Instability of Babbling Equilibria in Cheap Talk Games: Some Experimental Results*

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Abstract

This paper reports some experimental results on plays in cheap talk games with private information (sender-receiver games). We experimented with three cheap talk games with different payoff characteristics. We find high frequency of, and quick convergence to, separating equilibrium play when the game had separating equilibria. However, in a game with only babbling equilibria, we find that the frequency of equilibrium play is very low and there is no tendency of convergence to the babbling equlibria. The paper compares the performance of several variants of the AQRE model in explaining this phenomenon. The model in which players randomize between a logit AQRE and a quasi-separating play outperforms the other models for explaining the phenomenon. It seems that the players seek coordination even in the situation where coordination is in disequilibrium.

1 Introduction

This paper presents some experimental results on plays in cheap talk games with private information, and attempts to explain the reason for the anomalous results found in this experiment. Since cheap-talk situation is pervasive throughout our life, cheap talk games have received much attention in game theory. There are two kinds of games that are named cheap talk game: cheap talk game with complete information and cheap talk game with

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incomplete information. In the former, we are concerned with whether players' intention of succeeding play of a game can be correctly conveyed in preplay communication. In the latter, the question is studied whether players' private information can be conveyed correctly through cheap talks. In both cases, cheap talk games are known to be plagued by multiplicity. That is, there always exist babbling equilibria where cheap talks are totally uninformative, while informative communication seems to be frequently observed in our daily life.

Thus, most of the works on cheap talk games with incomplete information, whether theoretical or experimental, has focused attention on how to justify the informative separating equilibria. On the theoretical front, evolutionary game theorists find that separating equilibria evolve when both players' interests coincide. On the experimental front, as is surveyed by Crawford [8], most works have shown that good convergence to the separating equilibrium play is observed in laboratory in games where both players' interests coincide.

This paper also provides experimental results on cheap talks. We experimented with three cheap talk games with different payoff characteristics: The two out of them have separating equilibria and the other has only babbling equilibria. Consistently with the existing literature, we find high frequency of, and quick convergence to, separating equilibrium play when the game had separating equilibria. However, in a game with only babbling equilibria, we find that the frequency of equilibrium play is very low and there is no tendency of convergence to the babbling equlibria. More interestingly, players seem to play according to strategies in separating equilibria, although they do not constitute an equilibrium in reality.

The latter result is of interest in two respects. For one thing, this is anomalous in that players do not choose among the set of Nash equilibria of the underlying game. This led us to examining how well the QRE model of noisy equilibrium fares to explain our experimental data. Second, the result seems to shed some light on the cause of separating equilibrium play in cheap talk games. We can regard observed plays of a game as a joint product of a game form, payoff functions, and players' strategies. Our experimental result suggests that the plays of separating equilibria may well be attribuable to the game form of cheap talk game and players' perception of the game form, rather than a specific form of payoff functions. Players may have an intrinsic propensity to take the opponent's message at its face value and to attempt to coordinate using the message.

2 Theory and Hypotheses

2.1 Games and Equilibria

We consider cheap talk games with private information where a sender sends a payoff-irrelevant message about his type (private information) to a receiver and the receiver takes a payoff-relevant action. The type space for the sender is $T = \{A, B\}$ and the prior probability for the sender to be type A or B is 1/2. The sender's message space is $M = \{$"I am type A", "I am type B"$\}$. The receiver, observing the sender's message but not knowing his true type, chooses from her action space $D = \{A, B, C\}$. Then the payoffs for both players are determined according to the combination of sender's true type and receiver's action. The game is called a cheap talk game, because the message sent by

Game 1

		action		
		A	B	C
type	A	4, 4	1, 1	3, 3
	B	1, 1	4, 4	3, 3

Game 2

		action		
		A	B	C
type	A	3, 4	2, 1	4, 3
	B	2, 1	3, 4	4, 3

Game 3

		action		
		A	B	C
type	A	4, 4	1, 1	2, 3
	B	3, 1	2, 4	4, 3

Table 1: Sender-Receiver Game Payoff

the sender does not affect the payoffs for either player. In what follows, we restrict our attention to only pure strategy equilibria.

Table 1 show the payoffs of games we used in the experiment. They are called Game 1, 2, 3 respectively. In Game 1, both players' interests perfectly coincide and there exist two kinds of perfect Bayesian Nash equilibria; separating equilibria and babbling equilibria. Game 2 also has two kinds of perfect Bayesian Nash equilibria which are the same as in Game 1. However both players' interests do not perfectly coincide in this game. Game 3 has only babbling equilibria[1].

To see the difference of these games more clearly, it is convenient to place them within the framework set by Crawford and Sobel [7], where the alignment of preferences can be expressed by a single parameter. In their model, sender types are drawn from the unit interval and the sender's and receiver's preferences over actions are concave. More specifically, the payoff to a sender of type t from action a is $-(a-(t+b))^2$ and the receiver's payoff is $-(a-t)^2$, where the alignment of preferences is measured by the parameter b. The receiver wants to choose action that is equal to the sender's type, while the sender may want the receiver to take an action that equals to the sum of his type and b. Following Blume et al. [4], suppose that b is type dependent. We discretize the type spece such that $t = 1/4$ for typa A and $t = 3/4$ for type B. Then, Game 1, in which both players' incentives are completely aligned, is characterized by $b = 0$ for both types. While Game 2 can be characterized by $b = 1/5$ for type A and $b = -1/5$ fot type B, in Game 3 $b = 0$ for type A and $b = -1/3$ for type B. Thus, in Game 2, each type has an incentive to misrepresent his type towards the other type's true value. In Game 3, type B sender wants to misrepresent his type, while type A does not have such an incentive.

In all of these games, there exists no action for the receiver that can be regarded as "dominated" at her off-the-path information set. So the strategy part of a perfect Bayesian Nash equilibrium corresponds to a Bayesian Nash equilibrium and vice versa. Also it should be noted that the set of sequential equilibria and the set of perfect Bayesian equilibria coincide in these games.

Our hypotheses in this experiment are summarized as follows:

[1] See the appendix for the detailed information on sequential equilibria of these games.

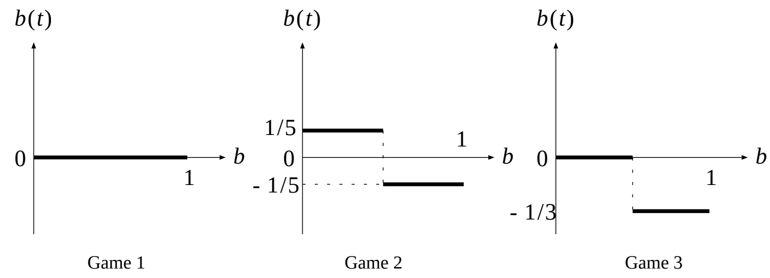

Figure 1: Incentives of Types in Games

Hypothesis 1 Separating equilibrium will be played more frequently than babbling equilibrium in Game 1 and 2.

Hypothesis 2 Separating equilibrium will be played more frequently in Game 1 than in Game 2.

Hypothesis 3 Babbling equilibrium will be played more frequently than any other outcomes in Game 3.

Since a cheap talk game is a dynamic game, there are always paths that are not observed in each actual play. So classification of observed plays into equilibrium plays had to be devised. In games with separating equilibria, when the observed play path coincides with the path predicted by equilibrium, we regarded the observed play as an equilibrium play. When the receiver's observed choice is the action that gives her the highest expected payoff given the prior probability over sender's types, we regarded the observed play as a play of babbling equilibria.

2.2 Logit AQRE and Noisy Equilibrium

Recent literature in experimental game theory hilights the usefulness and validity of McKelvey and Palfrey's [10, 11] noisy equilibrium concepts in explaining experimental data. In their model, players are assumed to be error-driven so that their best response functions are probabilistic rather than deterministic. The probability of each strategy is determined by a quantal response function, which maps the expected utilities from all strategies into the probability distribution over actions, with an action with higher expected utility played with higher probability. It is common knowledge that players are all error-driven. An QRE is a fixed point of this process. an AQRE is the counterpart of QRE for extensive form games.

A class of probabilistic response functions is of particular interest for experimental game theory. For any $\lambda \geq 0$, the logit quantal response function for player i is defined by

$$\sigma_{ij}(x_{ij}) = \frac{e^{\lambda x_{ij}}}{\sum_{k=1}^{J_i} e^{\lambda x_{ik}}},$$

where σ_{ij} is the probability that player i chooses action j, x_{ij} is the expected utility from playing action j, and J_i is the cardinality of player i's action space. A logit QRE is a QRE with this particular probabilistic response function. Note that play is completely random at $\lambda = 0$, while the quantal response function approaches a best response function as λ becomes large. Thus, λ can be seen as the degree of player's rationality. As λ goes to infinity, a logit QRE approaches a Nash equilibrium. The limit of a logit QRE as λ approaches infinity is called a limiting logit QRE, which provides a refinement of Nash equilibria.

The set of QRE is parameterized by λ, which allows us to find the value of λ that best fit the experimental data. By this method, we investigated the explanatory power of the AQRE model. For the detailed calculation of logit AQRE's for each game, see the appendix. We also examined the explanatory power of several other models: noisy Nash model with separating equilibrium (NNM-SE), noisy Nash model with babbling equilibrium (NNM-BE) and mixed model (MIXED). In NNM-SE, players are supposed to play truth-telling separating equilibrium with probability γ and play according to uniform distribution with probability $1 - \gamma$. In NNM-BE, players are supposed to play babbling equilibrium with probability γ and play according to uniform distribution with probability $1 - \gamma$. In MIXED, players are supposed to play truth-telling separating equilibrium with probability q and AQRE for babbling equilibrium with probability $1 - q$. For each session and each model, we calculated parameters that maximize log likelihood given the experimental data. We then compared the validity of the models with the AIC criterion.

3 Experimental Design

Our experiment basically follows the procedure adopted by Cooper et al. [5] [6]. Although they only deal with cheap talk games with complete information, the feature of their experimental design seems to have come to be a "standard" in conducting cheap talk game experiment in general: They applied lottery reward procedure that was first developed by Roth and Malouf [12] and further extended by Berg et al. [1] to induce risk-neutral utility function from subjects. They also carefully constructed a matching procedure.

The experimental procedure in the first session is as follows. Twenty-six subjects were recruited using standard recruiting instructions. They voluntarily participated in the experiment. Before the session, they were randomly divided into two groups of equal size. One group was direct reward condition, in which subjects were paid an amount proportionally to the payoff they earned in the games. The other group was lottery reward condition, in which the payoff subjects earned just determined the probability of winning higher prize in a two-prize lottery and the subjects were paied according to the outcome of the lottery. Separate rooms were assigned to both groups. When they entered the rooms, they were assigned their subject number at random. Each subject was given an envelope in which written instructions, recording sheet, questionnaire were enclosed. Instructors other than the authors of the paper read aloud the instruction and conducted the experiment manually. The instructors knew nothing about the equilibria of the games. The experiment proceeded according to the steps described below.

1. In each round, subjects were shown payoff table of the game they face in the current round and were told whether they were a sender or a receiver. They could not know with whom they are matched throughout the session.

2. Asignment of games, roles in the games to each subject, and who matched with whom were randomly determined.

3. In each room, twelve out of thirteen subjects actually participated (i.e. made decisions) in the experiment and one subject waited until the next round.[2]

4. The sender is assigned one of two types, "A" or "B," randomly with probability 1/2. The sender type is only shown to the sender and the receiver cannot know the sender's type before the payoffs for both subjects are determined.

5. The sender is told to choose between two messages, "I am type A" or "I am type B."

6. The receiver is shown the sender's message and is told to choose one of three actions, A, B, or C.

7. Payoffs for both players are determined by the sender's true type and the receiver's action according to the payoff tables. After all subjects had made decision, the sender's true type, the sent message, and the action taken by the receiver, payoffs for both were revealed on the blackboard.

8. A session consisted of thirteen rounds.

9. In the direct reward condition, reward was calculated as fifty times the sum of payoffs earned by each subject throughout the session and paid to her/him in cash. In the lottery reward condition, at each round and for each subject, a die was cast so that the winning probability is proportional to the game payoff earned by the subject in that round. The reward in the current round for the winner of the lottery was a fixed amount of money. The sum of reward throughout the session was calculated and paid to subjects. Participation fee was also given to each subject.

10. Prior to the actual experiment, three rounds of practice experiment were conducted, where equilibria and payoffs of the games were different from those used in the actual experiment. Payoffs earned in this practice did not count for final reward calculation.

The above procedure was also explained in the written instruction. Session time was about three hours, in which about an hour was spent for reading instructions and doing practice. The average reward for subjects was about three thousand yen.

Our experiment consists of 4 sessions, which were conducted at different time and location. Explanation on some differences among those sessions is as follows.

1. As will be shown in more detail below, since we found that results in both direct reward and lottery reward conditions did not differ, we decided to adopt direct reward method from the second session on.

2. In the payoff table of Game 1, which was used in the first session, receiver's action $A(B)$ is the best response when the sender's true type is $A(B)$ respectively. In order to prevent the receiver's action label from working as a coordination device, we permuted labels of the receiver's actions in session 2-4. For example, the action which is the best response for the receiver to type A sender in Game 1 was renamed action B.

[2]This is because of the nature of matching procedure we adopted. We devised random matching so that each subject plays both player roles and both sender's type equally often, matched with different subject at each round.

Session	Sample and sample number	Reward	Game	Labeling	Learning
1	Chuo Univ., 26 undergrad.	lottery/direct	1,2,3	as in Table 1	no
2	Saitama Univ., 13 undergrad.	direct	1,2,3	permuted	no
3	Kyoto Sangyo Univ., 26 undergrad.	direct	1,3	permited	yes
4	Toyo Univ., 26 undergrad.	direct	1,3	permuted	yes

Table 2: Differences across Sessions

3. In the first and second sessions, each subject was randomly assigned Games 1, 2, and 3. From the third session on, we redesigned experiment so that each subject in a group faced the same game (Game 1 or 3) throughout the session, since we wanted to focus the difference of learning dynamics observed in Game 1 and 3.

Table 2 summarizes the difference across sessions.

4 Experimental Results

4.1 Lottery vs. Direct reward

In the first session at Chuo University (February 3, 1999), we had both direct reward condition and lottery reward condition, each of which took place in a different room. At each round, one out of the three games is randomly assigned to subjects. The labeling of receiver's action was as in Table 1. Experimental results in Session 1 are summarized and shown in Table 3.

	reward					
	direct			lottery		
Game #	1	2	3	1	2	3
Separating equilibrium	24	14	-	25	20	-
Babbling equilibrium	1	7	8	1	1	10
Others	1	5	18	0	5	16
Total	26	26	26	26	26	26

Table 3: Summary data in Session 1

At a glance, we find high frequency of separating equilibrium play in Game 1 and 2. In fact, 24 outcomes out of 26 plays in Game 1 and 14 out of 26 plays in Game 2 were separating equilibrium in the direct reward condition. In the lottery reward condition, 25 out of 26 plays in Game 1 and 20 out of 26 plays in Game 2 were separating equilibrium play. Furthermore, the frequency of separating equilibrium was higher in Game 1 than in Game 2. On the other hand, babbling equilibrium was quite rare in Game 3 in both conditions (8 out of 26 plays and 10 out of 26 plays respectively).

Thus we had very similar results in both direct and lottery reward conditions. In fact, using χ^2 test, we find that experimental results are not different between direct and lottery reward conditions. Null hypothesis "the frequency of outcome distribution was

Game #	1	2	3
Separating equilibrium	22	12	-
Babbling equilibrium	3	14	8
Others	1	0	18
Total	26	26	26

Table 4: Summary data in Session 2

not different between direct and lottery payoff conditions" was not rejected at five percent significant level in Game 1 ($\chi^2 = 1.020$, $df = 2$, $p = 0.600$), Game 2 ($\chi^2 = 5.559$, $df = 2$, $p = 0.071$), and Game 3 ($\chi^2 = 0.340$, $df = 1$, $p = 0.560$).

Due to the above result, we decided to merge results in both conditions into one. Using this data, we conducted a χ^2 test to find that there was significant difference between the frequency of separating and babbling equilibrium in Game 1 ($\chi^2 = 84.993$, $df = 1$, $p = 0.000^{**}$) and Game 2 ($\chi^2 = 26.998$, $df = 1$, $p = 0.000^{**}$).

Then we compared the frequency of separating equilibrium in Game 1 and 2 with the frequency of babbling equilibrium in Game 3. We regarded the equilibrium outcome which had the highest frequency in each game as the representative equilibrium, then compared those frequency among three games. Using χ^2 test ($\chi^2 = 40.495$, $df = 2$, $p = 0.000^{**}$), we have significant difference among three games. In particular, the frequency of separating equilibrium in Game 1 was high, and the frequency of babbling equilibrium in Game 3 was quite low.

In summary, we have the following results in session 1.

1. There was no difference in results between direct and lottery reward procedure.
2. The frequency of separating equilibrium play was quite high in Game 1 and 2.
3. The frequency of separating equilibrium play was higher in Game 1 than in Game 2.
4. In Game 3, the frequency of babbling equilibrium play was quite low.

Thus, our hypothesis 1 and 2 were verified, but hypothesis 3 was not.

4.2 Results under Permuted Labeling

The second session took place at Saitama University on May 18, 1999. Thirteen subjects voluntarily participated in this session. As noted above, there were two different points in experimental design from the first session: We adopted only direct reward method and permuted action labels for the receiver.

Average reward was about three thousands yen. Instruction and practice time took about an hour and session time was about two hours. Experimental results in session 2 are summarized and shown in Table 4.

From Table 4, it is easily seen that we have almost the same tendency as in the first session. Actually, a χ^2 test showed that there was significant difference between

Game #	1	3
Separating equilibrium	61	-
Babbling equilibrium	13	43
Others	4	35
Total	78	78

Table 5: Summary data in Session 3

Game	1	3
Separating equilibrium	71	-
Babling equilibrium	6	35
Others	1	43
Total	78	78

Table 6: Summary data in Session 4

the frequency of separating and babbling equilibrium in Game 1 ($\chi^2 = 27.810$, $df = 1$, $p = 0.000^{**}$) but same result did not hold in Game 2 ($\chi^2 = 0.308$, $df = 1$, $p = 0.579$). We also compared the frequency of separating equilibrium in Game 1 with the frequency of babbling equilibrium in Game 2 and 3. Using χ^2 test ($\chi^2 = 15.433$, $df = 2$, $p = 0.000^{**}$), we have significant difference among three games. The frequency of separating equilibrium in Game 1 was much higher, and the frequency of babbling equilibrium in Game 3 was quite lower.

In sum, in spite of permutation of action labeling in this session, we had almost the same results as in the first session, namely that our hypotheses 1 and 2 were verified, but hypothesis 3 was not.

4.3 Difference of Learning Dynamics

The third session at Kyoto Sangyo University on July 14, 1999, and the fourth session at Toyo University December 21, 1999 were designed to see how our subjects learn on equilibrium plays in cheap talk games by giving them more time to learn a fixed game. In those sessions, all the subjects were divided into two groups, each of which played the same game all over the rounds. We used Game 1 and Game 3, so subjects in one room played Game 1 only and subjects in the other room played Game 3 only. The role in the game and the opponent player for each subject were randomly changed in order to eliminate any repeated game or reputation effect. Average reward was about three thousands yen in the third session. In the fourth session, since the participation fee and the multiplier used to calculate rewards from payoffs was halved, the average reward also halved. Instruction and practice time took about an hour and session time was about two hours. Experimental results we obtained are shown in Table 5 and Table 6.

Both tables show high frequency of separating equilibrium in Game 1. In fact, 61 (71) outcomes out of 78 plays in Game 1 were separating equilibrium in session 3 (4) respectively. On the other hand, babbling equilibrium was quite rare in Game 3 (43 (35) out of 78 plays in Session 3 (4)).

Doing χ^2 test using data in Session 3, we obtained that there was significant difference between the frequency of separating and babbling equilibrium in Game 1 ($\chi^2 = 59.233$, $df = 1$, $p = 0.000^{**}$). We compared the frequency of separating equilibrium in Game 1 with the frequency of babbling equilibrium in Game 3 to find there is a significant difference between two games ($\chi^2 = 9.346$, $df = 1$, $p = 0.002^{**}$). The frequency of separating equilibrium in Game 1 was much higher, and the frequency of babbling equilibrium in Game 3 was quite lower. So, again, our hypothesis 1 described in section 2 were verified, but hypothesis 3 was not.

Time series data are shown in Figure 2,3,4, and 5. We can observe quick and good convergence to separating equilibrium in Game 1. On the other hand, we don't have any tendency of convergence to babbling equilibrium in Game 3. There seems to be some essential difference between Game 1 and 3 not only in their total frequency of equilibrium play, but also in their dynamic learning nature.

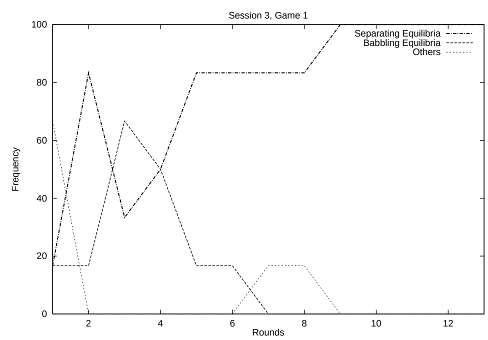

Figure 2: Learning Dynamics in Game 1 (Session 3)

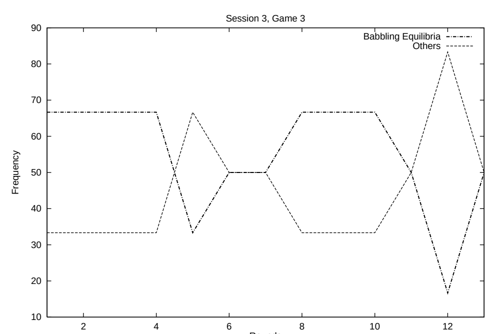

Figure 3: Learning Dynamics in Game 3 (Session 3)

5 Various Models for Explaining Players' Behavior

The experimental results reported in the previous sections support hypotheses 1 and 2, but not hypothesis 3. What is puzzling about the results for Game 3 is that players do

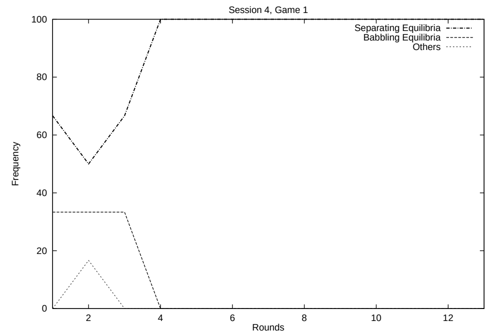

Figure 4: Learning Dynamics in Game 1 (Session 4)

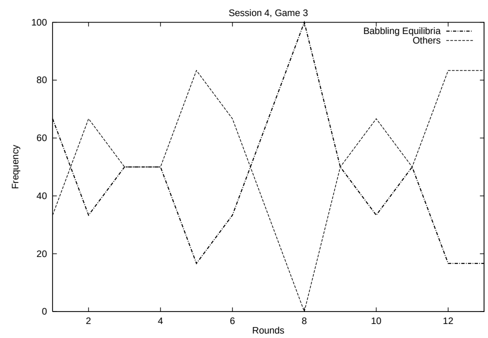

Figure 5: Learning Dynamics in Game 3 (Session 4)

not play babbling equilibria, although this game has only babbling equilibria. Casual observation of the result further show that senders tend to truthfully report their type and receivers tend to respond to senders' messages by playing strategies in separating equilibria, although such a strategy profile does not really constitute an equilibrium. In what follows, we call the play in which the sender truthfully reports his type and the receiver responds by coordinating strategy the "quasi-separating play." The observed deviation from equilibria led us to examine whether the AQRE model and its variants can explain our data set.

To fit the AQRE to our data, we use a standard maximum-likelihood approach, as described in detail in McKelvey and Palfrey [10]. For any parameter λ of the AQRE model, we obtain predicted frequencies of moves at each information set. Given a data set, our estimate of λ is the value of λ that maximizes the likelihood of that data set. It should be noted, however, that Game 1 and 2 have both separating and babbling equilibria. Although all the separating equilibria or babbling equilibria are not the limiting logit AQRE, there are multiple AQRE branches that correpond to separating and babbling equilibria. See the appendix for details. We call the AQRE branch that corresponds to separating equilibria (babbling equilibria) AQRE-SE (AQRE-BE) respectively. Thus we calculate maximum-likelihood λ for both branches.

We also examine the explanatory power of other models: the noisy Nash model (NNM) and the mixed model (MIXED). In the noisy Nash model, at any information set, players are supposed to adopt a Nash equilibrium strategy with probability γ and to randomize uniformly over all available actions with probability $1-\gamma$. As in the case of AQRE, we have two versions of the NNM, since Game 1 and Game 2 have both babbling and separating equilibria. The NNM-SE model has the separating equilibrium as its Nash equilibrium component, and the NNM-BE model has the babbling equilibrium. The estimate of γ is the value of γ that maximizes the likelihood of our data set. The MIXED model posits that players play the quasi-separating play with probability q, and with probability $1-q$ they play according to the AQRE model corresponding to babbling equilibria. We estimate λ and q simultaneously for the MIXED.

Tables 7-19 in the appendix summarize the AQRE, NNM, and MIXED estimates for each session and for each game. The maximum-likelihood λ and γ are caluculated by bootstrap method with one thousand samples. The values of standard error, median, lower and upper bound of 95 confidential intervals of λ or γ are also calculated in this process. We compare the performance of these models by AIC (Akaike Information criterion), which is $-2LL+2k$, where LL denotes log-likelihood and k denotes the number of parameters. In 8 out of 13 cases, the MIXED model shows the best performance. As for Game 3, the MIXED model performs best in 4 out of 5 cases. The AQRE-SE model is best in Game 1 and 2 with lottery reward condition in Session 1, and Game 1 and 2 in Session 2. However it does not perform well for Game 3.

6 Conclusion

This paper reports some experimental results on plays in cheap talk games with incomplete information. We conduct experiments with three cheap talk games with different payoff characteristics. We observe high frequency of separating equilibrium play in games with separating equilibria, and the frequency of separating equilibrium play is higher when both players' interests perfectly coincide. We also have quick and good convergence to separating equilibria in that case. These results are not surprising, as the evolutionary game theory predicts so. On the other hand, however, we have low frequency of babbling equilibrium play and no tendency of convergence to babbling equilibrium in the game with only babbling equilibria. This anomaly led us to examining the explanatory power of the noisy equilibrium model. We compare the performance of variants of the AQRE model. The AQRE-SE model performs well in games with separating equilibria, while the MIXED model performs best for games with only babbling equilibria.

Thus, it seems that players have intrinsic propensity to play a quasi-separating play. Observed plays of a game are a joint product of a game form, payoff functions, and players' strategies. Our experimental result suggests that the plays of separating equilibria may well be attribuable to the game form of cheap talk game and players' perception of the game form, rather than a specific form of payoff functions. Put differently, some players may not be able to fully discriminate among different strategic situations. Testing this hypothesis, however, requires further study.

References

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

[2] Blume, A., Y.G. Kim, and J. Sobel (1993). "Evolutionary Stability in Games of Communication", *Games and Economic Behavior*, 5, 547-575.

[3] Blume, A., DeJong, D.V., Kim, Y.G., and Sprinkle, G.B. (1998). "Experimental Evidence on the Evolution of Meaning of Messages in Sender-Receiver Games", *American Economic Review*, 88, 1323-1340.

[4] Blume, A., DeJong, D.V., Kim, Y.G., and Sprinkle, G.B. (1998). "Evolution of Communication with Partial Common Interest", *Games and Economic Behavior*, 37, 79-120.

[5] Cooper, R., DeJong, D.V., Forsythe, R., and Ross, T.W. (1992). "Communication in the Battle of Sexes Game", *Rand Journal of Economics*, 20, 568-87.

[6] Cooper, R., DeJong, D.V., Forsythe, R., and Ross, T.W. (1992). "Communication in Coordination Games", *Quarterly Journal of Economics*, 107, 739-71.

[7] Crawford, V. and Sobel, J. (1982). "Strategic Information Transmission", *Econometrica*, 50, 1431-51.

[8] Crawford, V. (1998). "A survey of Experiments on Communication via Cheap Talk", *Journal of Economic Theory*, 78, 286-98.

[9] Dickhaut, J.W., McCabe, K.A., and Mukherji, A. (1995). "An Experimental Study of Strategic Information Transmission", *Economic Theory*, 6, 389-403.

[10] McKelvey, R.D. and Palfrey, T.R. (1995). "Quantal Response Equilibria for Normal Form games", *Games and Economic Behavior*, 10, 6-38.

[11] McKelvey, R.D. and Palfrey, T.R. (1998). "Quantal Response Equilibria for Extensive Form games", *Experimental Economics*, 1, 9-41.

[12] Roth, A.E. and Malouf, W.K. (1979). "Game-Theoretic Models and the Role of Bargaining", *Psychological Review*, 86, 574-94.

[13] Wärneryd, K. (1993). "Cheap Talk, Coordination, and Evolutionary Stability", *Games and Economic Behavior*, 5, 532-546.

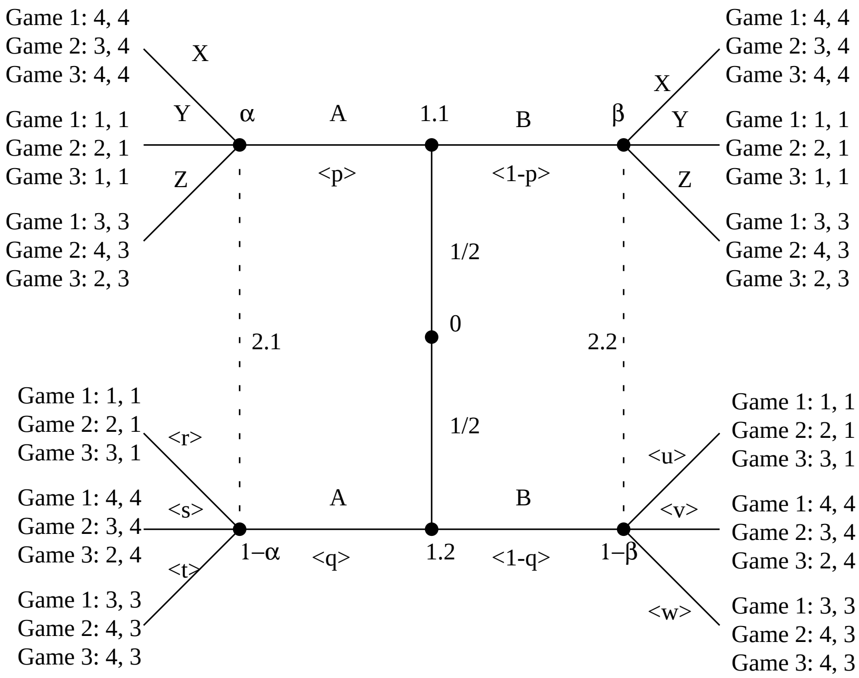

Figure 6: Cheap Talk Games Used in the Experiment

Appendices

A Sequential Equilibria of Game 1, 2 and 3

We provide all the sequential equilibria in games used in the experiment. In what follows, notations are as shown in Figure 6.

In Game 1, we have the following sequential equilibria.

1. A separating equilibrium as a combination of the stragegy profile $(p = 1, q = 0, r = 1, s = 0, t = 0, u = 0, v = 1, w = 0)$ with belief $(\alpha = 1, \beta = 0)$.

2. A separating equilibrium as a combination of the stragegy profile $(p = 0, q = 1, r = 0, s = 1, t = 0, u = 1, v = 0, w = 0)$ with belief $(\alpha = 0, \beta = 1)$.

3. A set of babbling equilibria in which players play according to $(p = 1, q = 1, r = 0, s = 0, t = 1, u = 0, v = 0, w = 1)$ with belief $(\alpha = 1/2, \beta \in [1/3, 2/3])$.

4. A set of babbling equilibria in which players play according to $(p = 0, q = 0, r = 0, s = 0, t = 1, u = 0, v = 0, w = 1)$ with belief $(\alpha \in [1/3, 2/3], \beta = 1/2)$.

5. A set of babbling equilibria in which players play according to $(p = 0, q = 0, r = 0, s = 0, t = 1, u = 0, v = 0, w = 1)$ with belief $(\alpha = p/(p+q), \beta = (1-p)/(2-p-q))$, where $p, q \in (0, 1)$ is such that $p/2 \le q \le 2p, 2p - 1 \le q \le (p + 1)/2$.

Game 2 has the following sequential equilibria.

1. A separating equilibrium as a combination of the stragegy profile $(p = 1, q = 0, r = 1, s = 0, t = 0, u = 0, v = 1, w = 0)$ with belief $(\alpha = 1, \beta = 0)$.

2. A separating equilibrium as a combination of the stragegy profile $(p = 0, q = 1, r = 0, s = 1, t = 0, u = 1, v = 0, w = 0)$ with belief $(\alpha = 0, \beta = 1)$.

3. A set of babbling equilibria in which players play according to $(p = 1, q = 1, r = 0, s = 0, t = 1, u = 0, v = 1, w = 0)$ with belief $(\alpha = 1/2, \beta \in [0, 1/3])$.

4. A set of babbling equilibria in which players play according to $(p = 1, q = 1, r = 0, s = 0, t = 1, u = 0, v = 0, w = 1)$ with belief $(\alpha = 1/2, \beta \in [1/3, 2/3])$.

5. A set of babbling equilibria in which players play according to $(p = 1, q = 1, r = 0, s = 0, t = 1, u = 1, v = 0, w = 1)$ with belief $(\alpha = 1/2, \beta \in [2/3, 1])$.

6. A set of partial babbling equilibria in which players play according to $(p = 0, q = 0, r = 0, s = 1, t = 0, u = 0, v = 0, w = 1)$ with belief $(\alpha \in [0, 1/3], \beta = 1/2)$.

7. A set of babbling equilibria in which players play according to $(p = 0, q = 0, r = 0, s = 0, t = 1, u = 0, v = 0, w = 1)$ with belief $(\alpha \in [1/3, 2/3], \beta = 1/2)$.

8. A set of partial babbling equilibria in which players play according to $(p = 0, q = 0, r = 1, s = 0, t = 0, u = 0, v = 0, w = 1)$ with belief $(\alpha \in [2/3, 1], \beta = 1/2)$.

9. A set of partial babbling equilibria in which players play according to $(p = 1/2, q = 0, r = 1, s = 0, t = 0, u = 0, v = 1/2, w = 1/2)$ with belief $(\alpha = 1, \beta = 1/3)$.

10. A set of partial babbling equilibria in which players play according to $(p = 1/2, q = 1, r = 0, s = 1/2, t = 1/2, u = 1, v = 0, w = 0)$ with belief $(\alpha = 1/3, \beta = 1)$.

11. A set of partial babbling equilibria in which players play according to $(p = 0, q = 1/2, r = 0, s = 1, t = 0, u = 1/2, v = 0, w = 1/2)$ with belief $(\alpha = 0, \beta = 2/3)$.

12. A set of partial babbling equilibria in which players play according to $(p = 1, q = 1/2, r = 1/2, s = 0, t = 1/2, u = 0, v = 1, w = 0)$ with belief $(\alpha = 2/3, \beta = 0)$.

13. A set of partial babbling equilibria in which players play according to $(p = 0, q = 0, r = 0, s \in (0, 1), t \in (0, 1), u = 0, v = 0, w = 1)$ with belief $(\alpha = 1/3, \beta = 1/2)$, where $s + t = 1$.

14. A set of partial babbling equilibria in which players play according to $(p = 0, q = 0, r =\in (0, 1), s = 0, t \in (0, 1), u = 0, v = 0, w = 1)$ with belief $(\alpha = 2/3, \beta = 1/2)$, where $r + t = 1$.

15. A set of babbling equilibria in which players play according to $(p = 0, q = 0, r = 0, s = 0, t = 1, u = 0, v = 0, w = 1)$ with belief $(\alpha = p/(p+q), \beta = (1-p)/(2-p-q))$, where $p, q \in (0, 1)$ is such that $p/2 \leq q \leq 2p, 2p - 1 \leq q \leq (p + 1)/2$.

The set of sequential equilibria in Game 3 is as follows.

1. A set of partial babbling equilibria in which players play according to $(p = 1, q = 1, r = 0, s = 0, t = 1, u = 0, v = 1, w = 0)$ with belief $(\alpha = 1/2, \beta \in [0, 1/3])$.

2. A set of babbling equilibria in which players play according to $(p = 1, q = 1, r = 0, s = 0, t = 1, u = 0, v = 0, w = 1)$ with belief $(\alpha = 1/2, \beta \in [1/3, 2/3])$.

3. A set of partial babbling equilibria in which players play according to $(p=0, q=0, r=0, s=1, t=0, u=0, v=0, w=1)$ with belief $(\alpha \in [0, 1/3], \beta = 1/2)$.

4. A set of babbling equilibria in which players play according to $(p=0, q=0, r=0, s=0, t=1, u=0, v=0, w=1)$ with belief $(\alpha \in [1/3, 2/3], \beta = 1/2)$.

5. A set of partial babbling equilibria in which players play according to $(p=0, q=0, r=0, s \in (0,1), t \in (0,1), u=0, v=0, w=1)$ with belief $(\alpha = 1/3, \beta = 1/2)$, where $s+t=1$.

6. A set of babbling equilibria in which players play according to $(p=0, q=0, r=0, s=0, t=1, u=0, v=0, w=1)$ with belief $(\alpha = p/(p+q), \beta = (1-p)/(2-p-q))$, where $p, q \in (0,1)$ is such that $p/2 \leq q \leq 2p, 2p-1 \leq q \leq (p+1)/2$.

B Instructions

This is an experiment on economic decision making. You can earn some amount of money in cash in this experiment, if you make appropriate choices according to what is explained below.

In this experiment, each group consists of two persons, one of whom we call "S-player" and the other "R-player." Scores of both players are determined by choices of both players. We will not inform you who are "S-players (R-players)" or who are matched with whom at each round. Matching players are determined at random at each round. In each round, one of you has to "wait" and do nothing until the next round.

We repeat such an experimental round several times. When all the rounds finish, the instructors will tell you the end of experiment. Your reward is finally determined based on the score you earned all over the rounds. More detailed experimental procedure follows.

B.1 Experimental Procedure

In this experiment, each round proceeds as follows:

1. Each of you are told whether you are an "S-player" or an "R-player" at this round.

2. If you are an "S-player," you are also told whether you are type A or type B at this round.

3. "S-player" chooses between two alternatives "I am a type A" or "I am a type B."

4. "R-player," informed of the choice of "S-player" who is your matched opponent, chooses from among three alternatives "A," "B," and "C."

5. The score is determined according to the type of "S-player," which is assigned at the beginning of this round, and the choice by "R-player".

6. The final reward is determined based on the score you earned all over the rounds, and then paid in cash.

Let us see the details of each stage more closely.

Step 1.

Each pair of subjects participate in each decision making, so there are 6 pairs and 1 person has to wait. One subject of a pair is called "S-player," while the other subject "R-player." Throughout the experiment, you are never told who and who match to form a pair. All that you are told is the number assigned to the pair to which you belong and whether you are an "S-player" or "R-player." All of these are predetermined according to some random matching rule by the experimenters.

More specifically, at each round a "Payoff table" is distributed to each of those who participate in the experiment. On the table, you will find a payoff table and the number assigned to the pair to which you are belonging at this round. We will later explain how to read the payoff table in more detail. If you are an "S-player," "Answer sheet" will also be distributed.

Fill in the blank of your "Recording sheet" with the number of your pair that you have found on the "Answer sheet." Circle the letter "S" in the Player field of your "Recording sheet" if you are an "S-player," "R" if "R-player."

If you are told to wait at this round, write "wait" in the Pair field of your "Recording sheet," and wait silently until the next round.

Step 2

Look at the upper half of your "Answer sheet." If you are told to be an "S-player" in Stage 1, you are also told whether you are type A or type B. Throughout the experiment, the probabilities of being type A and type B are equal. No one except you knows whether you are type A or type B.

If you are an "S-player" and your type is A, circle the letter "A" in the Type field of your "Recording sheet," likewise for the case that your type is B.

Step 3

Those who are told to be an "S-player" in the 1st stage choose between "Alternative A" or "Alternative B."

Alternative A: "I am a type A."
Alternative B: "I am a type B."

The choice is completely up to you. While the type of which you are informed in the second stage will not be known to the matched "R-player," the choice you made in the second stage will be known to the opponent.

If you choose "Alternative A," circle the letter A in the Alternative field on your "Recording sheet," likewise for the case that you choose "Alternative B." Also do the same for the "Choice of S-player" field in the lower half of your "Answer sheet" and hand it to the instructors.

Step 4

"R-player" chooses among "Alternative A," "Alternative B," and "Alternative C" knowing the choice made by "S-player" at stage 3. You can find the choice of the matched "S-player" on the "Answer sheet."

If you choose "Alternative A," circle the letter A in the Alternative field on your "Recording sheet," likewise for the case that you choose "Alternative B" or "Alternative C." Also do the same for the "Choice of R-player" field on the "Answer sheet" handed to you.

Step 5

Both players' scores are determined according to the choice made by "R-player" in stage 4 and *the type revealed to "S-player" in the second stage.* Note that *the choice by "S-player" in the third stage does not affect scores.*

The score table shows you how both players' scores are determined. The scores that both players get will be shown on the blackboard, so ensure your score at each round. After ensuring your score, write it in the Score field on your "Recording sheet."

Example.

Suppose you are distributed a payoff table as follows:

	type A		type B	
	S	R	S	R
Alternative A	90	20	60	30
	S	R	S	R
Alternative B	50	10	10	90
	S	R	S	R
Alternative C	80	70	30	50

If "S-player" is assigned type A in stage 2, look down under the column "type A" on this table. If "S-player" is assigned type B, then look down under the column "type B." The left digit in each cell indicates S-player's score and the right R-player's.

For example, suppose "S-player" is told that his type is type A and "R-player's" choice is "Alternative A," then "S-player" gets 90 and "R-player" gets 20 according to this payoff table. If "S-player" is told that his type is type B and "R-player's" choice is "Alternative B," then "S-player" gets 10 and "R-player" gets 90.

Also suppose that "S-player" is told that his type is A and "S-player" chooses "Alternative B." In this case, if "R-player" chooses "Alternative A," then "S-player" gets 90 and "R-player" gets 20. Next suppose that "S-player" is told that his type is B and "S-player" chooses "Alternative B." In this case, if "R-player" chooses "Alternative A," then "S-player" gets 60 and "R-player" gets 30.

Step 6

Stages 1-5 complete a round of the experiment. Your reward in cash in this round is fifty Yen times the score you get in this session. Fill in the Reward field on your "Recording sheet" with the number that is 50 times as large as the score in this round. The total reward in the experiment is the sum of each round's reward plus participation fee, a thousand Yen.

B.2 Notices

- Please be quiet throughout the experiment. You might be expelled if the instructor thinks it necessary. In that case, you might not be rewarded.
- You cannot leave the room throughout the experiment in principle.
- Please turn off your pocket bell or cellular phone.
- Do not take anything used in the experiment with you.

B.3 Questions

If you have any question concerning the procedure of experiment, raise your hand quietly. An instructor will answer your question in person. In some cases, the content of your question might disallow the instructor to answer it, however.

B.4 Practice

Before conducting the experiment, we have three sessions for practice. These are purely for practice and the results therein will not be counted in your reward. You can always refer to this instruction throughout the experiment.

Please take out "Recording sheet (Practice)" from your envelope and fill in your name and student ID.

We will distribute "Answer sheets (Practice)" and "Score table (Practice)" to those who are to be "S-players" in this session. To those who are to be "R-players" in this session, only "Score table (Practice)" will be distributed.

"S-players" should now circle the letter S in the Player field of the "Recording sheet (Practice)" and "R-players" the letter R.

"S-players" now make their choice looking at your own type on the "Answer sheet (Practice)" and the "Payoff table (Practice)." Mark your own type in the Type field of your "Recording sheet (Practice)" and also mark your choice in the Choice field of the "Recording sheet (Practice)." Next mark your choice on the "Answer sheet (Practice)" too. "Answer sheet (Practice)" will be collected later.

Then the lower half of the "Answer sheet (Practice)," on which "S-players" have already marked their choices, will be distributed to the matched "R-players." "R-players" can thus see the choice of "S-players," but not their true types. "R-players" should now make choice by examining the score table and mark your choice in the Choice field of your "Recording sheet (Practice)." Also mark your choice on the "Answer sheet (Practice)."

Let us now turn to actual experiment. Please fill in your name and student ID on your "Recording sheet."

C Recording Sheet

Recording Sheet

Name(   )   Student ID(   )

Round	Pair No.	Player	Type	Alternative	Payoff	Reward
1		S / R	A / B	A / B / C		
2		S / R	A / B	A / B / C		
3		S / R	A / B	A / B / C		
4		S / R	A / B	A / B / C		
5		S / R	A / B	A / B / C		
6		S / R	A / B	A / B / C		
7		S / R	A / B	A / B / C		
8		S / R	A / B	A / B / C		
9		S / R	A / B	A / B / C		
10		S / R	A / B	A / B / C		
11		S / R	A / B	A / B / C		
12		S / R	A / B	A / B / C		
13		S / R	A / B	A / B / C		

* Multiply the number in the Payoff field by 50 and put the resultant number into the reward field.

D Logit AQRE for the Games in the Experiment

The logit AQRE for extensive-form games is described in details in McKelvey and Palfrey [11]. We test the validity of the logit AQRE model and its variants to explain our data set. This section presents the calculation results concerning the AQRE in each game.

D.1 Game 1

Let p be the probability with which the type A sender chooses message A and q be the probability with which the type B sender sends message A. Also let the probability with which the receiver receiving message A chooses action A, B, C be r,s,t respectively, and the probability with which the receiver receiving message B chooses action A, B,C be u,v,w respectively.

The equations that determines the logit AQRE correspondences for Game 1 is as follows.

$$
\begin{aligned}
p &= \frac{e^{\lambda(r-2s+3)}}{e^{\lambda(r-2s+3)}+e^{\lambda(u-2v+3)}} = \frac{1}{1+e^{\lambda(u-2v-r+2s)}} \\
q &= \frac{1}{1+e^{\lambda(-2u+v+2r-s)}} \\
r &= \frac{e^{\lambda\frac{4p+q}{p+q}}}{e^{\lambda\frac{4p+q}{p+q}}+e^{\lambda\frac{p+4q}{p+q}}+e^{\lambda\frac{3p+3q}{p+q}}} = \frac{1}{1+e^{\lambda\frac{-3p+3q}{p+q}}+e^{\lambda\frac{-p+2q}{p+q}}} \\
s &= \frac{1}{1+e^{\lambda\frac{3p-3q}{p+q}}+e^{\lambda\frac{2p-q}{p+q}}} \\
u &= \frac{1}{1+e^{\lambda\frac{3p-3q}{2-p-q}}+e^{\lambda\frac{1+p-2q}{2-p-q}}} \\
v &= \frac{1}{1+e^{\lambda\frac{-3p+3q}{2-p-q}}+e^{\lambda\frac{1-2p+q}{2-p-q}}}
\end{aligned}
$$

There are multiple logit AQREs and we find the following strategy profiles the limiting logit AQREs.

Truth-telling separating equilibrium $(p=1, q=0, r=1, s=0, u=0, v=1)$.

Lying separating equilibrium $(p=0, q=1, r=0, s=1, u=1, v=0)$.

Mixed strategy babbling equilibrium $(p=1/2, q=1/2, r=0, s=0, u=0, v=0)$.

Note, however, that pooling babbling equilibria, $(p=1, q=1, r=0, s=0, u=0, v=0)$ or $(p=0, q=0, r=0, s=0, u=0, v=0)$ are not the limiting logit AQRE.

D.2 Game 2

In Game 2, the following is the equations for logit AQRE correspondences.

$$
\begin{aligned}
p &= \frac{1}{1+e^{\lambda(u-2v-r+2s)}} \\
q &= \frac{1}{1+e^{\lambda(-2u+v+2r-s)}} \\
r &= \frac{1}{1+e^{\lambda\frac{-3p+3q}{p+q}}+e^{\lambda\frac{-p+2q}{p+q}}} \\
s &= \frac{1}{1+e^{\lambda\frac{3p-3q}{p+q}}+e^{\lambda\frac{2p-q}{p+q}}} \\
u &= \frac{1}{1+e^{\lambda\frac{3p-3q}{2-p-q}}+e^{\lambda\frac{1+p-2q}{2-p-q}}} \\
v &= \frac{1}{1+e^{\lambda\frac{-3p+3q}{2-p-q}}+e^{\lambda\frac{1-2p+q}{2-p-q}}}
\end{aligned}
$$

In this AQRE correspondence, the following strategy profiles are the limiting logit AQREs.

Truth-telling separating equilibrium $(p=1, q=0, r=1, s=0, u=0, v=1)$.

Lying separating equilibrium $(p = 0, q = 1, r = 0, s = 1, u = 1, v = 0)$.

Mixed strategy babbling equilibrium $(p = 1/2, q = 1/2, r = 0, s = 0, u = 0, v = 0)$.

Note, however, that pooling babbling equilibria, $(p = 1, q = 1, r = 0, s = 0, u = 0, v = 0)$ or $(p = 0, q = 0, r = 0, s = 0, u = 0, v = 0)$ are not a limiting logit AQRE.

D.3 Game 3

The following is the equations for logit AQRE correspondences in Game 3.

$$\begin{aligned}
p &= \frac{1}{1+e^{\lambda(2u-v-2r+s)}} \\
q &= \frac{1}{1+e^{\lambda(-u-2v+r+2s)}} \\
r &= \frac{1}{1+e^{\lambda\frac{-3p+3q}{p+q}}+e^{\lambda\frac{-p+2q}{p+q}}} \\
s &= \frac{1}{1+e^{\lambda\frac{3p-3q}{p+q}}+e^{\lambda\frac{2p-q}{p+q}}} \\
u &= \frac{1}{1+e^{\lambda\frac{3p-3q}{2-p-q}}+e^{\lambda\frac{1+p-2q}{2-p-q}}} \\
v &= \frac{1}{1+e^{\lambda\frac{-3p+3q}{2-p-q}}+e^{\lambda\frac{1-2p+q}{2-p-q}}}
\end{aligned}$$

In this AQRE correspondence, the following strategy profiles are shown to be limiting logit AQREs.

Mixed strategy babbling equilibrium $(p = 1/2, q = 1/2, r = 0, s = 0, u = 0, v = 0)$.

Note, however, that pooling babbling equilibria, $(p = 1, q = 1, r = 0, s = 0, u = 0, v = 0)$ or $(p = 0, q = 0, r = 0, s = 0, u = 0, v = 0)$ are not a limiting logit AQRE.

E Estimation

The estimation procedure is as follows. First, we calculate AQRE correspondence with a program written in Fortran. We used various initial values to obtain all the AQRE correspondenses described in the previous section. Second, using grid search method, we find the parameter value that maximizes log likelihood. Third, using bootstrap method, we obtained standard error, median, lower and upper bound of 95confidence interval. Last, we compare various model by the AIC criterion.

The models whose performance we compared are as follows:

AQRE-SE We find the maximum-likelihood estimation of λ in the AQRE branch corresponding to the truth-telling separating equilibrium, if it exists;

AQRE-BE We find the maximum-likelihood estimation of λ in the AQRE branch corresponding to the babbling equilibrium in which the sender uses both messages with equal probability;

		n	freq.	AQRE-SE	AQRE-BE	NNM-SE	NNM-BE	MIXED
t =A	m =A	12	0.923	0.990	0.500	0.950	0.500	0.499
	m =B	1	0.077	0.010	0.500	0.950	0.500	0.501
t =B	m =A	0	0.000	0.010	0.500	0.050	0.500	0.499
	m =B	13	1.000	0.990	0.500	0.951	0.500	0.501
m =A	a =A	11	0.917	0.850	0.333	0.934	0.333	0.000
	a =B	0	0.000	0.004	0.333	0.033	0.333	0.000
	a =C	1	0.083	0.146	0.333	0.033	0.333	1.000
m =B	a =A	0	0.000	0.004	0.333	0.033	0.333	0.000
	a =B	13	0.929	0.850	0.333	0.934	0.333	0.000
	a =C	1	0.071	0.146	0.333	0.033	0.333	1.000
λ or γ				1.817	0.001	0.901	0.000	19.588
q								0.920
LL				-12.610	-46.588	-12.752	-46.584	-11.291
s.e.				0.003	0.000	0.001	0.001	
median				1.817	0.001	0.901	0.000	
C.I. low				1.363	0.000	0.800	0.000	
C.I. high				3.289	0.001	1.000	0.000	
AIC				27.220	95.175	27.504	95.168	26.583

Table 7: Evaluation of Various Models: Seccion 1, Game 1, direct reward condition

NNM-SE Noisy Nash Model described in McKelvey and Palfrey (1999), in which players use truth-telling separating equilibrium with probability γ and unifrom distribution with probability $1-\gamma$. In games without separating equilibria, the truth-telling separating equilibrium is replaced by the quasi-separating play in the above statement;

NNM-BE Noisy Nash Model. A model in which players play a babbling equilibrium with probability γ and play from uniform distribution with probability $1-\gamma$;

MIXED A model in which players play a truth-telling separating equilibrium with probability q and play according to the AQRE model for babbling equilibrium with probability $1-q$.

The estimattion results are summerized in the Tables 7-19. In summary, the MIXED model outperforms the other models in 8 out 13 cases.

		n	freq.	AQRE-SE	AQRE-BE	NNM-SE	NNM-BE	MIXED
t =A	m =A	10	0.769	0.757	0.500	0.782	0.500	0.500
	m =B	3	0.231	0.243	0.500	0.218	0.500	0.500
t =B	m =A	0	0.000	0.243	0.500	0.218	0.500	0.500
	m =B	13	1.000	0.757	0.500	0.782	0.500	0.500
m =A	a =A	5	0.500	0.610	0.333	0.708	0.333	0.207
	a =B	1	0.100	0.030	0.333	0.146	0.333	0.207
	a =C	4	0.400	0.360	0.333	0.146	0.333	0.587
m =B	a =A	2	0.125	0.030	0.333	0.146	0.333	0.207
	a =B	11	0.688	0.610	0.333	0.708	0.333	0.207
	a =C	3	0.188	0.360	0.333	0.146	0.333	0.207
λ or γ				1.956	0.003	0.563	0.000	2.087
q								0.600
LL				-36.226	-46.588	-35.026	-46.574	-33.694
s.e.				0.000	0.003	0.001	0.001	
median				1.958	0.003	0.001	0.000	
C.I. low				1.791	0.001	0.362	0.000	
C.I. high				2.282	0.766	0.736	0.135	
AIC				74.453	95.176	72.052	95.148	71.388

Table 8: Evaluation of Various Models: Seccion 1, Game 2, direct reward condition

		n	freq.	AQRE-BE	NNM-SE	NNM-BE	MIXED
t =A	m =A	12	0.923	0.500	0.756	0.500	0.568
	m =B	1	0.077	0.500	0.244	0.500	0.432
t =B	m =A	7	0.539	0.500	0.244	0.500	0.527
	m =B	6	0.462	0.500	0.756	0.500	0.473
m =A	a =A	14	0.737	0.333	0.674	0.333	0.013
	a =B	0	0.000	0.333	0.163	0.333	0.004
	a =C	5	0.263	0.334	0.163	0.333	0.983
m =B	a =A	0	0.000	0.333	0.163	0.333	0.004
	a =B	5	0.714	0.333	0.674	0.333	0.014
	a =C	2	0.286	0.334	0.163	0.333	0.982
λ or γ				0.003	0.511	0.000	9.782
q							0.600
LL				-46.588	-36.507	-46.583	-32.381
s.e.				0.016	0.001	0.001	
median				0.003	0.511	0.000	
C.I. low				0.001	0.362	0.000	
C.I. high				1.711	0.707	0.135	
AIC				95.176	72.014	95.166	68.762

Table 9: Evaluation of Various Models: Seccion 1, Game 3, direct reward condition

		n	freq.	AQRE-SE	AQRE-BE	NNM-SE	NNM-BE	MIXED
t =A	m =A	13	1.000	1.000	0.500	0.984	0.500	0.500
	m =B	0	0.000	0.000	0.500	0.017	0.500	0.500
t =B	m =A	0	0.000	0.000	0.500	0.016	0.500	0.500
	m =B	13	1.000	1.000	0.500	0.984	0.500	0.500
m =A	a =A	13	1.000	0.962	0.333	0.978	0.333	0.000
	a =B	0	0.000	0.000	0.333	0.011	0.333	0.000
	a =C	0	0.000	0.038	0.333	0.011	0.333	1.000
m =B	a =A	0	0.000	0.000	0.333	0.011	0.333	0.000
	a =B	12	0.923	0.962	0.333	0.978	0.333	0.000
	a =C	1	0.077	0.038	0.333	0.011	0.333	1.000
λ or γ				3.219	0.001	0.967	0.000	17.992
q								0.970
LL				-4.244	-46.588	-5.499	-46.586	-4.661
s.e.				0.008	0.000	0.001	0.000	
median				3.219	0.001	0.967	0.000	
C.I. low				2.183	0.000	0.900	0.000	
C.I. high				3.289	0.001	1.000	0.000	
AIC				10.488	95.176	12.998	95.172	13.322

Table 10: Evaluation of Various Models: Seccion 1, Game 1, lottery reward condition

		n	freq.	AQRE-SE	AQRE-BE	NNM-SE	NNM-BE	MIXED
t =A	m =A	10	0.769	0.912	0.500	0.903	0.500	0.500
	m =B	3	0.231	0.089	0.500	0.098	0.500	0.500
t =B	m =A	2	0.154	0.089	0.500	0.097	0.500	0.500
	m =B	11	0.846	0.912	0.500	0.903	0.500	0.500
m =A	a =A	12	1.000	0.876	0.333	0.870	0.333	0.316
	a =B	0	0.000	0.001	0.333	0.065	0.333	0.316
	a =C	0	0.000	0.123	0.333	0.065	0.333	0.368
m =B	a =A	0	0.000	0.001	0.333	0.065	0.333	0.316
	a =B	13	0.929	0.876	0.333	0.870	0.333	0.316
	a =C	1	0.071	0.123	0.333	0.065	0.333	0.368
λ or γ				2.668	0.001	0.805	0.000	0.302
q								0.810
LL				-19.487	-46.588	-20.023	-46.586	-20.006
s.e.				0.015	0.000	0.003	0.000	
median				2.668	0.001	0.805	0.000	
C.I. low				2.282	0.000	0.652	0.000	
C.I. high				3.515	0.001	0.935	0.000	
AIC				40.974	95.176	42.046	95.172	44.012

Table 11: Evaluation of Various Models: Seccion 1, Game 2, lottery reward condition

		n	freq.	AQRE-BE	NNM-SE	NNM-BE	MIXED
t =A	m =A	12	0.923	0.556	0.639	0.500	0.556
	m =B	1	0.077	0.444	0.361	0.500	0.444
t =B	m =A	9	0.692	0.519	0.361	0.500	0.519
	m =B	4	0.308	0.481	0.639	0.500	0.481
m =A	a =A	11	0.524	0.251	0.519	0.308	0.251
	a =B	2	0.095	0.210	0.240	0.308	0.210
	a =C	8	0.381	0.540	0.241	0.385	0.540
m =B	a =A	0	0.000	0.207	0.240	0.308	0.207
	a =B	3	0.600	0.254	0.519	0.308	0.254
	a =C	2	0.400	0.539	0.241	0.385	0.539
λ or γ				1.711	0.279	0.077	1.711
q							0.320
LL				-45.309	-43.638	-46.451	-40.505
s.e.				0.014	0.003	0.003	
median				1.711	0.272	0.077	
C.I. low				0.001	0.066	0.000	
C.I. high				1.711	0.477	0.365	
AIC				92.617	89.276	94.902	85.011

Table 12: Evaluation of Various Models: Seccion 1, Game 3, lottery reward condition

		n	freq.	AQRE-SE	AQRE-BE	NNM-SE	NNM-BE	MIXED
t =A	m =A	12	0.923	0.871	0.500	0.723	0.500	0.500
	m =B	1	0.077	0.129	0.500	0.277	0.500	0.500
t =B	m =A	0	0.000	0.129	0.500	0.277	0.500	0.500
	m =B	13	1.000	0.871	0.500	0.723	0.500	0.500
m =A	a =A	10	0.833	0.628	0.230	0.630	0.231	0.047
	a =B	0	0.000	0.054	0.230	0.185	0.231	0.047
	a =C	2	0.167	0.319	0.539	0.186	0.538	0.907
m =B	a =A	1	0.071	0.054	0.230	0.185	0.231	0.047
	a =B	1	0.071	0.628	0.230	0.630	0.231	0.047
	a =C	12	0.856	0.319	0.539	0.186	0.538	0.907
λ or γ				1.107	1.701	0.447	0.308	5.939
q								0.540
LL				-29.561	-44.284	-39.820	-44.284	-30.435
s.e.				0.000	0.020	0.001	0.004	
median				1.107	1.701	0.447	0.308	
C.I. low				1.022	0.450	0.312	0.077	
C.I. high				1.247	2.662	0.560	0.481	
AIC				61.122	90.568	81.640	90.568	64.870

Table 13: Evaluation of Various Models: Seccion 2, Game 1

		n	freq.	AQRE-SE	AQRE-BE	NNM-SE	NNM-BE	MIXED
t =A	m =A	11	0.846	0.626	0.500	0.597	0.500	0.500
	m =B	2	0.154	0.374	0.500	0.403	0.500	0.500
t =B	m =A	2	0.154	0.374	0.500	0.403	0.500	0.500
	m =B	11	0.846	0.626	0.500	0.597	0.500	0.500
m =A	a =A	7	0.539	0.399	0.212	0.462	0.212	0.139
	a =B	0	0.000	0.106	0.212	0.269	0.212	0.139
	a =C	6	0.462	0.495	0.577	0.269	0.577	0.722
m =B	a =A	4	0.308	0.106	0.212	0.269	0.212	0.139
	a =B	0	0.000	0.399	0.212	0.462	0.212	0.139
	a =C	9	0.692	0.495	0.577	0.269	0.577	0.722
λ or γ				1.755	2.008	0.194	0.365	3.295
q								0.290
LL				-40.197	-43.359	-45.345	-43.385	-39.691
s.e.				0.001	0.030	0.001	0.006	
median				1.755	2.008	0.194	0.365	
C.I. low				1.711	0.467	0.000	0.077	
C.I. high				1.844	3.795	0.370	0.654	
AIC				82.394	88.718	92.690	88.770	83.382

Table 14: Evaluation of Various Models: Seccion 2, Game 2

		n	freq.	AQRE-BE	NNM-SE	NNM-BE	MIXED
t =A	m =A	10	0.799	0.500	0.547	0.500	0.500
	m =B	3	0.201	0.500	0.453	0.500	0.500
t =B	m =A	7	0.539	0.500	0.453	0.500	0.500
	m =B	6	0.462	0.500	0.547	0.500	0.500
m =A	a =A	8	0.471	0.306	0.396	0.308	0.280
	a =B	5	0.294	0.306	0.302	0.308	0.280
	a =C	4	0.235	0.388	0.302	0.385	0.440
m =B	a =A	2	0.222	0.306	0.302	0.308	0.280
	a =B	1	0.111	0.306	0.396	0.308	0.280
	a =C	6	0.667	0.388	0.302	0.385	0.440
λ or γ				0.472	0.094	0.077	0.904
q							0.140
LL				-46.435	-46.258	-46.451	-45.806
s.e.				0.021	0.006	0.003	
median				0.472	0.087	0.077	
C.I. low				0.001	0.000	0.000	
C.I. high				1.711	0.314	0.308	
AIC				94.870	94.516	94.902	95.612

Table 15: Evaluation of Various Models: Seccion 2, Game 3

		n	freq.	AQRE-SE	AQRE-BE	NNM-SE	NNM-BE	MIXED
t =A	m =A	37	0.949	0.966	0.500	0.900	0.500	0.500
	m =B	2	0.051	0.034	0.500	0.100	0.500	0.500
t =B	m =A	3	0.077	0.034	0.500	0.100	0.500	0.500
	m =B	36	0.923	0.966	0.500	0.900	0.500	0.500
m =A	a =A	32	0.800	0.778	0.333	0.867	0.333	0.000
	a =B	0	0.000	0.013	0.333	0.066	0.333	0.000
	a =C	8	0.200	0.209	0.333	0.066	0.333	1.000
m =B	a =A	0	0.000	0.013	0.333	0.066	0.333	0.000
	a =B	33	0.868	0.778	0.333	0.867	0.333	0.000
	a =C	5	0.132	0.209	0.333	0.066	0.333	1.000
λ or γ				1.461	0.001	0.801	0.000	17.686
q								0.850
LL				-56.119	-139.761	-63.737	-139.738	-53.870
s.e.				0.006	0.000	0.002	0.000	
median				1.461	0.001	0.802	0.000	
C.I. low				1.287	0.001	0.712	0.000	
C.I. high				1.801	0.003	0.879	0.000	
AIC				114.238	281.522	129.474	281.476	111.740

Table 16: Evaluation of Various Models: Seccion 3, Game 1

		n	freq.	AQRE-BE	NNM-SE	NNM-BE	MIXED
t =A	m =A	31	0.795	0.556	0.530	0.500	0.556
	m =B	8	0.205	0.444	0.470	0.500	0.444
t =B	m =A	27	0.692	0.519	0.470	0.500	0.519
	m =B	12	0.308	0.481	0.530	0.500	0.481
m =A	a =A	19	0.328	0.251	0.374	0.224	0.251
	a =B	4	0.069	0.210	0.313	0.224	0.210
	a =C	35	0.603	0.540	0.313	0.551	0.540
m =B	a =A	3	0.150	0.207	0.313	0.224	0.207
	a =B	9	0.450	0.254	0.374	0.224	0.254
	a =C	8	0.400	0.539	0.313	0.551	0.539
λ or γ				1.711	0.061	0.327	1.711
q							0.120
LL				-127.311	-139.324	-131.933	-125.338
s.e.				0.000	0.000	0.000	
median				1.711	0.061	0.327	
C.I. low				1.711	0.000	0.173	
C.I. high				1.711	0.179	0.481	
AIC				256.622	280.648	265.866	254.676

Table 17: Evaluation of Various Models: Seccion 3, Game 3

		n	freq.	AQRE-SE	AQRE-BE	NNM-SE	NNM-BE	MIXED
t =A	m =A	38	0.974	0.995	0.500	0.962	0.500	0.500
	m =B	1	0.026	0.005	0.500	0.039	0.500	0.500
t =B	m =A	1	0.026	0.005	0.500	0.038	0.500	0.500
	m =B	38	0.974	0.995	0.500	0.962	0.500	0.500
m =A	a =A	36	0.923	0.876	0.333	0.948	0.333	0.000
	a =B	0	0.000	0.002	0.333	0.026	0.333	0.000
	a =C	3	0.077	0.122	0.333	0.026	0.333	1.000
m =B	a =A	0	0.000	0.002	0.333	0.026	0.333	0.000
	a =B	37	0.949	0.876	0.333	0.948	0.333	0.000
	a =C	2	0.051	0.121	0.333	0.026	0.333	1.000
λ or γ				2.007	0.001	0.923	0.000	17.992
q								0.940
LL				-31.099	-139.764	-31.729	-139.755	-27.912
s.e.				0.019	0.000	0.001	0.000	
median				2.078	0.001	0.923	0.000	
C.I. low				1.626	0.001	0.868	0.000	
C.I. high				3.151	0.001	0.967	0.000	
AIC				64.198	281.527	65.458	281.510	59.825

Table 18: Evaluation of Various Models: Seccion 4, Game 1

		n	freq.	AQRE-BE	NNM-SE	NNM-BE	MIXED
t =A	m =A	32	0.820	0.556	0.543	0.500	0.556
	m =B	7	0.180	0.444	0.457	0.500	0.444
t =B	m =A	28	0.718	0.519	0.457	0.500	0.519
	m =B	11	0.282	0.481	0.543	0.500	0.481
m =A	a =A	20	0.333	0.251	0.390	0.269	0.251
	a =B	10	0.167	0.210	0.305	0.269	0.210
	a =C	30	0.500	0.540	0.305	0.462	0.540
m =B	a =A	2	0.111	0.207	0.305	0.269	0.207
	a =B	10	0.556	0.254	0.390	0.269	0.254
	a =C	6	0.333	0.539	0.305	0.462	0.539
λ or γ				1.711	0.086	0.192	1.711
q							0.140
LL				-133.232	-138.940	-137.020	-130.377
s.e.				0.002	0.000	0.001	
median				1.711	0.088	0.192	
C.I. low				0.224	0.000	0.038	
C.I. high				1.711	0.204	0.346	
AIC				268.464	279.880	276.040	264.753

Table 19: Evaluation of Various Models: Seccion 4, Game 3