the University of Texas, Austin, out of which eight sessions are used for the study (I omit one session in order to avoid inconsistency, as explained later). A total of 174 subjects participated in these sessions, creating a dataset with 2784 observations. Four of the sessions feature the sequential game discussed above (I call this *Treatment NH*), and five sessions were conducted where the subjects were given information about the behavioral trends observed in a past session (I call this *Treatment H*) (details later).

Each experimental session consist of two parts: in the first part, Part One, the players sequentially play Task 1 and Task 2, but the principals do not have the option of delegation. So, in this part, the two tasks can be treated independently; hence this part can be treated as the "Control." Part Two gives the principals the option to delegate the first task, and thus can be treated as the "Treatment." Below I describe the specific features of the experimental design followed in this study.

- **Within Subjects Design:** In this experiment, I use the *"within subjects"* design, where the same subject pool serves both as the Control and the Treatment. This helps us increase the number of observations at a lower budget. It also reduces the error variance due to individual fixed effects since there are more observations for each participant.

- **Role Switching:** So that all the subjects are aware of the incentives faced by both the roles, I use "role switching" in the design. At the beginning of each experimental session, every participant randomly receives a role: either a principal or an agent with equal probability. After that, at the beginning of each round the role switches, i.e., if an individual is assigned as a principal in round one, he/she will be an agent in round two, and so on.

- **Random and Anonymous Matching:** To implement the static nature of the theoretical model, I use random and anonymous matching among the participants in different roles in every round.

- **Risk Neutrality:** To simulate the theoretical set up, the subjects earn payoff points in each round, rather than monetary earnings. At the end of each session, I conduct lotteries to pay the subjects in order to impose risk neutrality. I follow the approach proposed by Walker, Smith and Cox [43] and use their finding that risk neutrality can be induced in subjects' decisions by paying them in lotteries on money that are linear in the outcome probabilities.

- **Fair Payment Scheme:** The payment scheme is designed to be fair and efficient. While conducting the lottery, the computer takes care of the roles and types the subject was assigned and adjusts the probability of winning accordingly. At the lottery, for each participant, the computer randomly draws an integer between 0 and the maximum payoff points that subject could have earned, given the roles and types that he/she was assigned to in each round. This ensures fairness of the lottery.

For the baseline treatment (*Treatment NH*), there are three sessions with 24 participants each and one with 20 participants; for the treatment with historical information given to the subjects: *Treatment H*, two sessions have 22 participants, one has 20 and the other has 18 participants. zTree software [27] is used to design the interface and record the participants' responses. At the beginning of a session, each participant is assigned a random subject number generated by the computer. The experimental instructions are then given verbally to the participants along with some slides and a copy of the instructions are also distributed among them (the detailed instructions are attached as Appendix C.2).

At the beginning of each round, every participant receives a role: either a principal or an agent, with role switching in every round. Then, the agents are randomly assigned as biased or unbiased types (with equal probability) and randomly and anonymously matched to the subjects assigned as principals in that round. The principals do not observe the type of the agent he/she is matched to in that round, but receive a randomly generated signal sent by the computer. The matching and signalling structures remain the same throughout the session. To avoid any positive or negative connotations, I call the types Green (for Unbiased) and Red (for Biased); the signals as Lime (high) and Pink (low).

Since the game consists of multiple tasks, it is imperative that the subjects are trained in each of these tasks and have sufficient experience with them before playing the sequential game. So, at the beginning, the players face the two tasks separately. Stage One of Part One features four rounds of task 2, where in each round the matched pair of a principal and an agent play the coordination game described above. After that, instructions about task 1 are given and a short quiz is conducted to ensure the subjects' understanding of the task. Stage Two of Part One features six rounds of the entire game, where each matched pair of a principal and an agent will play task 1 and task 2 sequentially, but without the option to delegate task 1. Thus, the data generated from Stage Two of Part One can be used as the Control. Part Two consists of ten rounds of the entire game, with the principals having the option to delegate task 1 to the agents; thus this stage provides the data from the Treatment.

Apart from conducting four sessions with the benchmark treatment *(Treatment NH)*, I also conduct five sessions with historical information given to the subjects. In these sessions, termed as the *Treatment H sessions*, Part One is conducted similar to the *Treatment NH sessions.* However, before Part Two, the subjects are given information about

(a) the proportion of principals who chose high effort after delegating Task 1 and after not delegating, and

(b) the proportion of Red (Biased) and Green (Unbiased) agents who chose high effort after being delegated and after not being delegated[3].

In the first session with *Treatment H* , the information given is from the previous *Treatment NH session.* The next *Treatment H sessions* are conducted using information from the last *Treatment H session.* Hence, in the first *Treatment H session*, the subjects are informed about behavioral trends of others who, in turn, were not given any information; whereas in the next Treatment H sessions, subjects observe the data generated from a session where historical information was given. To avoid any possible inconsistency due to this, I omit the data from the first *Treatment H session* and use the data from the remaining four sessions.

For the payment scheme, I use lotteries to implement risk-neutrality of the players. In each round, depending on the choices made by a participant and the matched partner, the participants are awarded payoff points specified in the theoretical model. At the end of a session, two lotteries are conducted, one for each Part. In Lottery One, a random integer was drawn by the computer from the interval of 0 to the maximum number of points a participant could have earned in Part One, given his/her roles and types. If the actual points earned was greater than the random integer, the participant got \$15, otherwise \$2. In Lottery Two, a random integer was drawn by the computer from the interval of 0 to the maximum number of points a participant could have earned in Part Two and if the actual points earned was greater than that random integer, the participant was rewarded \$15, otherwise he/she got \$4.

[3] See Appendix C.3 for the slide through which the historical information was given in one of the Treatment H sessions.

4.0.1. Hypotheses:

In the baseline treatment (*Treatment NH*), I examine the data observed to see if the subjects' choices are consistent with any of the equilibrium predictions of the theoretical game, and if the subjects indeed use delegation as a signaling device. Here I state the hypothesis, later on we will see if the results support these hypothesis.

Firstly, Part One (observations from subjects playing the entire game without the delegation option) serves as a benchmark. In absence of any connection between the two tasks, from the proportion of coordination, I get a benchmark about the coordination behavior of the subject pool. The Part Two data will then shed light on the equilibrium selection behavior.

A *Hypothesis NH (Part One):* In Part One of the baseline treatment, in Task 1 the principal will choose high effort and in Task 2, $(e_{2P}, e_{2A}) = (0, 0)$ will be played irrespective of the principal's signal or the agent's types, so the outcome will be consistent with the Pareto inferior outcome $(5, 5)$.

A1 Also, the choices should not significantly depend on which session or period the data is from, nor on the subject specific effects.

B *Hypothesis NH (Part Two):* In Part Two of the baseline treatment, the separating equilibrium will be chosen, where the high signal principal will delegate Task 1 and achieve coordination in Task 2 if matched with an Unbiased agent.

This hypothesis can be broken into several components:

B1 The principal with a high signal more frequently chooses to delegate the task 1 than the principal with a low signal.

B2 After delegating task 1 to the matched agent, the principal is more likely to choose high effort in task 2 than when not delegating.

B3 After observing delegation by the principal, the matched Unbiased agent chooses high effort more often than after observing no delegation.

In the sessions where the subjects are given information about the past session (*Treatment H*), I test if there is a statistically significant difference in the equilibrium selection behavior. In those sessions, in addition to testing the above hypothesis, I test the following hypothesis as well:

C *Hypothesis H:* In Part Two in *Treatment H sessions* , the separating equilibrium is played more often than in *Treatment NH sessions.* Also, delegation is more frequently observed with *Treatment H.*

5. RESULTS

5.1. *Treatment NH*: Part One

First let us examine the results from the Part One , with 552 observations. Apart from showing if the subjects' play conforms to any equilibrium behavior, the results also shed light on the natural cooperative tendency in the subject pool.

1. *Observation 1:* The Unbiased agents choose high effort in Task 2 significantly more often (t-stat: -8.3757). The following table reports the total number and proportion of occasions where the agent chose high effort.

Type\Task 2 Effort	High	Low	Total
Unbiased	68 (41.72%)	95 (58.28%)	163
Biased	2 (1.77%)	111 (98.23%)	113
Total	70	206	276

2. *Observation 2:* The principals choose high effort in Task 1 (which is the dominant strategy) almost always (t-stat: 6.6641), indicating the consistency of behavior in the subject pool.

	Task 1 Effort: Low	Task 1 Effort: High	Total
Principal	20 (7.25%)	256 (92.75%)	276

3. *Observation 3:* The principals choose low effort in Task 2 if they receive low signal. They choose high effort in Task 2 significantly more often if the private signal is high (t-stat: -6.3011).

Signal\Task 2 Effort	High	Low	Total
High Signal	50 (45.87%)	59 (54.13%)	109
Low Signal	23 (13.77%)	144 (86.23%)	167
Total	73	203	276

4. The inefficient outcome $(5, 5)$ is chosen significantly more often than the Pareto dominant outcome $(9, 9)$ in Task 2.

Equilibrium Chosen	Frequency	Percent
Outcome $(9, 9)$	22	7.97%
Outcome $(5, 5)$	203	73.55%
Total Play	276	100%

Also, the subjects' behavior mostly conforms to an equilibrium prediction; only 18% of the times the behavior observed is different than predicted by an equilibrium. Together, these four observations show support for Hypothesis A[4].

[4] In Appendix A, Table 8 shows the results of a t-test to check if the proportion of coordination

Next, with the help of logistic regressions, I seek to understand the factors that affect the Task 2 effort choices by the principals and agents. In particular, I examine if there is any subject-specific, session-specific or period-specific fixed effect on the choice of Task 2 effort. The following table (Figure 1) summarizes the findings. The principals' choice of Task 2 effort depends only on the private signal, while the agents' choice mainly depends on the type. Also, as the session proceeds, the agents become pessimistic about cooperation possibilities and choose low efforts increasingly often, but the effect is not statistically significant at 10% level. Overall, these results support Hypothesis A1.

	Principal b/se	Agent b/se
Task 2 Effort		
signal	1.708***	
	(0.30)	
Subject	0.011	- 0.024
	(0.02)	(0.02)
session	-0.234	-0.056
	(0.14)	(0.15)
Period	-0.044	-0.213*
	(0.09)	(0.09)
Type		3.720***
		(0.74)
Constant	1.397	-0.847
	(1.91)	(2.15)

* p<0.05, ** p<0.01, *** p<0.001

FIG. 1 Task 2 Effort Choices in the Part One Group of *Treatment NH*

5.2. *Treatment NH*: Part Two

From the data collected from Part Two, analyzing the 920 observations, I observe the following trends. As before, the t-statistics are reported within parentheses.

1. Principals with high signal delegate more often than with low signal (t-stat: -4.1037). Thus, the private belief about the matched agent's type positively influences the delegation decision, as posited in Hypothesis $B1$.

equilibrium play (outcome $(9, 9)$) is significantly different from the proportion of the Pareto dominated equilibrium play (outcome $(5, 5)$). The evidence suggests that the majority of the participants chose not to coordinate in Part One.

Signal\Delegation	Delegate	No Delegate	Total
High	55 (28.65%)	137 (71.35%)	192
Low	36 (13.43%)	232 (86.57%)	268
Total	91	369	460

2. After Delegation, principals more often follow up with high effort choice in Task 2 (t-stat: -5.0013). This supports Hypothesis B2.

Delegation\Task 2 Effort	High	Low	Total
After Delegation	33 (36.26%)	58 (63.74%)	91
After No Delegation	52 (14.09%)	317 (85.91%)	369
Total	85	375	460

3. After observing Delegation, Unbiased agents are more likely to respond by choosing High Effort in task 2, as posited in Hypothesis B3 (t-stat: -3.3962).

Delegation\Task 2 Effort	High	Low	Total
After Delegation	24 (42.11%)	33 (57.89%)	57
After No Delegation	35 (20%)	140 (80%)	175
Total	59	173	232

Biased agents almost never choose high effort.

Delegation\Task 2 Effort	High	Low	Total
After Delegation	0 (0%)	34 (100%)	34
After No Delegation	2 (1.03%)	192 (98.23%)	194
Total	2	226	228

4. After a delegation occurs, the proportion of plays choosing (High, High) in Task 2 is significantly greater than after no delegation. The following table shows that after delegation it is ten times more likely to end up at $(9, 9)$ in Task 2.

Delegation\Task 2 Outcome	Task 2 payoff : $(9, 9)$	Total
After Delegation	11 (12.09%)	91
After No Delegation	6 (1.63%)	369
Total	17	460

I also run a logistic regression to explain the delegation decision and the Task 2 effort choice. The results[5] are described in the following table (Figure 2):

The agent's effort choice significantly depends on her type and also whether he was delegated. Also, as the sessions proceeds, he chooses high effort less often. For the principal, delegation decision depends only on the signal, though the

[5] I drop the variables "session"and "subject", which were insignificant at 5% level.

	Agent b/se	Principal b/se	Delegation b/se
If Principal Delegated	1.001**	0.966***	
	(0.33)	(0.28)	
Type	3.541***		
	(0.73)		
Period	-0.121*	0.028	-0.057
	(0.06)	(0.05)	(0.04)
signal		1.686***	0.984***
		(0.28)	(0.24)
Constant	-2.626	-1.393	1.435
	(2.12)	(1.70)	(1.56)

* p<0.05, ** p<0.01, *** p<0.001

FIG. 2 Task 2 Effort Choices in Part Two Group with *Treatment NH*

variable "period" has a dampening effect (not significant at 1% level). The principal's Task 2 effort choice significantly depends on her own delegation decision and private signal.

5.2.1. Equilibrium Selection

Now we turn to our central question: whether delegation is used in equilibrium as a signal to obtain coordination. First, note that the Pareto-inferior Perfect Bayesian Equilibrium without using delegation and the Perfect Bayesian Equilibrium satisfying Forward Induction Refinement with using delegation both predict a similar outcome if the Principal observes a low signal: both equilibria predict that the Principal will not delegate Task 1 and subsequently choose low effort in Task 2, and the matched Agent will respond by choosing low effort in Task 2. So, we examine the proportion of times each of the equilibria is chosen separately for each signal realization and put higher emphasis on the behavior observed after a High signal is observed.

If a High Signal is observed, the Forward Induction equilibrium (termed as *"FI"* hereafter) is chosen significantly less often than the Pareto-inferior Perfect Bayesian Equilibrium ("Perfect Bayesian Equilibrium" hereafter). The next table summarizes the proportions of plays conforming to the two respective equilibrium predictions.

Equilibrium Chosen \ Signal	High	Low	Total
FI	19 (9.90%)	212 (79.10%)	231
PBE	105 (54.69%)	212 (79.10%)	317
Total Equilibrium Play	124 (64.58%)	212 (79.10%)	336(73.04%)

We conduct a t-test to test Hypothesis B and find that the FI equilibrium is chosen significantly less often (Table 1).

TABLE 1
FI is not Chosen Frequently

Two-sample test with equal variance					
Group	Obs	Mean	Std Er	95% Conf. Interval	
PBE	192	.546875	.0360194	.4758281	.6179219
FI	192	.0989583	.0216064	.0563406	.1415761
Combined	384	.3229167	.0238928	.2759392	.3698941
diff		$t = 10.6640$	d.f. $= 382$		
Ho: diff= 0					
Ha: diff $<$ 0		Ha: diff != 0		Ha: diff $>$ 0	
$Pr(T < t) = 1.0000$		$Pr(\|T\| > \|t\|) = 0.0000$		$Pr(T > t) = 0.0000$	

Since t-tests use the normality assumption, I also use a non-parametric test, viz. Mann-Whitney U test and obtain similar results (z-stat: 7.72, significant at 1% level). Combining the observations with High and Low signal realizations, we observe that FI is chosen 50.21% of the times, while $Perfect\ Bayesian\ Equilibrium$ is chosen 68.9% of the times and the difference is statistically significant at 1% level (t-stat: 5.88).

This result clearly shows that the proportion of plays conforming to the Pareto dominated Perfect Bayesian Equilibrium is significantly greater than the proportion conforming to the Perfect Bayesian Equilibrium that satisfies the forward induction criterion. This result contradicts Hypothesis B.

Also, the proportion of plays conforming to an equilibrium prediction is also significantly lower (only 64.58%, as shown in the above table) compared to the same if a Low signal is observed (79.10%). A t-stat shows that difference is significant (Table 2).

To sum up the results from this treatment, we observe that:

(a) The observed play mostly conforms to a Perfect Bayesian Equilibrium.

(b) *After* a delegation decision, the choices made by the principal and the agent supports the theoretical prediction of forward induction.

(c) However, the PBE that survives the forward induction criterion is seldom chosen. Principals do not delegate often. The Pareto inferior Perfect Bayesian Equilibrium is chosen significantly more frequently, indicating that forward induction fails to predict the outcome in this context. To gain more insight into this result, and to know the role of information in this context, I use the next set of treatments. Here I check if historical information, even though theoretically completely irrelevant in this context, has any impact on the decisions and belief formation.

TABLE 2

Equilibrium Play Observed More Often with Low Signal

Two-sample test with unequal variance					
Group	Obs	Mean	Std Er	95% Conf. Interval	
Low Signal	268	.7910448	.0248812	.7420564	.8400331
High Signal	192	.6458333	.0346057	.5775749	.7140917
Combined	460	.7304348	.0207117	.6897332	.7711363
diff		$t = 3.4070$	d.f. = 368.979		
Ho: diff= 0					
Ha: diff < 0			Ha: diff != 0		Ha: diff > 0
$Pr(T < t) = 0.9996$			$Pr(\lvert T\rvert > \lvert t\rvert) = 0.0007$		$Pr(T > t) = 0.0004$

5.3. *Treatment H*

The main question in this set of treatments is: how does the delegation choice depend on the information given to the participants? Theoretically, since the sessions are completely independent of each other, the information describing summary statistics of one session should not impact any decision in another.

I use the data from the last three sessions (I will call them History sessions, or *Treatment H*) containing 1312 observations. In each session, before Part Two, the participants were given summary statistics about the past History session[6]. Analyzing this data, I examine if this additional information affects the decision making of the subjects and equilibrium selection in general. The observations from these four sessions are listed below:

1. *Observation 1:* The data from the Part One in *Treatment H sessions* is similar to the Part One data observed in *Treatment NH sessions*.

   The Unbiased agents choose Task 2 effort in a similar way (t-statistic for comparing the Task 2 effort between *Treatment NH* and *Treatment H* is 1.63, insignificant at 10% level), similar for the Biased agents (t-stat: -0.7303). The principals choose Task 2 effort similarly (for low-signal principals, t-stat: 1.53, for high-signal, t-stat: 1.35). The coordination achieved in Task 2 is also similar (t-stat: 0.31). This is not surprising, given that the Part One was not given any additional information. For the Part Two , we need to examine the results more closely. The tables (8) and the logistic regressions (Figure 5)are given in Appendix A.

[6] In all of these sessions, the historical information given was from the last session conducted with similar informational environment. For the sake of consistency, I do not use the first session where the data given was from a session which was conducted without history. I examine this omitted session in Appendix C and show that the results are robust.

2. *Observation 2:* The principals who observe high signals delegate more often in *Treatment H* than in *Treatment NH* (t-stat: −2.75).

Treatment\Delegation	Delegation	No Delegation	Total
History	65 (42.76%)	87 (57.24%)	152
No History	55 (28.65%)	137 (71.35%)	192
Total	120	224	344

The result of the t-test is shown in Table 3. Here, we test if the proportion of principals who delegate after observing high signal is different between *Treatment NH sessions* and *Treatment H sessions.* The test finds clear evidence of a significant difference in delegation behavior across treatments.

TABLE 3
Higher Delegation Frequency with History

Two-sample test with equal variance					
Group	Obs	Mean	Std Er	95% Conf. Interval	
Treatment NH	192	0.2864583	.0327133	.2219327	.350984
Treatment H	152	.4276316	.040261	.348084	.5071792
Combined	344	.3488372	.0257341	.2982207	.3994537
diff		$t = -2.7503$	d.f. = 342		
Ho: diff= 0					
Ha: diff < 0		Ha: diff != 0		Ha: diff > 0	
$Pr(T < t) = 0.0031$		$Pr(\|T\| > \|t\|) = 0.0063$		$Pr(T > t) = 0.9969$	

Since t-tests use the normality assumption, I also use a non-parametric test, viz. Mann-Whitney test to check if the proportion of delegation choices is significantly different in *Treatment H*, and these results are also similar to the t-test, as shown in Table 4 .

3. *Observation 3:* The proportion of times the observed play conforms to the forward induction equilibrium is significantly higher in *Treatment H* compared to *Treatment NH.* i.e. the separating equilibrium with delegation as a way to achieve cooperation is chosen more frequently in *Treatment H.* The following table captures the number (and proportion) of times the forward induction equilibrium (*FI*) and the Pareto-dominated PBE (*PBE*) is chosen in *Treatment H.* As discussed before, we put more emphasis on the results for the observations with High signal realization, since for Low signal, the two equilibrium

TABLE 4
Treatment H vs NH: Mann-Whitney Test

Two-sample Wilcoxon rank-sum (Mann-Whitney) test			
History	Obs.	Rank-sum	Expected
Without History	192	31060	33120
With History	152	28280	26220
Combined	344	59340	59340
unadjusted variance	839040.00		
adjustment for ties	−267271.84		
adjusted variance	571768.16		
$H_0 : d(NH) - d(H)$			
$z = -2.724$			
$\Pr ob > \lvert z \rvert$	$= 0.0064$		

predictions converge.

Equilibrium Selection After High Signal

Equilibrium Outcome\Treatment	H	NH	Total
FI	29 (19.08%)	19 (9.90%)	48
PBE	79 (51.97%)	105 (54.69%)	184
Total No of Equilibrium Plays	108 (71.05%)	124 (64.58%)	232 (67.44%)

Using t-test we examine if the frequency of choosing the respective equilibrium depends on the information given. While we find that the frequency of choosing the Pareto dominated PBE does not significantly vary from *Treatment H* to *Treatment NH* (t-stat:0.4999, statistically insignificant), for the *FI*, the treatment matters, as shown next (Table 5).

Overall frequencies (for both High and Low signal realizations) are given below:

Equilibrium Selection

Equilibrium Outcome\Treatment	H	NH	Total
FI	244 (59.51%)	231 (50.22%)	475 (54.6%)
PBE	294 (71.71%)	317 (68.91%)	611(70.23%)
Total No of Equilibrium Plays	323 (78.78%)	336 (73.04%)	659 (75.75%)

For PBE, we check that the treatment does not significantly affect the proportion of plays conforming to this Pareto-dominated equilibrium (both t-test and Mann-Whitney test findings agree; t-stat: −.8991). For the Forward Induction equilibrium, however, History matters. The following table (Table 6) shows the

TABLE 5

FI Chosen More Often With History

Two-sample test with equal variance					
Group	Obs	Mean	Std Er	95% Conf. Interval	
Treatment NH	192	.0989583	.0216064	.0563406	.1415761
Treatment H	152	.1907895	.0319757	.127612	.2539669
Combined	344	.1395349	.0187094	.1027352	.1763346
diff		$t = -2.4553$	d.f. $= 342$		
Ho: diff= 0					
Ha: diff < 0		Ha: diff != 0		Ha: diff > 0	
$Pr(T < t) = 0.0073$		$Pr(\|T\| > \|t\|) = 0.0146$		$Pr(T > t) = 0.9927$	

results of the Mann-Whitney test to check if the proportion of play selecting the separating equilibrium is significantly different in *Treatment H*, and I do find support in the result.

TABLE 6

FI Chosen More Often: Mann-Whitney Test

Two-sample Wilcoxon rank-sum (Mann-Whitney) test			
History	Obs.	Rank-sum	Expected
Without History	460	191565	200330
With History	410	187320	178555
Combined	870	378885	378885
unadjusted variance	13689217		
adjustment for ties	−3509103		
adjusted variance	10180114		
$H_0 : d(NH) - d(H)$			
$z = -2.747$			
$\Pr ob > \|z\|$	$= 0.0060$		

We also observe that the proportion of plays conforming to an equilibrium prediction is significantly different in Treatment H (mean: 78.78%) vs in Treatment NH (mean: 73.04%) at 5% level (t-stat: −1.97). These results indicate that the given information about past session affects belief formation and is more conducive to forward induction reasoning.

1. The following table (Figure ??) shows the logistic regression results to see what factors affect the Task 2 effort choices and delegation decisions in *Treatment H.* As predicted in the theoretical model, the Green Agent's effort choice significantly depends on whether he is delegated Task 1; the Principal's effort choice depends on own delegation decision and private signal whereas her delegation decision depends on private signal.

6. DISCUSSION

6.0.1. Reluctance for Delegation

In both the treatments we observe that the subjects are quite reluctant to delegate Task 1, even though they have a high private belief about the matched agents 'unbiasedness. This finding matches with many of the experimental works studying delegation. Fehr et.al. ([24]), and Bartling et.al. ([3]) find that in an authority-delegation game, individuals often retain authority even when its delegation is in their material interest; suggesting that authority has non-pecuniary consequences for utility. It has been widely discussed that indivuduals often intrinsically value decision rights beyond their instrumental benefit. This intrinsic valuation of decision rights has potentially important consequences for corporate governance, human resource management, and optimal job design. In that light, the finding that subjects use delegation very seldom is not srprising and can be a potential reason behind the Pareto-dominated PBE being played more often.

6.0.2. On Forward Induction

In this paper, I find that in general, the participants choose the pooling Perfect Bayesian Equilibrium. Delegation is not used often and later in Task 2 (Low, Low) effort choice is observed. Thus, the forward induction logic breaks down here. The results indicate that the forward induction reasoning is unlikely to be empirically valid in this context. This finding is consistent with the existing studies ([14], [30]) which discuss the limitations of forward induction reasoning. It has been found that, especially in coordination games with multiple Pareto ranked equilibria, forward induction refinement does not have much predictive power. Forward induction relies essentially on the common belief of rationality assumption. So, if the players are unsure of other players' rationality, they can choose the "safe" option of playing low effort and this can lead to the observed results.

6.0.3. Importance of Information

In *Treatment H*, the information about the past session significantly increases the proportion of coordination. This clearly indicates that this historical information has a role to play in formation of belief and equilibrium selection. Two important notes about this trend: Firstly, it seems that the availability of this historical information is what matters, not the information itself. In the data, I find that the proportion of times the "coordination" outcome[7] was chosen in these Treatment H sessions does not significantly differ across sessions. As the following figure (Figure 3) shows, the proportion of coordination does not exhibit any trend over time.

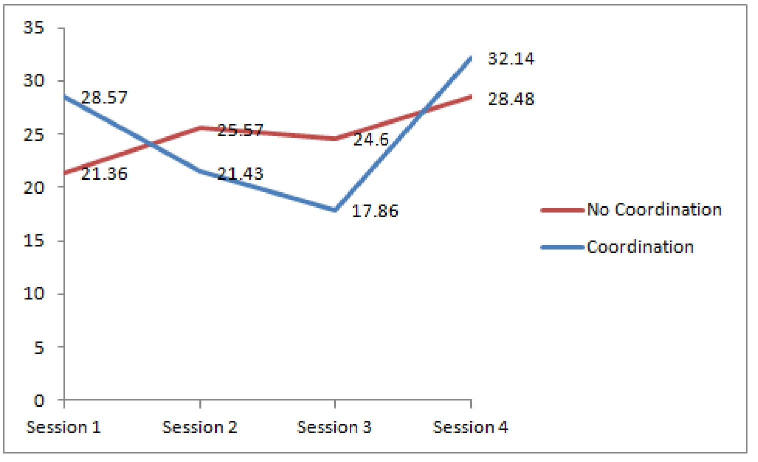

FIG. 3 Coordination Does Not Depend on Session

Also, in a regression (Figure 4) to explain the coordination behavior, I find that the variable "session" is not statistically statistically significant at 5% level.

Also, as noted before in the logistic regression explaining the principals' effort choice in *Treatment H* (Figure **??**), the variable "session" is not affecting the choice significantly.

Clearly, the coordination proportion does not show any significant cumulative growth pattern over the sessions. Given that each subsequent session were given data from a previous session which already had historical information, this lack of pattern is all the more stark. These results suggest that the effect of information on coordination behavior can not be explained by the given information itself; rather the availability of information is what creates a significant difference.

Secondly, the public announcement of the information may help the subjects in forming the second order beliefs about the other subjects. It will be interesting to see if the same information given privately has the same impact on equilibrium selection.

So, I offer the conclusion that the equilibrium selection and belief formation depend on the informational environment of the game. In this particular Bayesian

[7] As defined before, by "Coordination", I refer to the outcome where principals delegate and then in Task 2 end up with (High, High) effort choice.

	Coordination b/se
coor	
signal	2.531***
	(0.52)
Period	0.090
	(0.08)
session	-0.085
	(0.14)
Subject	0.033
	(0.03)
Constant	-3.906
	(3.53)

* p<0.05, ** p<0.01, *** p<0.001

FIG. 4 Coordination does not depend on session

game, the information about past play increased the predictive power of forward induction refinement. These results thus stress the need of a fully formulated behavioral model of equilibrium selection in Bayesian games.

7. CONCLUSION

In this study I have shown that theoretically it is possible to explain the delegation phenomenon in various real life contexts as a signal of trust in order to achieve cooperation in a later phase. However, the experimental data show that the subjects do not often choose this equilibrium. However, providing more information about past play increases the proportion of subjects choosing this equilibrium, hence using delegation to achieve coordination.

On one hand, this paper sheds light on the determinants of coordination in many real life scenarios. In inter-organization partnerships, it is often crucial to sustain cooperation among the employer and the employee in order to enhance the value of the relationship. This study shows how the use of delegation can be used to signal the employer's trust in the employee's devotion and bring about cooperation. It also underlines the importance of factors like the workplace environment and past information in forming new employee's belief and consequently in equilibrium selection.

On the other hand, this study provides fresh evidence on equilibrium selection in a Bayesian game. The results suggest that to understand the issue of equilibrium selection, we need a better model of how beliefs are formed and how these beliefs depend on historical information.

8. APPENDIX A: RESULTS

Treatment NH: Coordination in Part One

Variable	Observation	Mean	Std. Error
Outcome $(9, 9)$		7.971014%	0.1865
Outcome $(5, 5)$		73.5507%	0.2665
Diff		-65.5797%	0.4295
Mean(Diff)	$t = -1.5e + 02$	$H_o : mean(diff) = 0$	
	$P(T < t) = 0.00$	$P(\|T\| > \|t\|) = 0.00$	$P(T > t) = 1.00$

Treatment H: Detailed Results

	Principal b/se	Agent b/se
Task 2 effort		
signal	1.893***	
	(0.37)	
Subject	-0.018	0.013
	(0.03)	(0.03)
session	0.094	0.000
	(0.12)	(0.12)
Period	-0.026	-0.124
	(0.10)	(0.11)
Type		2.679***
		(0.55)
Constant	-4.146	-2.267
	(3.01)	(3.12)

* p<0.05, ** p<0.01, *** p<0.001

FIG. 5 Task 2 Effort choice in the Part One Group of *Treatment H*

Behavior Trends of *Treatment H* (Part Two):

1. High signal principals delegate more often than low signal principals (t-stat: -6.8925).

Signal\Delegation	Delegate	No Delegate	Total
High	65 (42.76%)	87 (57.24%)	152
Low	36 (13.95%)	222 (86.05%)	258
Total	91	369	460

2. After Delegation, principals more often follow it up with high effort choice in Task 2 (t-stat: -17.8545).

Delegation\Task 2 Effort	High	Low	Total
After Delegation	67 (66.34%)	34 (33.66%)	101
After No Delegation	15 (4.85%)	294 (95.15%)	309
Total	82	328	410

3. After observing Delegation, Unbiased agents are more likely to respond by choosing High Effort in task 2 (t-stat: -11.2993).

Delegation\Task 2 Effort	High	Low	Total
After Delegation	37 (62.71%)	22 (37.29%)	59
After No Delegation	9 (5.96%)	142 (94.04%)	151
Total	46	164	210

Biased agents never choose high effort.

Delegation\Task 2 Effort	High	Low	Total
After Delegation	0 (0%)	42 (100%)	42
After No Delegation	0 (0%)	158 (100%)	158
Total	0	200	200

4. *Hypothesis H (Treatment):* The coordination rate is higher with delegation.

Delegation\Task 2 Outcome	Task 2: $(9, 9)$	Task 2: $(5, 5)$	Total
After Delegation	28 (27.72%)	34 (33.66%)	62
After No Delegation	0 (0%)	294 (95.15%)	294
Total	28	328	356

9. APPENDIX B: INSTRUCTIONS

Instructions (PI's Copy)

Comments and explanations of actions have been included in italics.

Part One

Thank you for participating in this experiment on economic decision making. Please pay attention to this instruction and also the accompanying slides. If you follow these instructions carefully and make careful decisions you might earn a considerable amount of money which will be paid to you in cash and in private at the end of the experiment.

(show them wads of cash)

The experiment will consist of two parts and last about one and a half hours. The amount of money you make will depend on the decisions you and all other participants make during the experiment.

Your computer will assign you an ID number, and at the end of the session you will be given an envelope with that ID number on it containing your monetary earnings. The person handing you your envelope will not know how much money is in the envelope. Thus, absolute anonymity and privacy will be maintained.

Please remain silent during the experiment. If you have any questions, or need assistance of any kind, raise your hand; one of the experiment administrators will come to you and you may whisper your question to him. Please do not talk, laugh, or exclaim out loud. We expect and appreciate your adherence to these rules.

You will be making choices using the computer mouse and keyboard. You may reposition the mouse pad so it is comfortable for you. Do NOT click the mouse buttons until told to do so.

(Please look up at the first slide)

This experiment will consist of two Parts, in each Part there will be several Stages. Each stage will feature a decision problem, which you will face for several "rounds". At the beginning of each stage, instructions about that stage will be given verbally and also will be displayed on the screen in front of the room. A copy of the instructions for Stage One of Part One are already handed out to you, for each stage fresh instructions will be distributed.

Throughout the experiment, at the beginning of each round, you will be assigned one of the two roles: PRINCIPAL or AGENT. You will be assigned to a role randomly at the beginning of the experiment. After that, in each round, the roles will be switched, i.e. if you are a PRINCIPAL in round 1, you will be an AGENT in round 2 and so on. There will be an equal number of PRINCIPALS and AGENTS in each round. At the beginning of each round, each participant will be randomly and anonymously matched with another participant of the other role, thus a matched pair will stay matched for at most one round.

The AGENTS can be one of two types: GREEN or RED. The AGENT's type will be randomly assigned at the beginning of EVERY round.

AGENT's type will be GREEN or RED with equal probability in every round, i.e., with probability (1/2) it will be GREEN, with probability 1/2 it will be RED. The AGENT will be informed of his or her type at the beginning of each round, but the PRINCIPAL will not know the type of the AGENT he or she is matched to.

However, the PRINCIPAL will privately observe a signal about his/her matched AGENT'S type. This signal is randomly drawn by the COMPUTER; AGENTS have no control over it, and will not be able to observe it.

(Next slide shows the signals distribution.)

The signal can be LIME or PINK. On average, for 1 out of 2 GREEN AGENTs, a LIME signal is observed, and for 2 out of 3 RED AGENTS a PINK signal is observed.

For example, if there are 24 participants in a session, in each round 12 of them are assigned as PRINCIPALS and the other 12 as AGENTS. Out of the 12 AGENTS in each round, on average 1/2 (or 6) of them will be GREEN and 6 will be RED. Out of the 6 GREEN agents, on average a LIME signal will be sent to the PRINCIPAL for 3 AGENTs, and a PINK signal will be sent for the other 3 of the 6 GREEN AGENTs. Look now at the RED column: out of the 6 RED agents, on average a

LIME signal is sent for 2 of the 6, and a PINK signal is sent for the other 4 RED AGENTs.

So, in any round, if you are a PRINCIPAL and observe a LIME signal, it means that your matched AGENT is GREEN with probability 3/(3+2)=3/5, or 60%. If you are a PRINCIPAL and observe a PINK signal, it means that your matched AGENT is RED with probability 4/(4+3)=4/7 or 57.1%. This matching and signalling structure will be followed throughout the experiment.

AGENT's type distribution (for total number of AGENTS=12)

	GREEN	RED	
LIME	3	2	5
PINK	3	4	7
	6	6	12

(please look up at the next slide)

In each round, depending on the decisions you and the participant matched to you make, you will earn some payoff points.

(next slide discusses how your cash rewards from Part One will be calculated.)

The computer will calculate the sum of payoff points you earned from all the rounds in Part One. Also, in each round, given the role and type assigned to you in that round, there is a maximum number of payoff points that you can earn. The computer will keep track of these maximum payoff points for each participant. The sum of your earned payoff points relative to the sum of maximum payoff points you could earn will determine your cash rewards for Part One as follows.

At the end of the experimental session, for each participant the computer will draw a random integer between 0 and the maximum number of points the participant can get in Part One, given the assigned roles and types in each round. If your earned payoff points total is greater than that random integer, you will win a prize of $15, otherwise you will receive $2 from Part One. A similar lottery will be conducted for Part Two, to be discussed later.

(Please look up at the next slide)

Stage One

In Part One of this experiment, there will be two Tasks or decision problems. To gain experience, we will first start with a decision task which we will call Task 2.

In each round, the PRINCIPAL and the AGENT of a matched pair will make a choice in the following scenario. There are two possible choices: X and Y. You will not know your matched participant's choice until after you make your own choice, and the participant matched to you will not know your choice until after he or she has made it. In other words, you both make your decisions simultaneously without knowing the choice that the other person is making.

(next slide shows the payoff table)

The payoff consequences depend on the choice the PRINCIPAL and the AGENT make, and the AGENT's type.

	PRINCIPAL picks X	PRINCIPAL picks Y
GREEN AGENT picks X	9 / 9	5 / 1
GREEN AGENT picks Y	1 / 5	5 / 5

	PRINCIPAL picks X	PRINCIPAL picks Y
RED AGENT picks X	9 / 1	5 / 1
RED AGENT picks Y	1 / 5	5 / 5

You must choose either "X" or "Y" by clicking on your choice displayed above in the game table. The left table is for GREEN agents, so if a GREEN AGENT chooses "X" and the matched PRINCIPAL chooses "X" *(point with laser)*, each receives 9 payoff points, as indicated in the upper left cell. In each cell the lower left corner entry (which is colored according to the AGENT's type) is the payoff for the AGENT and the upper-right corner black entry is for the PRINCIPAL. If a GREEN AGENT chooses "X" and the matched PRINCIPAL chooses "Y," the AGENT receives 1 points and the PRINCIPAL receives 5 points (upper right-hand cell). If the GREEN AGENT chooses "Y" and the PRINCIPAL chooses "X", the AGENT receives 5 points and the PRINCIPAL receives 1 points (lower left-hand cell). If the GREEN AGENT and the PRINCIPAL both choose "Y", each receives 5 points (lower right-hand cell). Similarly, if the AGENT is RED, the AGENT's and the matched PRINCIPAL's payoff consequences are given by table on the right. For example, if a RED AGENT chooses "X" and the matched PRINCIPAL chooses "X", the AGENT receives 1 points and PRINCIPAL receives 9 points.

However, remember that a PRINCIPAL does not know the matched AGENT's type before making a choice. (point with laser) The PRINCIPAL will only receive a LIME or a PINK signal.

A PRINCIPAL who receives a LIME signal, knows only that with 60% (3/5) probability the AGENT is GREEN and the relevant payoff table is the one on the LEFT, and with 40% (2/5) probability the AGENT is RED and the relevant payoffs is the one on the RIGHT.

A PRINCIPAL who receives a PINK signal knows only that the AGENT is RED with 57.1% (4/7) probability and the relevant payoff table is the one on the RIGHT, and with 42.9% (3/7) probability, the AGENT is GREEN and the relevant payoff table is the one on the LEFT.

After all the participants have entered a valid choice, the AGENT's type and the choices made by you and the participant you were matched with for this round will be displayed on your monitor along with the resulting payoff points you earned in this round.

Before we begin, we will have a short quiz. Please turn to the next page and answer the short questions. We will discuss the answers in five minutes.

(quiz.

while they do quiz, the screen with payoff tables displayed.

change slide after quiz.)

Anyone needs more time to finish the quiz?

Okay, now we will discuss the answers to the Quiz. *(please look up at the next slide)*

Answer to Quiz:

1. You are assigned as a GREEN type AGENT in a particular round and randomly and anonymously matched with a PRINCIPAL. If you choose X and the PRINCIPAL chooses Y, what will be your payoff in this round?

Ans: 1.

(change slide)

Since you are assigned as a GREEN AGENT, the payoff table on the left is relevant to you. If you pick X, the green shaded cells give the possible payoffs. The PRINCIPAL chooses Y, which gives the grey shaded cells. The resulting payoffs are displayed in the dark shaded cell and YOUR payoffs are on the left corner.

(change slide)

2. You are assigned as a PRINCIPAL in a particular round and randomly and anonymously matched with an AGENT. You observe a LIME signal in this round. If you choose X, what are the possible payoffs you can get?

Ans: 9 or 1.

If the matched AGENT is GREEN and picks X, you get 9. If the matched AGENT is RED and picks X, you get 9. If the matched AGENT picks Y, you get 1 irrespective of which Type the AGENT is.

(slide change)

In the table, since the PRINCIPAL chooses X, the blue shaded cells give possible payoffs, but the PRINCIPAL does not know which table is relevant. Since he has received LIME signal, AGENT is GREEN and the left table is relevant with 60% probability. So all four payoffs that are possible are: 9, 1, 9 and 1.

(change slide)

3. In Task 2, what is the maximum payoff you can expect to earn if you are assigned as:

a. GREEN AGENT: Ans: 9 (if you and the matched PRINCIPAL both choose X)

b. PRINCIPAL matched to a GREEN AGENT: Ans: 9 (both PRINCIPAL and AGENT choose X)

c. RED AGENT: Ans: 5 (if you choose Y, no matter what the PRINCIPAL chooses)

d. PRINCIPAL matched to a RED AGENT: Ans: 9 (you and RED AGENT choose X)

(change slide and keep it at T2 table)

We will now begin interaction with the computers. If you have any questions before we begin the experiment, please RAISE YOUR HAND and a moderator will be with you shortly.

We will now begin the experiment. Please pay attention to your monitor and click the mouse when prompted to do so. Please click on the Continue button on each screen after you have read the information and/or made the choice. There are four rounds in this stage, once we have finished all the rounds, I will direct your attention to the screen in the front of the room again for the instructions for Stage Two.

Stage Two

Before starting Stage Two, we will discuss Task 1. Task 1 involves one of each matched pair (either the PRINCIPAL or the AGENT) choosing LEFT or RIGHT, where the payoff points each participant gets are given by this table:

Choice:	LEFT	RIGHT
PRINCIPAL gets	1	2
GREEN type AGENT gets	1	2
RED type AGENT gets	1	0

Please look at your computer screen and take the quiz on this task.

(quiz on personal computer screen)

(slide change after done with quiz)

We will now begin Stage Two of Part One, which contains six rounds. In this stage, you will do Task 1 and Task 2 sequentially. The sequence of actions is as follows:

- You will be assigned as PRINCIPAL or AGENT, with roles switching in every round as before. The AGENTs will receive their types (GREEN or RED) and the PRINCIPALs will not know the types but observe PINK or LIME signals. The matching and signalling will be exactly same as before.
- First, each matched pair will do Task 1. In this stage, the PRINCIPALs will be choosing LEFT or RIGHT and the AGENTs will have to wait for the PRINCIPAL to make the decision. The payoff points are as before. AGENTs will observe the PRINCIPAL's choice only after the entire round is completed.

- After completing Task 1, you will do Task 2 with the participant you are matched with. Task 2 is identical to what you did in Stage One. In each pair, both of you will simultaneously choose X or Y, as in Stage One. The instructions for AGENTs and PRINCIPALs will be displayed on your monitor.

Please turn to your monitors now.

(blank displayed while they play.)

Part Two

We are about to begin Part Two of the experiment. This part will consist of only one stage, which will contain ten rounds.

In each round, depending on the decisions you and the participant matched to you make, you will earn some payoff points. The computer will calculate the sum of payoff points you earned from all the rounds in Part Two. Also, in each round, given the role and type assigned to you in that round, there is a maximum number of payoff points that you can earn. The computer will keep track of these maximum payoff points as well. The sum of your earned payoff points relative to the sum of maximum payoff points you could earn in Part Two will determine your cash rewards for Part Two as follows.

At the end of the experimental session, for each participant the computer will draw a random integer between 0 and the maximum number of points the participant can get in Part Two, given the assigned roles and types in each round. If your earned total payoff points is greater than that random integer, you will win a prize of $15, otherwise you will receive $4 from Part Two.

((please look up at the next slide)

Stage One

In Stage One of Part Two, you will do Task 1 and Task 2 sequentially. The sequence of actions is as follows:

You will be assigned as PRINCIPAL or AGENT, with roles switching in every round as before. The AGENTs will receive their Types (GREEN or RED) and the PRINCIPALs will not know the Types but observe PINK or LIME signals. The matching and signalling will be exactly same as before.

(please look up to the next slide)

First you will do Task 1 with the participant you are matched with in this round. In this task, as before, the possible choices are LEFT or RIGHT, but there is one important difference.

If you are a PRINCIPAL in a round, you can choose whether to delegate the task to your matched AGENT, i.e. let him/her choose between LEFT or RIGHT. If you are an AGENT, you will observe if your matched PRINCIPAL has chosen to delegate the task to you. If the PRINCIPAL does NOT delegate, he/she will be making the choice on his/her own. If the PRINCIPAL DELEGATES the task, the matched AGENT will be choosing. The payoff consequences are given as before.

(slide change)

If the PRINCIPAL delegates Task 1, AGENT's choices will not be visible to the PRINCIPAL right after Task 1, but only after the completion of Task 2. After the entire round is completed, the choice made in the tasks, consequent payoffs and AGENT's type will be revealed.

(please look up to the next slide)

After completing Task 1, each matched pair will do Task 2 as before. Both of you will simultaneously choose X or Y.

(slide change and keep it blank)

Now, please turn to your computer to make choices in this Part. The instructions for AGENTs and PRINCIPALs and the payoffs will be displayed on your monitors.

After the ten rounds of this stage, the COMPUTER will conduct the lotteries for the two Parts to determine your cash rewards.

Please turn to your monitors now.

(later)

Please complete the questionnaire displayed on your screen. To preserve your privacy, type xxx when asked for name; do not write your own name. While you give us your valuable feedback, we will be putting your winning amounts in the respective envelopes. Please fill out the receipt with your winning amount as well. Thanks for participating in this experiment!

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