Public Announcements and Coordination in Dynamic Global Games: Experimental Evidence

Olga Shurchkov

Online Appendix:

Not for publication

Contents

A. The role of the realization of the fundamental, theta

Tables A1 and A2 control for theta in all specifications, and are otherwise identical to Tables 4 and 5, respectively.

Firstly, I find that conditioning on theta does not substantively change my main findings. In particular, the announcement has a significant positive effect on the probability of attacking and on the belief about the size of the attack only in the second stage of the treatment with new information.

Secondly, Table A1 shows that there is a positive and significant coefficient on theta in all specifications in the first stage. This implies that subjects are relatively more aggressive in terms of their first-stage likelihood of attacking in rounds with high realizations of theta, conditional on the private signal and the announcement. This finding is consistent with the evidence presented in Figure 1 in the paper which shows that the aggregate size of the attack does not significantly differ from the theoretical prediction in rounds with low realizations of theta, whereas the size of the attack is significantly larger than predicted in rounds with high realizations of theta.

Table A1 Logistic Estimates of the Determinants of Individual Actions in Stage 1, Conditional on θ

	Dependent Variable: Action in Stage 1			
Variable	1	2	3	4
Private signal, x	-0.010***	-0.007***	-0.010***	-0.007***
	(0.0010)	(0.0010)	(0.0010)	(0.0010)
Realization of θ	0.005***	0.004***	0.004***	0.003**
	(0.001)	(0.001)	(0.001)	(0.001)
Announce A	0.059	0.026		
	(0.047)	(0.024)		
Belief		0.311***		0.302***
		(0.032)		(0.032)
Announce A, First 5 Rounds			0.150***	0.079**
			(0.055)	(0.031)
Announce A, Remaining Rounds			0.039	0.017
			(0.044)	(0.022)
Session	1	1	1	1
No. of observations	436	436	436	436

Notes: All specifications report average marginal effects estimates from logit regressions with subject fixed effects and robust standard errors clustered at the group-round level in parentheses. All specifications use data from session 1 which revealed the announcement in stage 1. Significance levels: *** 1 percent; ** 5 percent; *10 percent.

Thirdly, Table A2 shows that theta realization actually has a negative effect on the probability of attacking in the second stage, although the effect is only significant in Columns 3 and 5. This implies that, after a failed first-stage attack, the subjects are less aggressive in the second stage in rounds with lower realizations of theta.

Table A2 Logistic Estimates of the Determinants of Individual Actions in Stage 1, Conditional on θ

| | Dependent Variable: Action | | | | | | |
| | Stage 2; NI | | | Stage 2; NNI | | Pooled Data; NI & NNI | |
Variable	1	2	3	4	5	6	7
Private signal, x	0.015	0.016	0.005***	-0.003	-0.002	-0.006***	-0.002**
	(0.016)	(0.0150)	(0.0020)	(0.002)	(0.0020)	(0.0010)	(0.0010)
Realization of θ	-0.019	-0.019	-0.006***	-0.003	-0.004**	0.002**	0.001**
	(0.016)	(0.0150)	(0.0020)	(0.002)	(0.0020)	(0.0010)	(0.0010)
Announce A	0.173***		0.016**	-0.017			
	(0.049)		(0.006)	(0.046)			
Announce A, First 5 Rounds		0.123***			0.076		
		(0.045)			(0.095)		
Announce A, Remaining Rounds		0.223***			-0.061*		
		(0.038)			(0.034)		
Belief			0.116***				0.265***
			(0.012)				(0.012)
Second Stage Dummy						-0.073***	-0.002
						(0.009)	(0.011)
NI Dummy						-0.088	0.042
						(0.071)	(0.042)
NI + Announce A						0.030	-0.002
						(0.049)	(0.024)
NNI + Announce A						-0.025	-0.024**
						(0.034)	(0.009)
Second Stage + Announce A						0.023	0.000
						(0.027)	(0.011)
Second Stage + NI						0.006	-0.017
						(0.025)	(0.027)
Second Stage + Announce A + NI						0.098**	0.030
						(0.039)	(0.031)
Session	2&3	2&3	2&3	4	4	2, 3, & 4	2, 3, & 4
No. of observations	205	205	205	85	85	842	842

Notes: All specifications report average marginal effects estimates from logit regressions with subject fixed effects and robust standard errors clustered at the group-round level in parentheses. Sp. 1 - 5 are based on Stage 2 data of sessions 2&3 which revealed the announcement in stage 2. Sp. 6&7 use pooled first- and second-stage data for sessions 2-4 which revealed the announcement in stage 2; rounds that continued into the second stage only. Significance levels: *** 1 percent; ** 5 percent; *10 percent.

B. Determinants of Individual Beliefs

Table A3 shows the determinants of individual beliefs about the size of the attack. In particular, Columns 1-3 show that individuals form their beliefs in the first stage based on the strength of their private signal, as one would expect based on the theory prediction. A higher x implies a significant decrease in the expected size of the attack in the first stage. On average, the announcement plays no role in belief formation in the first stage (Column 1). This too is consistent with the implication of uniqueness of equilibrium that subjects should disregard the first-stage announcement. Columns 2 and 3 reveal that subjects learn to play according to this equilibrium prediction over the first few rounds of play: the announcement positively affects individual beliefs, but only in the first 5 rounds of the experiment.

Columns 4-6 report second-stage estimates for the main treatment: new information in the second stage. The significant positive effect of the announcement on the belief about the size of the attack in all three specifications is consistent with the theory prediction of a new attack becoming possible under conditions of multiplicity in this treatment. Note that the specification in Column 6 reveals that the private signal, conditional on the realization of theta, is no longer a significant determinant of the belief about the attack fraction, making the announcement the sole driver of aggressiveness in this treatment.

Columns 7-9 offer a placebo test of the pure announcement effect and show that, in the second stage of the treatment with no new information, the announcement has no effect on individual beliefs both on average (Column 7) and when I consider the first five rounds of the experiment (Columns 8 and 9). This too supports the theory prediction that, in the environment where the only second-stage information is the fact that the game survived a first-stage attack, the subjects are more pessimistic about their chances of mounting a successful second-stage attack.

Columns 10 and 11 pool the data to show the combined effects for the rounds that continued into the second stage. The interaction coefficient of interest is reported in the last row (Second Stage + Announce A + NI). Once again, the estimates confirm that receiving an announcement of A in addition to new information in the second stage significantly increases the expected size of the attack. Theta realization does not have a significant effect and does not change the coefficients on other variables of interest (Column 11).

Note that the theta realization does not seem to be a significant determinant of beliefs in any of the specifications (Columns 3, 6, 9, and 11), and its inclusion does not substantively change any of the estimates, except in Column 6. Here, the private signal, conditional on theta, is no longer a significant determinant of the belief about the attack fraction, making the announcement the sole driver of aggressiveness in this treatment.

Table A3 OLS Estimates of the Determinants of Individual Beliefs about the Size of the Attack

	Dependent Variable: Belief about the Fraction of Subjects Attacking										
	Stage 1			Stage 2; NI			Stage 2; NNI			Stage 2 Pooled Data	
Variable	1	2	3	4	5	6	7	8	9	10	11
Private signal, x	-0.005***	-0.004***	-0.006***	-0.004***	-0.004***	0.009	-0.003**	-0.003***	-0.0001	-0.004***	-0.004***
	(0.0003)	(0.0003)	(0.002)	(0.001)	(0.001)	(0.013)	(0.001)	(0.001)	(0.002)	(0.0010)	(0.0010)
Announce A	0.077			0.180**			-0.015				
	(0.050)			(0.064)			(0.068)				
Announce A, First 5 Rounds		0.206***	0.206***		0.140**	0.139*		-0.06	-0.061		
		(0.058)	(0.058)		(0.067)	(0.067)		(0.086)	(0.087)		
Announce A, Remaining Rounds		0.052	0.053		0.250***	0.248**		0.004	-0.001		
		(0.049)	(0.049)		(0.087)	(0.087)		(0.076)	(0.075)		
Realization of θ			0.001			-0.013			-0.004*		-0.001
			(0.002)			(0.013)			(0.002)		(0.001)
Second Stage Dummy										-0.041***	-0.041***
										(0.011)	(0.011)
NI Dummy										-0.035	-0.033
										(0.082)	(0.084)
NI + Announce A										0.056	0.056
										(0.049)	(0.049)
NNI + Announce A										-0.024	-0.024
										(0.065)	(0.065)
Second Stage + Announce A										0.002	0.002
										(0.037)	(0.037)
Second Stage + NI										-0.039	-0.038
										(0.026)	(0.026)
Second Stage + Announce A + NI										0.122**	0.122**
										(0.049)	(0.049)
Session	1	1	1	2&3	2&4	2&3	4	4	4	2, 3, & 4	2, 3, & 4
R-squared	0.49	0.50	0.50	0.52	0.53	0.53	0.35	0.36	0.38	0.46	0.46
No. of observations	450	450	450	300	300	300	195	195	195	990	990

Notes: All specifications include subject fixed effects; robust standard errors are clustered at the group-round level in parentheses. Sp. 1 - 3 use data from session 1 which revealed the announcement in Stage 1. Sp. 4 - 9 are based on Stage 2 data of sessions 2-4 which revealed the announcement in stage 2. Sp. 10 & 11 use pooled first- and second-stage data for sessions 2-4; rounds that continued into the second stage only. Significance levels: *** 1 percent; ** 5 percent; *10 percent.

C. Individual-Level Learning over Rounds

Table A4 below performs the analysis of the effect of past attack outcomes on the probability of attacking at the individual level. I find that the attack outcome in the previous round does not significantly increase the probability of attacking either in the first or in the second stage, controlling for all other factors.

Table A4 Effects of Past Attack Outcome on Individual Actions

Variable	Dependent Variable: Pr (Action A)			
	Stage 1		Stage 2 Pooled Data	
	1	2	3	4
Attack Outcome in Previous Round	0.073	0.05	0.024	0.012
	(0.073)	(0.045)	(0.0270)	(0.0080)
Private signal, x	-0.006***	-0.003***	-0.004***	-0.001
	(0.001)	(0.0010)	(0.0010)	(0.0010)
Announce A	0.016	-0.001		
	(0.059)	(0.031)		
Belief		0.339***		0.280***
		(0.035)		(0.019)
Second Stage Dummy			-0.069***	-0.008
			(0.009)	(0.009)
NI Dummy			-0.081	0.037
			(0.074)	(0.037)
NI + Announce A			0.022	-0.003
			(0.052)	(0.021)
NNI + Announce A			-0.036	-0.044***
			(0.033)	(0.010)
Second Stage + Announce A			0.020	0.000
			(0.028)	(0.014)
Second Stage + NI			-0.005	-0.007
			(0.024)	(0.021)
Second Stage + Announce A + NI			0.107***	0.020
			(0.040)	(0.027)
Session	1	1	2, 3, & 4	2, 3, & 4
No. of observations	313	313	842	842

Notes: All specifications report average marginal effects estimates from logit regressions with subject fixed effects and robust standard errors clustered at the group-round level in parentheses. Sp. 1 & 2 use data from session 1 which revealed the announcement in stage 1. Sp. 3 & 4 use pooled first- and second-stage data for sessions 2-4 which revealed the announcement in stage 2; rounds that continued into the second stage only. Significance levels: *** 1 percent; ** 5 percent; *10 percent

D. Sample Experimental Instructions

You are now participating in an economic experiment. Please read the following instructions carefully, paying attention to details. You will receive all the information you require for participation in the experiment. If you do not understand something, please raise your hand. We will answer your question at your desk.

Communication between participants is absolutely forbidden during the experiment! Not obeying this rule will lead to immediate exclusion from the experiment and all payments. If you have a question during the experiment, please raise your hand.

Your payment in this experiment will be calculated in points at first. The total point score you earn during the experiment will be converted to US Dollars at the end of the experiment. The following exchange rate applies in this case:

10 points = 20 cents

You will receive the amount of points you earned during the experiment plus $10 for appearing in **cash**.

The experiment consists of **15 rounds;** each round consists of one or two decision stages.

You are one of **16 people** who interact with each other during the experiment. In each round of the experiment, a <u>different</u> **announcer** is chosen in randomly from these 16 people. The rules that the announcer must follow are described below in a separate section of the instructions. The instructions are the same for the other 15 people. Since almost all of you will, at one point, become an announcer, please, read both sets of instructions.

In the first stage of each round, you must choose either action A or B, based on the information available to you. If there is a second stage in a round, you will again have to decide choose either action A or B.

Income: Announcer

If you are chosen as an announcer in a particular round, you will be asked to choose either action A or B. Your income depends on whether or not you can match the choices of other 15 people.

♦ If you choose action A:
- You will earn an income of 60 points, if action A is **successful**.
- You will incur a loss of 60 points, if action A is **not successful**.

♦ If you choose action B:
- You will earn an income of 60 points, if action A is **not successful**.
- You will incur a loss of 60 points, if action A is **successful**.

Whether action A is successful or not depends on whether more than Y% of the other 15 people chose action A.

If action A is successful in the first stage (i.e., enough of the 15 other people chose it), the round will end and the next one will begin. If action A was not successful in the first stage (i.e., less than Y% of the other 15 people selected it), the round will continue into the second stage. You will NOT have to make another announcement in this second stage. Losses, which may occur if your announcement does not match the choices of other 15 people, will be financed by the income from other rounds or, if necessary, from the show up-fee of $10.

Income: Non-Announcer

You must choose either action A and action B in every stage of every round.

♦ If you choose action A, you will incur a **cost of 60 points** and you will earn a **gross income of either 100 or 0 points**, depending whether action A is successful or not.
  - If action A is **successful**, you will earn an income of $100 - 60 = 40$ points
  - If action A is **not successful,** you will incur a loss of $0 - 60 = -60$ points.

  Again, whether action A is successful or not depends on whether more than Y% of the 15 people chose action A.

♦ If you choose action B, you will neither incur costs nor earn an income, independent of what others have chosen. Your income from B is thus always 0.

If action A is successful in the first stage (i.e., enough of the 15 other people chose it), the round will end and the next one will begin. If action A was not successful in the first stage (i.e., less than Y% of the other 15 people selected it), the round will continue into the second stage. In the second stage, each of the 15 non-announcers must again choose either action A or B. The round always ends after stage 2, at which point the next round begins (15 rounds in total). Losses, which may occur if action A is unsuccessful, will be financed by the income from other rounds or, if necessary, from the show up-fee of $10.

What determines whether action A is successful or not?

The number Y dictates the minimum percentage of people that need to choose action A for action A to be successful. The number **Y is randomly determined in each round and remains fixed for the duration of each round.** If, for example, Y is 60, then at least 60% of the 15 people (i.e. at least 9 people) must choose action A for it to be successful. In this case, all who choose action A earn an income amounting to $100 - 60 = 40$ points. If fewer than 60% select A (8 people or fewer), A will be unsuccessful. In this case, all who choose A will incur a loss amounting to 60 points $(0 - 60 = -60)$.

The computer selects the number Y at the beginning of each round from a normal distribution with an average value of 75 and a standard deviation of 55. This means that the **average value** of Y is 75, but the number Y drawn may deviate from the average value in a round. Positive and negative deviations from the number 75 are equally probable. The distribution (standard deviation) of the number Y was chosen in such a way that there is approximately a 33% probability that Y lies between 20 and 75 and an equal probability of approximately 33% that Y lies between 75 and 120. For reasons of simplicity, the number Y selected is rounded to one decimal point.

Please note that Y can also take on a negative value. In this case, a single individual suffices to make action A successful. Y can also exceed 100. In this case, action A is never successful, even if all 15 people (i.e. 100%) choose action A. The attached information sheet shows the minimum number of people needed to choose A in order for A to be successful.

Information
Your Private Hint Number

You do not know how large Y is when you make your decision. You only know that Y has an average value of 75 and a distribution of 55.

If you **ARE NOT the announcer** (i.e., you are one of the other 15 people in the group), you will receive a **private hint number x** that gives you information about the value of Y. The private hint number x is given in the form of $x = Y + z$, where z is a normally distributed random variable with an average value of 0 and a standard deviation of 10. **On average, the private hint number x accurately reflects the value of Y, because the value of the random variable z is zero on average.** However, in any given situation, the hint number can differ from Y. **In particular, there is approximately 67% probability that Y lies within ±10 of your hint number x.**

Example 1: You receive a private hint number of 24.5 in stage 1. There is thus a probability of approximately 67% that the unknown random number Y lies within ± 10 of your private hint number (i.e., there is 67% probability that Y lies between 14.5 and 34.5).

Example 2: You receive a private hint number of 62.8 in stage 1. There is a 67% probability that Y lies between 52.8 and 72.8.

In the 2nd stage of each round, each of the 15 non-announcers will receive an additional, **much more precise, private hint number**. The additional private hint number is a lot more precise (100 times more precise) such that there is approximately 67% probability that **Y now lies within ±1 of your hint number.** Please, note that the value of the random number Y is the same in stage 1 and stage 2. However, because of **the additional, more precise hint number, you can better gauge the value of Y in stage 2.**

Example 1: You receive a private hint number of 20.2 in stage 2. There is thus a probability of approximately 67% that the unknown random number Y lies within ± 1 of your private hint number (i.e., there is 67% probability that Y lies between 19.2 and 21.2).

Example 2: You receive a private hint number of 63.1 in stage 2. There is a 67% probability that Y lies between 62.1 and 64.1.

If you **ARE the announcer**, **you will NOT receive a hint number** in that round**.**

Exact procedure in stage 1 of a round

The computer first draws the random number Y. The random number is the same for all participants. The announcer then chooses to announce either A or B (see the example below). Next, this announcement and a private hint number are given to each of the other 15 participants. Since the private hint numbers vary around the true value of Y, each of the 15 participants usually receives a different private hint number. However, there is always a 67% probability that the true value of Y lies within the interval of ±10 of the private hint number.

Each of the 15 non-announcers then decides whether to choose action A or B. The decision is entered on the decision screen (see the next page for the example). When you have made your decision, please press the OK button. You can revise your decision until you press the OK button.

The first screen that the ANNOUNCER sees:

Round		
1 of 15		Remaining Time [sec]: 51

YOU ARE THE ANNOUNCER IN THIS ROUND

Please, choose either action A or B

I announce: ○ A
             ○ B

OK

The first screen the 15 NON-ANNOUNCERS see:

You are in currently Stage 1.

THE ANNOUNCER CHOSE ACTION   B

Your hint number is   88.5

Please, choose either action A or B

I choose: A
             B

OK

After all the 15 people have decided, each is asked on a new screen about his or her assessment of the frequency of action A.

The next screen will contain relevant information. If action A is successful, each of the 16 participants will be informed about how many people chose action A, the fact that action A was successful, the actual value of the random number Y, and the income in the round. If action A was not successful, each of the 16 participants will be informed that action A was not successful, that the round will continue into the second stage, and each will learn the income in the first stage. The announcer will be also reminded that he or she does NOT need to make another announcement in the second stage (see the next page for an example).

The ANNOUNCER'S information screen

Information for Stage 1

You were the announcer in this round

You announced action   B

Action A was not successful. The round will continue into Stage 2.

Your income in this round is   60.00

You will NOT have to make another announcement. Please, wait for the experiment to continue.

next screen

The NON-ANNOUNCER'S information screen in Stage 1

Information for Stage 1

You chose action   A

Action A was not successful; the round will continue into Stage 2.

Your income in Stage 1 is   -60.00

next screen

The exact procedure in stage 2 of a round

If action A was not successful in the first stage, the announcer does **not** make another announcement. The other 15 participants will **not** be informed of actual value of Y, but will receive an additional, more precise hint number such that there is 67% probability that Y lies within the interval of ±1 of the private hint number. Then, the 15 participants must again decide between actions A and B. The rules of this stage are otherwise identical to those in the first stage.

The NON-ANNOUNCER'S decision screen in Stage 2
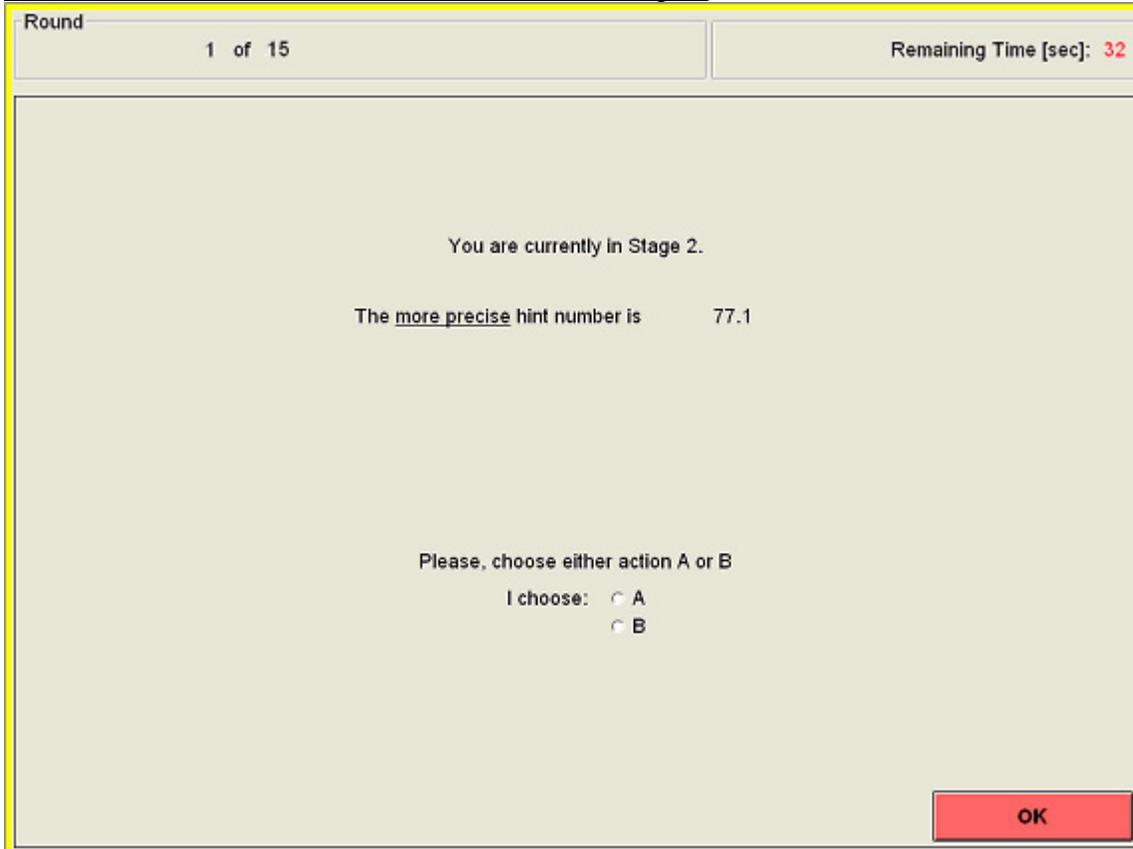
The calculation of income in stage 2 is exactly the same as that in stage 1. Individuals who opt for action B neither earn an income nor incur a cost. Those who opt for action A earn an income of 100 – 60 = 40 points, if action A is successful, and an income of 0 – 60 = –60 points, if action A is not successful.

Another information screen appears at the end of stage 2 that informs you about the following (please, refer to the screen on the next page):

- Your income in stage 1
- Number of people who chose action A in stage 2
- The random number Y in this round
- Whether action A was successful in stage 2
- Your income in stage 2
- Your total income in this round

The NON-ANNOUNCER'S information screen in Stage 2

Complete Information after Stage 2

You chose action A in Stage 2

Your income in Stage 1 was	-60.00
The total number of people who chose action A in Stage 1 was	10
The total number of people who chose action A in Stage 2 was	12
The random number was	76.2

In Stage 2, action A was successful.

Your income in Stage 2 is	40.00
Your total income in this round is	-20.00

next screen

A new round then begins; the computer first draws a new random number Y. You will then receive a new private hint number based on the new random number Y, which will give you information about Y.

The incomes stemming from each round will be added up at the end of the experiment. In addition to the show-up fee, this will constitute your entire income for the experiment. Losses that might result from individual rounds will be funded by means of income from other rounds or, if necessary, from the show-up fee of $10.

Control questions

Please answer all of the following questions. If you have any questions, please raise your hand!

1. The random number Y has the value of -3.4. How many people must choose action A for A to be successful?

   At least _____ people must choose A.

2. The random number Y has the value of 34.2. How many people must choose action A for A to be successful?

   At least _____ people must choose A.

3. The random number Y has the value of 105.0. How many people must choose action A for A to be successful?

   At least _____ people must choose A.

4. Your private hint number in stage 1 is 16.4. Find the interval around your private hint number within which the random number Y lies with a probability of 67%.

   The interval around my private hint number is _____

5. Your private hint number in stage 2 is 48.1. Find the interval around your private hint number where the random number Y lies with a probability of 67%.

   The interval around my private hint number is _____

6. The random number Y is 63.1, and your private hint number is 56.4. Assume you choose action A at stage 1 of this round. Four other people also select action A.

   a) How much do you earn at stage 1 of this round?   I earn _____ points.

   b) You again choose action A at stage 2 and 9 other people also choose action A. How much do you earn at stage 2 of this round?

   I earn _____ points in stage 2.

7. The random number Y is 63.1, and your private hint number is 56.4. Assume you choose action B at stage 1 of this round. Four other people select action A.

   a) How much do you earn at stage 1 of this round?   I earn _____ points.

b) You then choose action B at stage 2 and 10 other people choose action A. How much do you earn at stage 2 of this round?

I earn _____ points in stage 2.

8. The random number Y is 63.1, and your private hint number is 56.4. Assume you choose action B at stage 1 of this round. Four other people select action A.

a) How much do you earn at stage 1 of this round?   I earn _____ points.

b) You then choose action A at stage 2 and 10 other people choose action A. How much do you earn at stage 2 of this round?

I earn _____ points in stage 2.

Information sheet

The random number Y indicates the minimum percentage of people who must choose action A in order for action A to be successful. The following table shows how many people must choose action A in order for action A to be successful, if the random number assumes certain values.

In order to understand the table, you should keep in mind that 1 of 15 participants represents 6.6%, 2 of 15 participants represent 2 x 6.6% = 13.3%, etc.

The right column shows the minimum number of participants who must choose action A for action A to be successful. The left column shows the corresponding intervals for the random number Y.

IF THE UNKNOWN NUMBER Y LIES IN THE FOLLOWING INTERVAL:	THE FOLLOWING MINIMUM NUMBER OF THE 15 PEOPLE MUST CHOOSE A FOR ACTION A TO BE SUCCESSFUL.
<0	0
0 – 6.6	1
6.7 – 13.3	2
13.4 – 20.0	3
20.1 – 26.6	4
26.7 – 33.3	5
33.4 – 40.0	6
40.1 – 46.6	7
46.7 – 53.3	8
53.4 – 60.0	9
60.1 – 66.6	10
66.7– 73.3	11
73.4 – 80.0	12
80.1 – 86.6	13
86.7 – 93.3	14
93.4 – 100	15
>100	>15 (i.e. impossible)