Authority and Communication in the Laboratory*

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Abstract

We report findings from experiments on two delegation-communication games. An uninformed principal chooses whether to fully delegate her decision-making authority to an informed agent or to retain the authority and communicate with the agent via cheap-talk to obtain decision-relevant information. In the game in which the delegation outcome is payoff-dominated by both the truthful and the babbling communication outcomes, we find that principal-subjects almost always retain their authority and agent-subjects choose to truthfully communicate. Significantly more choices of delegation than of communication are observed in another game in which the delegation outcome payoff-dominates the unique babbling communication outcome; yet there is a non-negligible fraction of principal-subjects who holds on to their authority and agent-subjects who transmit some information. A level-\(k\) analysis of the game indicates that a principal-subject “under-delegates” due to the belief that her less-than-fully-strategic opponent will provide information; such belief is in turn consistent with the actual play.

Keywords: Cheap-Talk Communication; Decision-Making Authority; Delegation; Laboratory Experiment; Level-\(k\) Model

JEL classification: C72; C92; D82; D83

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1 Introduction

Different states of the world typically call for different decisions to be made. More often than not, however, authority to make decisions and access to information about the state do not fall on the same entity. The final approval of hiring a faculty member, for example, rests with the provost or the dean, but it is the search committee who has first-hand information about the candidates. Regional management may have better information about local business conditions, but decision-making authority typically remains in the hands of corporate headquarters. Decision-making in situations of this sort therefore requires coordination among separate parties. And when interests are misaligned among them, the coordination is bound to be plagued by incentive problems.

This paper experimentally investigates two simple yet important means of coordination when decision-making authority and access to information do not coincide: full 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 relies on information provided by the agent in deciding what course of action to take. An agent whose interests are not in perfect accord with the principal’s may have an incentive to withhold or manipulate information; valuable information is lost in communication, depriving the principal of making a decision that accurately reflects the current state of the world. In delegation, on the other hand, by allowing the agent to make decisions the principal puts the agent’s information into full use. Yet if the parties do not share the same preferences over decision outcomes, losing control over decisions may well be worse than losing information. Whether the delegation outcome or the communication outcome is more favorable to the principal depends on the incentive environment the parties face.

In practice, the choices between delegation and communication are often buried in various organizational details, making it difficult to ascertain empirically how different possible outcomes of the coordination means may contribute to the selections. Our experimental study attempts to fill the void; we use two simple delegation-communication games as a vehicle to examine how individuals choose between the coordination means under different incentive structures. In our games, a principal (she) is endowed with a decision-making authority, an authority to choose among alternative actions; an agent (he) is privately informed about a binary type. Without any interaction with the agent, the principal first decides whether to fully delegate her authority to the agent. If she chooses to delegate, the agent will choose the action. If she chooses not to delegate, the agent will send her a message, after which she chooses the action herself; the choice not to delegate is thus a choice to communicate. Talk is cheap - the message in communication has no payoff consequence (à la Crawford and Sobel [18]). Players’ payoffs are jointly determined by the action taken and the agent’s type. To examine the decision of interests in an environment
as simple as possible, we abstract away any consideration of contracting or monetary transfers.

Our two games, Game C and Game D, differ by the incentives provided to the players. Game C, in which equilibrium predicts that the principal chooses communication, is a game with “conditional common interests.” For both types of the agent, the most preferred action is the least preferred for the principal, while the players share the same preference order over the remaining actions. By not surrendering her control, the principal can make sure that her worst outcomes will not realize. Given the aligned preferences over the remaining actions, the agent is willing to provide information in communication, allowing the principal to achieve her best outcome.\(^1\) Game D, in which equilibrium predicts that the principal chooses delegation, has in place a mismatch between the principal’s best action and the agent’s worst for one of the agent’s type (type 2) and an alignment of interests for another (type 1). This preference structures make informative communication impossible: type 2 always has an incentive to say that he is type 1. Without receiving any useful information in communication, the principal takes the pooling action, which is her second best outcome. If the agent is delegated to take the action, type 2 also prefers to take the pooling action, but type 1 will take the principal’s most preferred action. By delegating the action choice, the principal fully utilizes the agent’s information, allowing her to advance her payoff when type 1 prevails.

We implement Game C and Game D in the laboratory, and our main findings are as follows. In Game C, we observe, highly consistent with the equilibrium prediction, that the decision-making authority is almost always retained and communication pursued. In Game D, significantly more choices of delegation than of communication are observed. While this finding is also consistent with the equilibrium prediction, we observe a non-negligible fraction of principal-subjects who holds on to their authority and “under-delegates”: there is a higher incidence of off-equilibrium play in Game D in which communication is chosen despite that delegation is the optimal choice (of a fully rational and strategic principal). Concurrently, in the communication subgames off the equilibrium path, agent-subjects engage in “over-transmission of information”: they provide useful information to the principals despite the prediction of unique babbling equilibrium. The tendency to transmit information is also observed in Game C: in the communication subgame on the equilibrium path, subjects coordinate over the truth-telling equilibrium despite the existence of a babbling equilibrium.

We explore using a level-\(k\) model the connection between the non-equilibrium occurrences of “under-delegation” and “over-transmission of information” in Game D. The level-\(k\) paradigm, which offers a non-equilibrium approach to strategic thinking, posits that players belong to an array of cognitive-hierarchy types who ascribe different levels of sophistication to their opponents

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\(^1\)Even though there always exists a babbling equilibrium in cheap-talk games, we design the payoffs so that losing control over the action is so unfavorable to the principal that even with the babbling outcome communication is still preferred.
and best respond accordingly. First studied by Stahl and Wilson [43],[44] and Nagel [38] and further developed by Camerer et al. [9], Costa-Gomes et al. [12] and Costa-Gomes and Crawford [11], level-$k$ models are increasingly applied to rationalize experimental data that exhibit systematic deviations from equilibrium. We specify a level-$k$ model that allows us to fit our data from Game D to the empirical distributions of cognitive-hierarchy types recurrently documented in the literature of experimental level-$k$ analysis. In the hiring of faculty members, it is not uncommon that the dean prefers not to fully delegate and, expecting impartial reports, asks the department to write recommendations on candidates - even when it is clear that the dean, who has the interests of several academic units in mind, does not perfectly share the interests of individual departments. Our fitted level-$k$ model indicates that a similar situation occurs in our game: a principal “under-delegates” because she believes that her agent opponent is less than fully strategic and will provide information to her. Furthermore, such belief of “over-transmission of information” is consistent with the actual play.

Delegation as a means of resolving the principal-agent problems created under information asymmetry has received extensive theoretical attention. A series of papers starting from Holmstrom [31],[32] studies how the principal can optimally delegate by restricting the set of actions that the agent can take. In a different line of inquiry, Dessein [19] considers a model that features full delegation and cheap-talk communication as alternatives. The environment of our experiment is closest to his model. While theoretical work abounds, experimental/empirical studies on delegation are scarce. To the best of our knowledge, the current paper, Dominguez-Martinez et al. [21] and Fehr et al. [24] are the only experimental studies that address the informational role of delegation. Their experiments are designed in accordance with the authority model of Aghion and Tirole [1], in which the agent exerts effort into learning the profitability of potential projects. Our design, on the other hand, builds on the existing literature of communication game experiments. In particular, we append a delegation decision to communication games similar to those in Blume et al. [5],[6].

The rest of the paper proceeds as follows. Section 2 lays out the details of Game C and Game D, analyzes their equilibria, and introduces our experimental hypotheses derived therefrom. Section 3 describes our experimental design. Section 4 reports the experimental findings. Section 5 presents the level-$k$ analysis. Section 6 concludes with remarks on future research topics.

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2See Crawford et al. [17] for a comprehensive survey of recent theoretical and empirical developments of the level-$k$ paradigm.

3Subsequent work includes, for example, Melumad and Shibano [36], Alonso and Matouschek [2], and Kovác and Mylovanov [34].

4There are other experimental studies that consider delegation in other contexts and under different motivations. For example, Huck et al. [33] and Georgantzis et al. [28] consider delegation as a commitment device in Cournot-duopoly experiments; Bartling and Fischbacher [3] and Hamman et al. [30] consider delegation in dictator games; and Fershtman and Gneezy [25] introduce the uses of delegates into ultimatum games.
2 Theory and Hypotheses

2.1 Delegation-Communication Games

Our delegation-communication games consist of two players, 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 is that \( t_1 \) and \( t_2 \) are equally likely.

The principal, without interacting with the agent, first makes a delegation decision \( g \in \{c, d\} \), where in \( c \) the principal retains her authority to choose action and in \( d \) she fully delegates such authority to the agent. If the principal chooses \( c \), both players enter into a communication subgame in which the agent sends a cheap-talk message \( m \in M \) to the principal, after which the principal chooses \( a \in A \); the principal’s choice of no delegation is thus a choice of communication. A strategy of the principal consists of a delegation decision, \( g \in \{c, d\} \), and an action rule under no delegation, \( \alpha_c : M \to \Delta A \). A strategy of the agent consists of an action rule when he is delegated, \( \alpha_d : T \to A \), and a message rule when he is not, \( \sigma_c : T \to \Delta M \).

Payoffs are distributed after \( a \) is taken at which time the game ends. Payoffs to the players are functions of the pair \((t, a)\). The two games, Game C and Game D, differ by the profiles of payoffs and the action sets (Figure 1). In Game D, there are three elements in the action set: \( A = \{a_1, a_2, a_3\} \). Game C is the same as Game D except for two aspects: 1) Game C is appended with an additional column corresponding to the additional action \( a_4 \), resulting in a total of four actions in its action set; and 2) the agent’s payoff under the type-action pair \((t_2, a_2)\) changes from 100 in Game D to 800 in Game C. As we shall see below, these differences create different incentives that lead to very different predictions about how the games will be played in equilibrium.

2.2 Equilibrium Analysis

If the principal in Game C delegates, to maximize payoff the agent will, regardless of his type, take \( a_4 \) in the subgame in which he is the only active player. This yields the principal an expected payoff of 100, the worst possible outcome for her. If the principal retains her authority over the

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5Theoretically, there is no restriction on the message space except that its cardinality should not be 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.

6As will become clear below, the payoff structures are such that the principal will not want to randomize in the delegation decision; neither will the agent who is delegated to choose the action. However, in analyzing the communication subgames, especially that of Game D, we reason with the possibility that the players may randomize.

7In each of the cells in Figure 1, payoffs are presented as (agent’s payoff, principal’s payoff).
action, she makes sure that $a_4$ will not be taken, and the players enter into the communication subgame. The subgame, stripped of action $a_4$, is a communication game with common interests. It has two equilibria, one truth-telling and one babbling. For delegation to be saliently a dominated choice in the experiment, the payoffs are designed so that, regardless of which equilibrium prevails, the principal’s expected payoff from communication (800 in the truth-telling and 500 in the babbling) is higher than that from delegation. We summarize the above:

**Proposition 1.** In the equilibria of Game C, the principal does not delegate and chooses communication. In the communication subgame on the equilibrium path, there exist 1) a truth-telling equilibrium in which the principal takes action $a_i$ after the agent reveals his type $t_i$, $i = 1, 2$, and 2) a babbling equilibrium in which the principal takes $a_3$.

Game D has a very different prediction.\(^8\) If the principal delegates, the agent will take $a_1$ when his type is $t_1$ and $a_3$ when his type is $t_2$. Given the equal prior probabilities of $t_1$ and $t_2$, the principal’s expected payoff from delegation is 650.

If the principal chooses communication, the players enter into a communication subgame in which there is a unique babbling equilibrium with no information transmitted. To any message sent by the agent, there are in total seven candidate best responses that the principal can have: she can randomize among all three actions or any two of them, or she can take one of the actions with probability one. Any randomization with $a_1$ and $a_2$ in the support, however, cannot possibly be a best response, because the principal is indifferent between the two actions only if she believes that $t_1$ and $t_2$ are equally likely - in which case she strictly prefers $a_3$. And this rules out two candidates. Since $t_1$ agent strictly prefers $a_1$ to $a_3$ and $a_3$ to $a_2$, he strictly prefers one response in any pairwise comparison of the remaining five. 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 this to constitute an equilibrium, the other message must be sent exclusively by $t_2$ in which case the principal responds with $a_2$, the worst outcome.

\(^8\)Game D is an extracted version of “Game 4” in Blume et al. [6]. Their game is in turn a modified version of that in Myerson [37] (p.284). Part of our analysis below is adopted from Myerson [37].
for $t_2$. As such, neither will $t_2$ want to send this 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, yielding the principal an expected payoff of 500, is the pooling action $a_3$. Since choosing communication leads to a lower expected payoff, the principal in Game D prefers to delegate. We again summarize the analysis:

**Proposition 2.** In the unique equilibrium of Game D, the principal delegates to the agent her authority over the action. In the communication subgame off the equilibrium path, there exists a unique babbling equilibrium in which the principal takes action $a_3$.  

A remark about the structures of the game is in order. It may appear that there are two distinct differences between Game C and Game D - the presence/absence of the additional action $a_4$ and the alignment/misalignment of interests in the communication subgames - that interact to drive the different equilibrium predictions. Note, however, that the principal in Game C will never choose $a_4$ herself because it is strictly dominated by other actions. Accordingly, the degree of interest alignment is the only “variable” relevant for the two communication subgames, both of which have three relevant actions in place. As for the delegation decision, it is a result of comparison between two outcomes. While one side of the scale does involve the degree of interest alignment in communication, the other side involves what the agent will do in delegation. In respect of the latter, $a_4$ (for both $t_1$ and $t_2$) in Game C is no different from $a_1$ (for $t_1$) and $a_3$ (for $t_2$) in Game D: they are all actions that the delegated agent will take, carrying certain amount of payoff for the principal. Even though the presence of $a_4$ may make delegation dramatically worse in Game C, in terms of outcomes it is a quantitative not a qualitative distinction. Viewed in this light, the additional action in Game C does not create substantive asymmetry between the games.  

### 2.3 Experimental Hypotheses

Our experimental hypotheses focus on the delegation component of the games, although we shall also report findings from the communication subgames. The predictions in Propositions 1 and 2 regarding the choices between delegation and communication provide the basis for our first hypothesis. Since a hypothesis with point prediction will easily be refuted, we “weaken” the propositions in formulating the hypothesis. We take it as an evidence supporting the theoretical predictions if more equilibrium choices than non-equilibrium are observed:

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9Precisely, “uniqueness” here refers to the equilibrium outcome as there is always an inessential multiplicity of equilibria in cheap-talk games with different uses of messages supporting a given equilibrium outcome. A similar remark applies to Game C in which we use singular rather than plural for “equilibrium.”

10Indeed, the apparent asymmetry can be eliminated with no change to the strategic structures of the games by introducing a fourth action for Game D that carries payoff pairs (800, 800) under $t_1$ and (500, 500) under $t_2$. 

Hypothesis 1. In Game C, the observed frequency of communication is significantly higher than that of delegation. In Game D, the observed frequency of delegation is significantly higher than that of communication.

Our next hypothesis involves comparisons of the principals' payoffs:

Hypothesis 2. In Game C, the principals choosing communication have a higher expected payoff than have the principals choosing delegation. In Game D, the principals choosing delegation have a higher expected payoff than have the principals choosing communication.

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

3 Experimental Design

Game C and Game D share the same experimental procedures. We conduct four experimental sessions for each game. All the sessions are conducted at the Pittsburgh Experimental Economics Lab. Subjects are recruited from the undergraduate population of the University of Pittsburgh who have no prior experience in our experiment. The experiment is programmed and conducted with z-Tree (Fischbacher [26]).

Upon arrival at the lab, subjects are instructed to sit at separate computer terminals, and each receives a copy of the experimental instructions. The instructions are then explained aloud. A series of questions related to the instructions follows. The questions are reviewed after the subjects answer on their own. 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.

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). 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. With a view to imple-

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11To ensure dominance, during the experiment we avoid references to non-neutral languages. In this Section, for each major terminology that appears in the first time we shall state in parentheses the corresponding languages we use in the instructions. Refer to the Appendix B for a complete sample of the instructions (Game D).
menting a series of one-shot games dampening any reputational considerations, 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 to their paired agents the right to choose action. 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, chooses, in Game C, one of the four actions, $a_1$, $a_2$, $a_3$ or $a_4$ (\%, \#, *, or !), or, in Game D, one of the three, $a_1$, $a_2$ or $a_3$ (\% or # or *). 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, again 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. The message “$t_1$ or $t_2$” is provided so that if they so wish subjects have a clear option to conceal their types that does not entail outright lying. The instructions state that the agent’s message is “regarding the row of rewards for the current round” but make it clear that “regardless of which row the computer has chosen” the agent is “completely free in your choice of which message to send.” After the agent’s input, the message is revealed on the screen of the paired principal, who then chooses an 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. Subjects are explained this payment arrangement in the instructions.\(^\text{15}\)

\(^{12}\)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.

\(^{13}\)Exogenously meaningful messages provide focal points in communication. Since our focus is on the choice between delegation and communication, we use this design to avoid complications that may arise from subjects’ learning how to use and interpret meaningless messages. See Blume et al. [5],[6] for studies on the evolution of meanings of exogenously meaningless messages.

\(^{14}\)This represents an effort to partly remedy the potential confound of “lying aversion” (e.g., Sánchez-Pagés and Vorsatz [39] and Gneezy [29]), in which subjects are documented to have a preference for truth-telling even when it is against their monetary payoffs.

\(^{15}\)Each experimental session lasts for about 90 minutes, and subjects’ payments range from $11 to $23 with an average around $18. To avoid an extra layer of complexity in subjects’ understanding of the incentives, in our payment arrangement we do not use binary lotteries to induce risk neutrality (Roth and Malouf [45] and Berg et al. [4]). We believe that this does not affect the integrity of our study. Indeed, with the “safe” pooling action
4 Experimental Findings

4.1 Choices between Delegation and Communication

The observed choices between delegation and communication are supportive of Hypothesis 1. Table 1 provides a summary statistics of the frequencies of delegation and communication in the two games.\(^\text{16}\) Using the proportion of delegation as measuring unit, Table 2 and Figure 2 further provide breakdowns of these aggregate observations.\(^\text{17}\)

<table>
<thead>
<tr>
<th></th>
<th>Delegation</th>
<th>Communication</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Game C</td>
<td>28</td>
<td>1562</td>
<td>1,590</td>
</tr>
<tr>
<td>Game D</td>
<td>1,051</td>
<td>549</td>
<td>1,600</td>
</tr>
</tbody>
</table>

Our findings from Game C are highly consistent with the equilibrium prediction:

**Result 1.** In Game C, exceedingly more choices of communication than of delegation are observed. An average of 20% delegation occurs at the beginning, and it converges over rounds to almost all choices of communication. A temporary “restart effect” toward delegation is, however, observed when the subjects’ roles rotate between principal and agent.

In aggregate, only 2% delegation is observed in Game C when the equilibrium point prediction is 0%. The data in Table 2 are also representative of other rounds not reported: Round 1 in Session 1 is the only round in the whole game in which the proportion of delegation is as high as 40%; for the rest it never exceeds 20%, and the majority is no delegation at all. Not much learning is observed; subjects in the role of principal figure out early the optimal choice of communication and adhere to it. Yet we observe in Round 21 a small but obvious “restart effect” (Selten and Stoecker \([40]\)) when the subjects previously assuming the role of agents now play as principals. In three sessions, the proportions of delegation increase from 0% in Round...
Table 2: Proportions of Delegation

<table>
<thead>
<tr>
<th>Round</th>
<th>1</th>
<th>10</th>
<th>20</th>
<th>21</th>
<th>30</th>
<th>40</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Game C</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Session 1</td>
<td>0.4</td>
<td>0</td>
<td>0</td>
<td>0.2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Session 2</td>
<td>0.2</td>
<td>0</td>
<td>0</td>
<td>0.2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Session 3</td>
<td>0.1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.1</td>
</tr>
<tr>
<td>Session 4</td>
<td>0.1</td>
<td>0</td>
<td>0</td>
<td>0.1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Mean</td>
<td>0.2</td>
<td>0</td>
<td>0</td>
<td>0.13</td>
<td>0</td>
<td>0.03</td>
</tr>
<tr>
<td><strong>Game D</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Session 1</td>
<td>0.4</td>
<td>0.8</td>
<td>0.9</td>
<td>0.9</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Session 2</td>
<td>0.2</td>
<td>0.7</td>
<td>0.7</td>
<td>0.6</td>
<td>0.5</td>
<td>0.6</td>
</tr>
<tr>
<td>Session 3</td>
<td>0.4</td>
<td>0.6</td>
<td>0.6</td>
<td>0.6</td>
<td>0.6</td>
<td>1</td>
</tr>
<tr>
<td>Session 4</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.6</td>
<td>0.8</td>
<td>0.7</td>
</tr>
<tr>
<td>Mean</td>
<td>0.38</td>
<td>0.65</td>
<td>0.68</td>
<td>0.68</td>
<td>0.75</td>
<td>0.83</td>
</tr>
</tbody>
</table>

20 to 10 – 20% in Round 21. With one exception, all subjects in all rounds go back to choose communication starting from Round 23.

The findings from Game C are also consistent with the prediction, although we also observe non-negligible deviations from the equilibrium:

**Result 2.** *In Game D, there are significantly more choices of delegation than of communication. However, a non-negligible incidence of non-equilibrium retainment of decision-making authority is observed, especially in the initial rounds. The proportion of delegation increases over rounds, from slightly more choices of communication than of delegation at the beginning to an average of 80% delegation toward the final rounds.*

Overall a proportion of 66% is observed for delegation in Game D. In the first round of each session, the proportions range from 20% to 50%, and in aggregate it exceeds 50% after Round 7 and never goes back below. Using observations at the session level, the frequency of delegation is significantly higher than that of communication (the Wilcoxon signed-rank test renders $p = 0.0625$, the lowest $p$-value possible with four observations).\(^{18}\) The equilibrium point prediction is that the principal delegates with probability one. The observed play suggests that subjects do not choose the equilibrium play instantaneously - they learn over time to delegate (the Spearman rank-order coefficient between aggregated proportions of delegation and rounds

\(^{18}\)All our statistical tests use aggregated data from a session as an independent observation. While this has the disadvantage of reducing the power of the tests, it comes with the benefit of bypassing possible interdependence of play within a session. All the $p$-values we report are from one-tailed tests.
Apart from the within-game comparisons, the above findings also imply that there are significant differences across the games. Not surprisingly, the proportion of delegation is significantly higher in Game D than in Game C (the Mann-Whitney test renders $p = 0.01$). Perhaps more interestingly, there is also a significant difference in the proportions of equilibrium play (with respect to the choice between delegation and communication). While the observed play in both games is consistent with our theoretical predictions, the proportion of equilibrium play is significantly higher in Game C (the Mann-Whitney test renders $p = 0.01$).

### 4.2 Payoffs of Principals

We approximate expected payoffs of the principals with the average payoffs of all principal-subjects from all rounds in each session (Table 3).\footnote{Since the average payoffs are calculated conditioned on the delegation/communication choices, the payoffs are averaged over different numbers of observations in each session. Except for the payoffs from delegation in Game C in which we have only 28 observations for the whole game (Table 1), we have large enough observations}

![Graphs showing proportions of delegation in Games C and D](image-url)

- (a) Game C: Rounds 1-20
- (b) Game C: Rounds 21-40
- (c) Game D: Rounds 1-20
- (d) Game D: Rounds 21-40

Figure 2: Proportions of Delegation

is 0.94 with $p < 0.0001$). No obvious “restart effect” is observed.

Comparing the payoffs, we obtain the
following result confirming our Hypothesis 2:

**Result 3.** In Game C, the average payoffs of the principals choosing communication are significantly higher than those of the principals choosing delegation. In Game D, the average payoffs of the principals choosing delegation are significantly higher than those of the principals choosing communication.

<table>
<thead>
<tr>
<th>Table 3: Average Payoffs of the Principals</th>
</tr>
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<tbody>
<tr>
<td></td>
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<tr>
<td></td>
</tr>
<tr>
<td><strong>Delegation</strong></td>
</tr>
<tr>
<td>Game C</td>
</tr>
<tr>
<td>Session 1</td>
</tr>
<tr>
<td>Session 2</td>
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<tr>
<td>Session 3</td>
</tr>
<tr>
<td>Session 4</td>
</tr>
<tr>
<td>Mean</td>
</tr>
<tr>
<td>Game D</td>
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<tr>
<td>Session 1</td>
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<tr>
<td>Session 2</td>
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<tr>
<td>Session 3</td>
</tr>
<tr>
<td>Session 4</td>
</tr>
<tr>
<td>Mean</td>
</tr>
</tbody>
</table>

The principal-subjects in Game C choose communication presumably because they anticipate a higher payoff from communication than from delegation. Similarly, a higher payoff from delegation is expected in Game D. The observed payoffs off the equilibrium path provide an opportunity to compare such beliefs with “the reality.” And our findings suggest that, in aggregate, the forward-looking behaviors of the subjects are grounded on “correct” anticipations (for both games, the Wilcoxon signed-rank test on the respective directional differences of payoffs render the lowest possible \( p = 0.0625 \)).

In Game C, the observed payoffs from the on-equilibrium-path communication are very close to the equilibrium point prediction for the truth-telling equilibrium (an aggregated average in the other cases to reasonably approximate the uniform distribution of types. In the four sessions in Game D, 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 C under communication, the distributions are \((0.45, 0.55), (0.5, 0.5), (0.48, 0.52)\) and \((0.49, 0.51)\). Note that even for delegation in Game C, 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.

As we shall see in the next section, we draw a more refined, somewhat different conclusion for Game D when we look at individual subjects’ behavior.
of 773.1 vs. 800 predicted). In Game D, the observed payoffs from the on-equilibrium-path delegation are also strikingly close to the equilibrium point prediction (an aggregated average of 650.47 vs. 650 predicted).\footnote{In aggregate, delegated $t_1$ agents choose the predicted $a_1$ 100% of the time, and $t_2$ agents choose the predicted $a_3$ 96% of the time. The deviated action choices under $t_2$ together with the distributions of the types reported in fn.19 account for the slight deviations of the observed payoffs from the predicted.} Off the equilibrium paths, however, observed payoffs are in general higher than the predictions. In Game C, the observed payoffs when delegation is chosen are, except for one session, higher than the prediction (an aggregated average of 259.13 vs. 100 predicted).\footnote{In the total 28 instances of delegation in Game C (with 16 draws of $t_1$), $t_1$ agents choose $a_1$ and $a_4$, respectively, 12% and 88% of the time, and $t_2$ agents choose $a_2$ and $a_4$, respectively, 35% and 65% of the time. Note that in both cases, the choices are between the payoff cells (800, 800) and (1000, 100). Thus, the higher than predicted payoffs of the principals reflect the agents’ sacrifice of some payoffs for equality, echoing the findings from dictator games (e.g., Forsythe et al. [27]).} The same is true for the off-equilibrium-path communication in Game D (an aggregated average of 593.37 vs. 500 predicted).

The observed principals’ payoffs in communication provide indirect evidence that agent-subjects have a tendency to transmit information: when equilibrium prescribes truth-telling and babbling, they tell the truth; when equilibrium prescribes only babbling, they deviate from the equilibrium by revealing some information. We proceed to take a more direct look at the communication subgames.

### 4.3 Communication Subgames

Figure 3 presents the round-by-round variations, aggregated across sessions, of the proportions of observed play that are consistent with the equilibrium outcomes of the communication subgames. For the truth-telling outcomes in Game C, we present the proportions of the type-action pairs $(t_i, a_i)$, $i = 1, 2$; for the babbling outcomes in both games, we present the proportions of the pooling action $a_3$.

In Game C, among the eight type-action pairs, two are consistent with the truth-telling equilibrium and two with the babbling equilibrium. Thus, when types and actions are independent, the type-action pairs consistent with either equilibrium should be observed 25% of the time. Similarly, in Game D the proportion under independence is 33% for the unique babbling equilibrium. We take the proportion of the equilibrium type-action pairs in all 40 rounds in each session as an independent observation. In both Game C and Game D, we cannot reject the null hypothesis of independence in favor of the alternative hypothesis of babbling (the Wilcoxon signed-rank tests render, respectively, an extreme $p = 1$ and $p = 0.6875$). However, in Game C the null hypothesis of independence is rejected in favor of truth-telling (the Wilcoxon signed-rank test renders the lowest possible $p = 0.0625$).\footnote{Since the equilibrium predictions for the communication subgames are again nonstochastic, it is unlikely to
Figure 3: Proportions of Babbling and Truth-telling Outcomes in the Communication Subgames

As suggested by the documented principals’ payoffs, agents tend to transmit information. In Game C, we have a clear “equilibrium selection” in which subjects start coordinating over the Pareto-dominant truth-telling equilibrium early in the sessions. Despite the more noisy observations due to a relatively small sample conditioned on communication being chosen, in Game D we observe a decreasing trend in the proportion of the babbling outcomes (the Spearman rank-order coefficient between aggregated proportions and rounds is -0.67 with \( p < 0.0001 \)). Further looking into the associations between 1) types and messages, 2) messages and actions, and 3) types and actions in the communication subgame of Game D, we report in Figure 4 the proportions of these combinations aggregated over all rounds and then all sessions.\(^24\)

Over-transmission of information is documented in previous experimental studies of communication games (e.g., Blume et al. \([5],[6]\), Cai and Wang \([8]\), and Wang et al. \([46]\)).\(^25\) The same observe observations that are as sharp as the point predictions. We follow Blume et al. \([5],[6]\) in our statistical testing and consider it as an evidence in support of the equilibrium predictions when the observed proportion of a type of equilibrium outcomes exceeds that predicted by chance alone.\(^24\) As an illustration, for the proportion of the pair \((t_1, a_1)\), we first obtain the frequency of the pair observed in the communication subgames in all rounds of a session and divide it by the respective frequency of \(t_1\). We then average the proportions across sessions.\(^25\) Other experimental studies with communication as the major object of scrutiny or as an additional condition
Figure 4: Proportions of Type-Action, Type-Message, and Message-Action Pairs in the Communication Subgame of Game D

phenomenon is observed in our Game D. For the agents, types $t_1$ send “$t_1$” 97% of the time. Even with the clear incentive to be identified as $t_1$, 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 choices of $a_2$ than of the pooling $a_3$ are observed. 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 best outcomes 33% of the time (by taking $a_2$). These echo the findings that the principals’ average payoffs are higher than the predicted.26

for other games include, for example, Cooper et al. [10], Dickhaut et al. [20], and Duffy and Feltovich [22]. See also Crawford [13] for a survey.

26 As can be seen from the delegation decisions, Session 1 of Game C is exceptional from other sessions in which subjects appear to be better abided by equilibrium. The same is observed in the communication subgame. While types $t_1$ send “$t_1$” 96% of the time, we observe more uses of “$t_1$” by types $t_2$ (54%) and their uses of “$t_2$” drop to 18%. The principals are also less credulous: only 31% of the time they respond to “$t_1$” with $a_1$. And only 20% (36%) of the time the principals are able to receive the best outcome when the type is $t_1$ ($t_2$). These are consistent with the lower observed payoffs of the principals compared to other sessions of the game.
5 Level-

While our findings from Game D on the decision to delegate are largely consistent with the theoretical prediction, we also observe a non-negligible incidence of play in which delegation is not pursued. Given that equilibrium also fails to predict how subjects communicate, it may be worthwhile to explore if there are non-equilibrium models that can rationalize the observed deviations from equilibrium. In this section, we describe and evaluate a few level-

5.1 A Methodological Overview

Despite the consideration of both delegation and communication, we apply level-

27Although our focus is on Game D, our selected level-

28Games with communication are one type of games to which level-

29Crawford [14] is the first theoretical study of communication of intentions (pre-play communication) with level-


31Kawagoe and Takizawa [35] show that their level-

16
specification of $L_0$.

Given that there is no unique definition as to what count as “nonstrategic,” there is also no unique way of specifying the behavior of $L_0$. Our selection of a level-$k$ model for Game D, which in large part boils down to the specification of $L_0$, is guided by a common objective of level-$k$ analysis: to provide structures that restrict non-equilibrium behavior.\footnote{Perhaps because the level-$k$ paradigm has not fully passed the development stage, there is no definite consensus in the literature on the specification of $L_0$. In practice, the choices are usually among uniform randomness, attraction to salience or naivety (truthfulness or credulity). Crawford et al. \cite{17} point out, however, that consensus is emerging in particular applications and the specification needs to be adapted to the setting - which is reflected in our approach here.} This general guiding principle results in two practical criteria. First, we evaluate alternative models according to their predictive power of the qualitative behavior observed, in particular whether a model is populated by level types of principal with heterogeneous choices over delegation and communication. A stable distribution of level types emerges recurrently across studies. The empirical distributions typically concentrate on the three lowest types, with a higher frequency of $L_1$ than $L_2$ and a low or negligible frequency of $L_0$, sometimes in the proportion of roughly twice as many $L_1$ as $L_2$ (e.g., Camerer et al. \cite{9}, Costa-Gomes and Crawford \cite{11}, Crawford and Iriberri \cite{16}, and Blume et al. \cite{7}). Our second criterion leverages on these quantitative benchmarks: among the models that pass the first test, we further evaluate how well they provide structures that fit our data of individual subjects to the established level type distributions. As we shall show below, the qualitative and quantitative criteria together single out a suitable level-$k$ model for Game D.

\subsection{5.2 Specification of Level-$k$ Models}

As in most of the literature, we restrict attention to the three lowest level types. To evaluate specifications of $L_0$ that are reasonable in our setting, we start with both uniform randomness and naivety. A random agent randomizes uniformly over the messages, and a random principal over the actions. A naive agent reduces to a truthful agent who always reveals his type literally; a naive principal reduces to a credulous principal who expects to receive truthful messages and responds to a message at its literal meaning. The principal-agent combinations result in four possible level-$k$ models for Game D (Table 4). In all models, we assume that an $L_k$ player best responds to an $L_{k-1}$ opponent, $k = 1, 2$; thus, for example, an $L_1$ agent best responds to an $L_0$ principal, and an $L_2$ principal best responds to an $L_1$ agent.

Two aspects of our specifications depart from the common practices in the communication literature of level-$k$ analysis. Both the configurations of truthful-sender-random-receiver and truthful-sender-credulous-receiver, which correspond respectively to our Models N-R and N-N, have been adopted for $L_0$ (Crawford \cite{15} and Ellingsen and Östling \cite{23} for the former; Crawford...
Table 4: Specifications of $L_0$ and Level-$k$ Models

<table>
<thead>
<tr>
<th></th>
<th>Random $L_0$ Principal</th>
<th>Naive (Credulous) $L_0$ Principal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Random $L_0$ Agent</td>
<td>Model R-R</td>
<td>Model R-N</td>
</tr>
<tr>
<td>Naive (Truthful) $L_0$ Agent</td>
<td>Model N-R</td>
<td>Model N-N</td>
</tr>
</tbody>
</table>

[14], Cai and Wang [8], and Wang et al. [46] for the latter). Our introduction of a random agent (sender) represents a new addition to this literature, and it turns out that it would be necessitated by the consideration of predictive power.\(^{30}\) Our numbering of the level types represents another departure from Crawford [14], Cai and Wang [8], and Wang et al. [46], who assume that an $L_k$ receiver best responds to an $L_k$ sender (while an $L_k$ sender best responds to an $L_{k-1}$ receiver). Our convention is, however, commonly adopted in the larger literature of level-$k$ analysis.\(^{31}\)

We adopt three other auxiliary assumptions that apply to all four models. Given that the delegation decision itself involves minimal strategic thinking (Section 5.1), we assume that all level types of principal - including the $L_0$ - can correctly foresee what a (payoff-maximizing) delegated agent will do, in effect assuming that they all assign an expected payoff of 650 to the choice of delegation. In case of off-path events, which happens when 1) an $L_k$ agent sends message to a delegating $L_{k-1}$ principal, or 2) an $L_k$ principal receives a message that is not sent by any private type of an $L_{k-1}$ agent, we assume that 1) the agent behaves the same as the next lower level agent, and 2) the principal chooses action under the prior belief.\(^{32}\)

\(^{30}\)Random $L_0$ is nevertheless the usual assumption for normal-form games, to which level-$k$ analysis is first applied. For games with communication, Crawford et al. [17], for example, argue that a random $L_0$ could be rather unnatural, especially when the communication is conducted in a commonly understood language. The argument is sometimes reinforced by the consideration of predictive power; in Crawford [15], for example, it is noted that if uniform randomness was assumed for $L_0$ there would be no effective pre-play communication, rendering the level-$k$ analysis superfluous and devoid of any power to restrict behavior. In our setting, on the contrary, the same attention to predictive power calls for the inclusion of random $L_0$ agent.

\(^{31}\)In recounting the analysis in Crawford [14], Crawford et al. [17] renumber the types to conform to the common practice. They also point out that the numbering is partly a semantic issue. In our setting, adopting the different numbering convention results in analysis that is essentially covered by Models N-N and R-R.

\(^{32}\)What action the principal chooses after receiving off-path messages has no effect on her evaluation of the communication outcome. Thus, adopting alternative assumption here will not affect the analysis on delegation decision (see also fn. 34). For the agent’s off-path events, a reasonable alternative will be to assume that the agent believes that the principal has entered the subgame by tremble. As can be inferred below, however, this assumption makes necessary another assumption on how the agent breaks the indifference between messages. The major analytical conclusions under our simpler assumption would have remained unchanged if we had assumed tremble and broken the indifference with, for example, a lexicographic preference for honesty (e.g., Ellingsen and Östling [23]). A downside of our assumption is that whenever delegation is chosen, there will be two level types of agent behaving in the exact same manner, which sacrifices the resulting models’ identification power in terms of agent’s behavior. Yet any alternative assumption that gives rise to finer identification will necessarily be directly due to assumption. Together with the fact that our focus is on the delegation decision and thus the principal’s
We derive the predicted behavior in each model under the respective specification of $L_0$. Applying the qualitative criterion, our first finding is that Model N-N and Model R-R are ruled out as suitable level-$k$ models for Game D: in both models all three level types of principal make homogeneous delegation decisions, choosing communication in the former and delegation in the latter. Model R-N and Model N-R, on the other hand, feature some level types with heterogeneous decisions. Table 5 summarizes the predictions of Models R-N and N-R that we further explore, and we leave the analysis of the two ruled-out models to Appendix A.

Table 5: Level-$k$ Predictions for Game D

<table>
<thead>
<tr>
<th>Model R-N</th>
<th>Agent’s Strategy</th>
<th>Principal’s Strategy</th>
<th>Delegation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$t_1$</td>
<td>“$t_1$”</td>
<td></td>
</tr>
<tr>
<td>$L_0$</td>
<td>random</td>
<td>$a_1$</td>
<td>✓</td>
</tr>
<tr>
<td>$L_1$</td>
<td>“$t_1$”</td>
<td>$a_2$</td>
<td></td>
</tr>
<tr>
<td>$L_2$</td>
<td>“$t_1$”</td>
<td>$a_3$</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Model N-R</th>
<th>Agent’s Strategy</th>
<th>Principal’s Strategy</th>
<th>Delegation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$t_1$</td>
<td>“$t_1$”</td>
<td></td>
</tr>
<tr>
<td>$L_0$</td>
<td>“$t_1$”</td>
<td>random</td>
<td>✓</td>
</tr>
<tr>
<td>$L_1$</td>
<td>“$t_1$”</td>
<td>$a_2$</td>
<td></td>
</tr>
<tr>
<td>$L_2$</td>
<td>“$t_1$”</td>
<td>$a_3$</td>
<td></td>
</tr>
</tbody>
</table>

In Model R-N, an $L_0$ principal, believing in literal meanings, takes action $a_1$ after message “$t_1$”, $a_2$ after “$t_2$”, and $a_3$ after “$t_1$ or $t_2$”. Expecting to receive only truthful messages, she does not expect to see “$t_1$ or $t_2$” when evaluating the communication outcome. She thus anticipates to obtain therefrom a payoff of 800. Comparing it with the expected payoff of 650 from delegation, an $L_0$ principal chooses communication. Playing a best response to a random $L_0$ agent, an $L_1$ principal takes the pooling action $a_3$ regardless of which message is received and expects to receive 500 from communication. With a higher payoff from delegation, an $L_1$ principal chooses delegation. An $L_1$ agent, best responding to an $L_0$ principal, sends message “$t_1$” when he is of $t_1$ and “$t_1$ or $t_2$” when he is of $t_2$. An $L_2$ principal best responds accordingly by taking action $a_1$ after “$t_1$”, $a_2$ after “$t_1$ or $t_2$”, and, invoking the assumption for off-path events, $a_3$ after “$t_2$”. Since “$t_2$” is not expected to be received, the payoff from communication is 800 for an $L_2$ principal, leading her to choose communication. Note finally that an $L_2$ agent expects not to be called upon to move because an $L_1$ principal chooses delegation; the off-path assumption dictates that an $L_2$ agent best responds to an $L_0$ principal like an $L_1$ agent does.

behavior, the simplicity embodied in our assumption is achieved with a relatively small cost.
In Model N-R, a random $L_0$ principal obtains, under any beliefs about the agent’s private type, $\frac{1400}{3}$ from communication, which is lower than the 650 from delegation. The choice of a random principal is thus delegation. Best responding to a truthful $L_0$ agent, an $L_1$ principal takes $a_1$ after “$t_1$”, $a_2$ after “$t_2$”, and, under the off-path assumption, $a_3$ after “$t_1$ or $t_2$”. With a payoff of 800, an $L_1$ principal then chooses communication. Since an $L_1$ agent sends message only in an off-path event, she is assumed to be truthful just like an $L_0$ agent. Accordingly, an $L_2$ principal also responds the same as an $L_1$ principal. Finally, in response to an $L_1$ principal, an $L_2$ agent sends “$t_1$” for $t_1$ and “$t_1$ or $t_2$” for $t_2$.

### 5.3 Level Type Classification of Individual Subjects

Both Model R-N and Model N-R pass our first criterion by generating predictions that are consistent with the qualitative features of our observations: delegation is chosen but with non-negligible choices of communication, and the agent does not babble. We further evaluate the models quantitatively by fitting them with individual subject data. We classify each subject into one of the level types of the corresponding model and evaluate the resulting distribution in light of the empirical benchmarks. Since each subject assumes two roles and our focus is on the delegation decision, we use a subject’s behavior as principal for the classifications. We adopt a lexicographic classification methodology: we classify a subject by first looking at his or her delegation decisions; if we are unable to pin down a particular level type with the delegation decisions alone, we look next at how the subject responds to messages in the communication subgames.

In both models, the decision to delegate identifies one level type out of three. In the first round of classification, we type a subject as $L_0$ for Model N-R and $L_1$ for Model R-N if and only if out of the 20 delegation decisions, the subject makes 12 (60%) or more choices of delegation.\(^{33}\) It turns out that the first round suffices for us to select between Models N-R and R-N. The proportions of subjects making 12 or more choices of delegation range from 45% in one session to 90% in another, which means that Model N-R would have at least 45% of $L_0$. Given the low frequencies of $L_0$ commonly documented, Model N-R fits the data with too high a proportion of $L_0$, and this rules it out as a suitable level-$k$ model for Game D. On the other hand, the proportions are more reasonable for $L_1$, suggesting that Model R-N is providing a better fit. We focus on it from now on.

With $L_1$ pinned down for Model N-R in the first round of classification using the delegation

\(^{33}\)A 60% rule is adopted by Cai and Wang [8]. Wang et al. [46] adopt the more sophisticated “spike-logit” estimation used in Costa-Gomes and Crawford [11] and find no substantial difference with the more primitive rule. Given that our classification is based on a simple binary variable, we use the more parsimonious approach. The major conclusions of our analysis will be robust to deviations from the 60% rule (see fn. 34).
decisions, we proceed to the second round for \( L_0 \) and \( L_2 \). We look at how subjects with less than 12 choices of delegation respond to messages “\( t_2 \)” and “\( t_1 \) or \( t_2 \)” in the communication subgames, which allows us to distinguish between the two remaining level types. There are six message-action pairs, and we classify them into three categories: (“\( t_2 \), \( a_2 \)” and (“\( t_1 \) or \( t_2 \), \( a_3 \)” are consistent with \( L_0 \), (“\( t_2 \), \( a_3 \)” and (“\( t_1 \) or \( t_2 \), \( a_2 \)” with \( L_2 \), and (“\( t_2 \), \( a_1 \)” and (“\( t_1 \) or \( t_2 \), \( a_1 \)” contain no information for the purpose. For each subject not typed in the first round, we count the number of observations in each category. We then classify a subject as \( L_k \), \( k = 0, 2 \), if and only if the corresponding category contains observations that constitute at least 50% of all observations. Otherwise, we consider the subject as untyped. If there is a tie between \( L_0 \) and \( L_2 \) right at 50%, we adopt a tie-breaking rule in favor of \( L_0 \).

Table 6: Empirical Distribution of Level Types under Model R-N

<table>
<thead>
<tr>
<th></th>
<th>Proportion of ( L_0 ) Principals</th>
<th>Proportion of ( L_1 ) Principals</th>
<th>Proportion of ( L_2 ) Principals</th>
<th>Proportion of Untyped Principals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Session 1</td>
<td>0</td>
<td>0.9</td>
<td>0.1</td>
<td>0</td>
</tr>
<tr>
<td>Session 2</td>
<td>0.25</td>
<td>0.45</td>
<td>0.25</td>
<td>0.05</td>
</tr>
<tr>
<td>Session 3</td>
<td>0.2</td>
<td>0.7</td>
<td>0.2</td>
<td>0</td>
</tr>
<tr>
<td>Session 4</td>
<td>0.25</td>
<td>0.55</td>
<td>0.2</td>
<td>0</td>
</tr>
<tr>
<td>All Sessions</td>
<td>0.18</td>
<td>0.65</td>
<td>0.16</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Table 6 reports our complete classification results for the selected Model R-N. We are able to type all 80 subjects except one, with the tie-breaking rule deployed for four subjects. Consistent with previous findings, \( L_1 \) has the highest proportion. On average, after diluting the rather exceptional data from Session 1, 65% of the subjects are typed as \( L_1 \). Note that this is consistent with the findings of roughly twice as many \( L_1 \) as \( L_2 \) coupled with a negligible proportion of \( L_0 \), which implies that there should be close to \( \frac{2}{3} \) of \( L_1 \). Yet we do observe a non-negligible proportion of \( L_0 \). Correspondingly, we have a lower proportion of \( L_2 \), and in aggregate the number of \( L_2 \) falls short of being \( \frac{1}{2} \) of that of \( L_1 \). With lower-than-average proportions of \( L_1 \) in Sessions 2 and 4, however, the two-to-one ratio between \( L_1 \) and \( L_2 \) is roughly borne out in the individual sessions.

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34 The average percentages of delegation of \( L_0 \), \( L_1 \) and \( L_2 \) are, respectively, 22.85%, 90.6% and 13.1%; the proportions of \( L_1 \) would not have changed much had we adopted alternative cutoffs in the neighborhood of 60%. In the classification between \( L_0 \) and \( L_2 \), we count the pair (“\( t_2 \), \( a_3 \)” toward \( L_2 \), which is based on the off-path assumption that the principal will use the prior. If we had also allowed the literal-meaning-responding (“\( t_2 \), \( a_2 \)” as a possible pair from \( L_2 \) and move it to the category of providing no information (since then it would have been no longer exclusive from \( L_0 \)), our results would have been the same except for additional seven untyped subjects.

35 A non-negligible proportion of \( L_0 \), though non-typical, is not unprecedent. Blume et al. [7], for example, document on average 17% of \( L_0 \) which is very close to our 18%. Note also that our classification between \( L_0 \) and \( L_2 \) is based on a relatively small set of observations contingent on communication being chosen. We thus expect to see a higher noise component in this part of the results.

36 Even though predicted agent’s behavior does not allow a complete identification among the level types,
5.4 Interpretation and Discussion

Our qualitative and quantitative criteria together select Model R-N as the right \( k \)-level model for Game D, which provides a theoretical structure for us to interpret observed behavior. The choices of delegation by \( L_1 \) principals could be viewed as a response to strategic uncertainty manifested in a belief that the agent is acting randomly - not sure about what their partner will tell in communication, \( L_1 \) subjects choose delegation where behavior is more predictable. On the other hand, the choices of communication by \( L_0 \) and \( L_2 \) principals, whom together account for 34% of our subjects, are based on the belief that information will be transmitted in the communication subgame. The model predicts, for example, that both \( L_0 \) and \( L_2 \) principals respond to “\( t_1 \)” with action \( a_1 \), the best response when the literal meaning of the message is taken. In the empirical counterpart, subjects typed as \( L_0/L_2 \) respond with \( a_1 \) 79% of the time when “\( t_1 \)” is received with 59% of them always responding with \( a_1 \). Even though we do not observe subjects’ beliefs, we infer from their responses - themselves consequences of beliefs - that they anticipate their partner to transmit information. This provides a link between the under-delegation and the over-transmission of information: \( L_0 \) and \( L_2 \) subjects choose not to delegate because they anticipate transmission of information in the communication subgame; such belief is in turn consistent with the actual play as reported in Section 4.3.

There may be other plausible explanations for the phenomena of under-delegation and/or over-transmission of information. In the following, without aiming for a comprehensive survey, we comment on a few natural alternatives. We first revisit the equilibrium predictions. The behavior of an \( L_1 \) principal, i.e., choosing delegation, is the same as that of a fully rational, strategic principal making equilibrium choice. Thus, one can equally argue, given the classification results above, that we have \( \frac{2}{3} \) of the subjects playing according to the equilibrium. This raises the question of which model, equilibrium or non-equilibrium, can better explain our data. For the equilibrium argument, we may conclude that there is a high proportion of players understanding the equilibrium. To the extent that a fraction of roughly \( \frac{2}{3} \) of \( L_1 \) is part of the whole level-\( k \) package recurringly supported by empirical evidence, we, however, contend that the non-equilibrium model offers sharper predictions of our data. With the flexibility allowed by non-

there are differences between the behavior of \( L_0 \) and \( L_1/L_2 \). It might be of interest to exploit these differences and see if any peripheral support can be obtained for our classification results by looking at subjects’ behavior as agent. Focusing on messages sent after \( t_2 \) because those sent after \( t_1 \) are overwhelmingly “\( t_1 \)”, we find that the distributions over messages, “\( t_1 \)”, “\( t_2 \)” and “\( t_1 \) or \( t_2 \)”, are \((0.26, 0.36, 0.38)\) for subjects classified as \( L_0 \), \((0.36, 0.22, 0.42)\) for \( L_1 \), and \((0.27, 0.29, 0.44)\) for \( L_2 \). The distribution of \( L_0 \) is arguably more uniform than others’, and those of \( L_1 \) and \( L_2 \) have distinctive higher weight on the predicted “\( t_1 \) or \( t_2 \)”. While we make no pretense that this is a strong finding, as peripheral evidence it fits in the overall picture.

\(^{37}\)It might be of interest to also look at how \( L_1 \) subjects respond to “\( t_1 \)” in the rounds in which they choose communication so as to infer their beliefs on the agents’ strategies. However, the \( L_1 \) subjects make, on average, only 1.88 (out of 20) choices of communication. Furthering conditioning on the receipts of “\( t_1 \)”, we are left with too few data for a meaningful analysis.
equilibrium or behavior models, one may argue that it is inevitable that they will perform better. Even so, the non-equilibrium approach “pays for itself” with a better fit, and the failures of the other level-k models in meeting our model-selecting criteria suggest that it is indeed conceivable to be otherwise.

An alternative approach that retains equilibrium as the solution concept is to consider it in a behavioral model. In our setting, it is natural to consider a model in which with probability $0 < \lambda < 1$ the agent is mechanically truthful and with probability $1 - \lambda$ the agent remains strategic. By evaluating the communication subgame alone, however, one can find that the observed behavior cannot be consistent with equilibrium behavior of this model. Motivated by our aggregate findings on message uses, consider the following strategy for the strategic agent, which, in a model without behavioral agent, does not constitute an equilibrium: 1) $t_1$ sends “$t_1$” with probability one (the left half in Figure 4(b)), and 2) $t_2$ randomizes with at least “$t_1$” and “$t_1$ or $t_2$” in the support so that “$t_2$” may be sent solely by the mechanical $t_2$ (the right half in Figure 4(b)). Since both “$t_2$” and “$t_1$ or $t_2$” are sent exclusively by $t_2$, mechanical or strategic, the principal’s best response is $a_2$. On the other hand, $a_2$ can never be a best response to “$t_1$”.

For $a_2$ to dominate both $a_1$ and $a_3$, the principal’s belief has to put a weight of at least $\frac{4}{7}$ on $t_2$. Since $t_1$, mechanical and strategic, sends “$t_1$” with probability one, the principal’s probability assessment for $t_2$ will never exceed $\frac{1}{2}$ under the uniform prior. The principal’s best response is, depending on the value of $\lambda$, either $a_1$ or $a_3$. Since “$t_1$” and “$t_1$ or $t_2$” induce distinct actions, $t_2$ will not want to randomize over them; the presence of behavioral agent does not turn the strategy into an equilibrium one. An alternative strategy with both strategic private types randomizing over (only) “$t_1$” and “$t_1$ or $t_2$” does constitute an equilibrium under certain values of $\lambda$. However, this will imply that the principal’s responses to the two messages have to be the same, and this is inconsistent with the observed action choices (Figure 4(c)).

Another non-equilibrium type of decision rule that is sometimes considered alongside the cognitive-hierarchy types of level-k models is the so-called sophisticated type (e.g., Costa-Gomes et al. [12] and Costa-Gomes and Crawford [11]). Posited to best respond to the probability distribution of opponents’ behavior that may deviate from equilibrium, the decision rule is usually operationalized by using observed frequencies as proxy for the distribution of behavior. To demonstrate the relevance of sophisticated behavior to our observations, we focus on aggregate behavior in the 20 rounds after role rotation; we examine the principals’ aggregate responses in the second 10 rounds to the agents’ distributions of behavior in the first.\footnote{Analysis using aggregate data from the first 20 rounds or all 40 rounds gives similar conclusions (the latter, bypassing the idea of players responding to previously observed behavior, can easily be seen from the results reported in Section 4.3). And to bring out the essence of the analysis as concisely as possible, we, unlike Costa-Gomes et al. [12] and Costa-Gomes and Crawford [11], do not type individual subjects as is done in our level-k analysis.} In Round 21 – 30, the distributions over messages, “$t_1$”, “$t_2$” and “$t_1$ or $t_2$”, in communication are $(1, 0, 0)$ for $t_1$ and...
(0.36, 0.18, 0.46) for \(t_2\); the distributions over actions, \(a_1\), \(a_2\) and \(a_3\), in delegation are (1, 0, 0) for \(t_1\) and (0.01, 0.03, 0.96) for \(t_2\). Using these observed frequencies as inputs for predicting behavior, we first note that in communication a sophisticated principal responds to “\(t_1\)” with \(a_1\) and to both “\(t_2\)” and “\(t_1\) or \(t_2\)” with \(a_2\). Combined with the uniform prior, the above gives an expected payoff of 675.68 for choosing communication. On the other hand, the distributions over actions yield an expected payoff of 651.52 for delegation; a sophisticated principal therefore chooses communication. Note that, while the decisions of a sophisticated player are backed by understanding of others’ decisions that transcends the simple, mechanic rules of the cognitive-hierarchy types, in our setting the behavior of a sophisticated principal resembles that of our \(L_2\) (and \(L_0\)) principal.

Turning to the principals’ observed behavior, the aggregate proportion of delegation in Round 31 – 40 is 78%, and the distributions over actions in communication are (0.65, 0.25, 0.1) after “\(t_1\)”, (0, 0.69, 0.31) after “\(t_2\)”, and (0, 0.75, 0.25) after “\(t_1\) or \(t_2\)”. The observed action choices are largely consistent with the predicted responses to messages, but the proportion of delegation is too high to be consistent with the sophisticated decision to communicate. More importantly, the sophisticated decision rule, when considered alone, is not equipped to cater for the heterogeneous choices over delegation and communication - in terms of providing a structure for our observed behavior it is similar to our level-\(k\) model deprived of \(L_1\). We therefore consider it as complementary to but less complete than our level-\(k\) model.

Finally, in their experimental study of the authority model of Aghion and Tirole [1], Fehr et al. [24] also observe a tendency for subjects to retain authority, and they attribute it to subjects putting value on the authority itself, i.e., individuals cling to “power.” While we do not rule out that such psychological motive may also play a role among our subjects, we contend that it cannot be the major explanation for our findings.\(^\text{39}\) If the subjects’ value for authority was the major force at work, we would expect the proportions of delegation to be more stable over rounds rather than exhibiting an increasing trend (Figure 2(c)-(d)). It is more plausible that such trend reflects an increase in strategic maturity over rounds and after role rotation rather than a systematic decrease in subjects’ value for authority as they proceed along.

6 Concluding Remarks

In this paper, we report experimental findings from two delegation-communication games played by a principal and an agent. The principal faces the option of fully delegating to the agent or obtaining information from the agent to decide what action to take. In one game, Game C, a

\(^{39}\text{Dominguez-Martinez et al. [21] also observe under-delegation, and they relate it to the verifiability of information provided by the agent which is not relevant to our design.}\)
fully rational agent has an incentive to truthfully reveal his information. Such communication outcome provides a higher expected payoff to the principal than what she will receive from delegation. The observed play is highly consistent with the equilibrium prediction: almost all principal-subjects choose communication, and agent-subjects reveal all their information. In another game, Game D, a fully rational agent has no incentive to reveal his information, and the principal is better off if she delegates. While we do observe significantly more choices of delegation, communication is chosen in non-negligible proportion. And when communication is chosen, agent-subjects reveal information despite the equilibrium-prescribed babbling. We specify a level-\(k\) model that allows us to structuralize the non-equilibrium behavior observed in this game.

The level-\(k\) approach, developed to study players’ initial responses to novel games, focuses on introspective thinking rather than learning from external feedbacks. This is reflected in our analysis in which we classify subjects using their average behavior over rounds, thus excluding information about how their behavior evolves which may be due to learning. Strategic thinking and learning could, however, be complementary. In experimental research, subjects typically participate in repetitions of games. Even when the games are novel to them, the repetitions allow the subjects to accumulate experience and learn from it. In our Game D, we observe, for example, cases where subjects start off with choosing communication and switch to delegation after obtaining the lowest possible payoff of 100. If these subjects’ initial responses are shaped by beliefs that their opponents are non-strategic, the very bad outcomes from communication should provide evidence suggesting otherwise. Could this be amenable to a level-\(k\) model augmented with learning in which players enter the game with initial model about their opponents (e.g., they are naive) and reconsider it upon certain events during the course of the interactions?\(^{40}\) Could the potential increase in strategic maturity behind the increasing trend of delegation choices, which our level-\(k\) analysis does not directly address, be viewed as upgrades in level types? To address these issues one needs a dynamic theory of how the cognitive-hierarchy types evolve and what trigger it. We believe that this could be an important area for future research.

Another future research area that is more closely tied to our subject matter of delegation is about the form in which it occurs. While our study focuses on the choice between full delegation and communication as in Dessein [19], to the best of our knowledge restricting the delegated agent’s choices as in the optimal delegation tradition of Holmstrom [31],[32] has yet to be addressed experimentally. Our current design could be modified, for example, by giving the delegating principal an option to “sign off.” How this compares empirically with communication or an alternative design in which the principal commits to a decision rule ex-ante could be interesting questions for experimental research. We have begun to explore along these directions.

\(^{40}\)A similar idea could be found in the rule learning models of Stahl [41],[42].
Appendix A - Level-\(k\) Models R-R and N-N

In this appendix, we present the analysis of the two level-\(k\) models ruled out under our qualitative criterion. Table A1 summarizes the predictions of the models.

Table A1: Level-\(k\) Predictions for Game D

<table>
<thead>
<tr>
<th>Model N-N</th>
<th>Agent’s Strategy</th>
<th>Principal’s Strategy</th>
<th>Delegation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(t_1)</td>
<td>(t_2)</td>
<td>“(t_1)”</td>
</tr>
<tr>
<td>(L_0)</td>
<td>“(t_1)”</td>
<td>“(t_2)”</td>
<td>(a_1)</td>
</tr>
<tr>
<td>(L_1)</td>
<td>“(t_1)”</td>
<td>“(t_1) or (t_2)”</td>
<td>(a_1)</td>
</tr>
<tr>
<td>(L_2)</td>
<td>“(t_1)”</td>
<td>“(t_1) or (t_2)”</td>
<td>(a_1)</td>
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</tbody>
</table>

<table>
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<tr>
<th>Model R-R</th>
<th>Agent’s Strategy</th>
<th>Principal’s Strategy</th>
<th>Delegation</th>
</tr>
</thead>
<tbody>
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<td></td>
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<td>(t_2)</td>
<td>“(t_1)”</td>
</tr>
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<td>random</td>
<td>random</td>
</tr>
<tr>
<td>(L_1)</td>
<td>random</td>
<td>random</td>
<td>(a_3)</td>
</tr>
<tr>
<td>(L_2)</td>
<td>random</td>
<td>random</td>
<td>(a_3)</td>
</tr>
</tbody>
</table>

In Model N-N, a credulous \(L_0\) principal, same as that in Model R-N, takes \(a_1\) after “\(t_1\)”, \(a_2\) after “\(t_2\)”, and \(a_3\) after “\(t_1\) or \(t_2\)” and chooses communication. Best responding to a truthful \(L_0\) agent and following the off-path assumption, an \(L_1\) principal behaves exactly the same as an \(L_0\) principal. An \(L_1\) agent, best responding to a credulous \(L_0\) principal, sends “\(t_1\)” after \(t_1\) and “\(t_1\) or \(t_2\)” after \(t_2\). An \(L_2\) principal in turn best responds by taking \(a_1\) after “\(t_1\)”, \(a_2\) after “\(t_1\) or \(t_2\)”, and, using the off-path assumption, \(a_3\) after “\(t_2\)”. Anticipating to obtain 800 from communication, an \(L_2\) principal also does not choose delegation. Finally, the same behavior of an \(L_0\) and an \(L_1\) principals implies that an \(L_2\) agent behaves the same as an \(L_1\) agent.

Among the four models, Model R-R is the one that offers the least amount of structure to restrict behavior, and its analysis is rather trivial. Starting from a random \(L_0\) principal, who is the same as that in Model N-R, delegation is chosen at the lowest level of the hierarchy. Since then an \(L_1\) agent sends messages only in an off-path event, he is assumed to be random like an \(L_0\) agent. This implies that the behavior of an \(L_1\) and an \(L_2\) principal will be the same, which is to choose delegation given that the pooling \(a_3\) will be taken after communicating with a random agent. This further implies that an \(L_2\) agent will also send messages only in an off-path event and is therefore reduced to a random \(L_1\).
Appendix B - Instruction for Game D

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, {$}, {@[email protected]}, or {$ 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: {$}, {@[email protected]}, or {$ 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 B1: Reward Profile
References


