Supplemental Materials for "Monetary-Incentive Competition between Humans and Robots: Experimental Results"

October 11, 2018

A Video Demonstration and Screenshots

A.1 Video Demonstration

https://drive.google.com/open?id=1NOlo7DSo4IHz-ONN_i6vpKbVMNYJJSDu

A.2 Screenshots

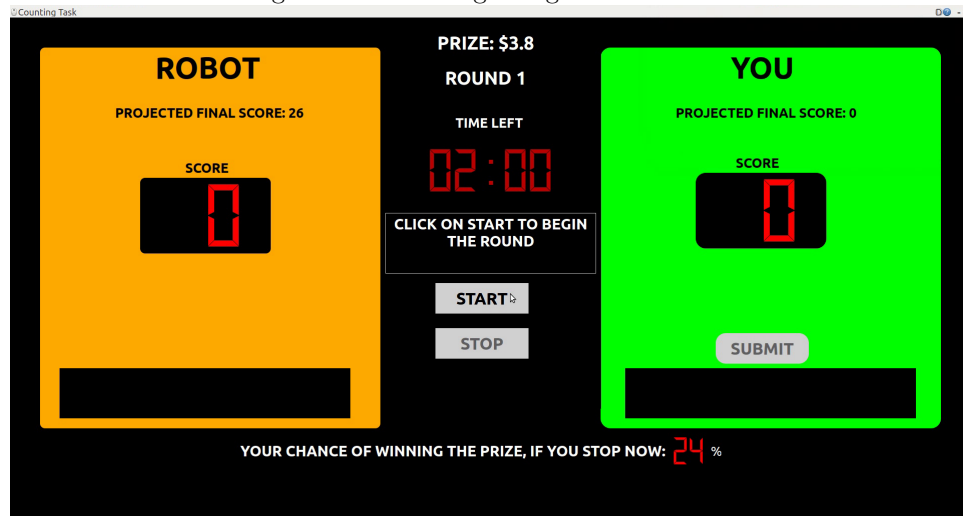Figure 1: Before beginning the round
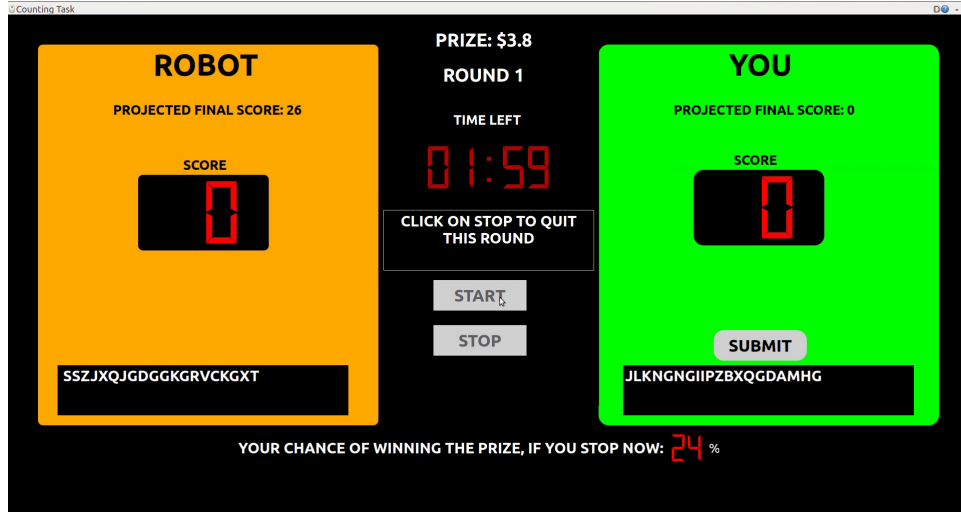
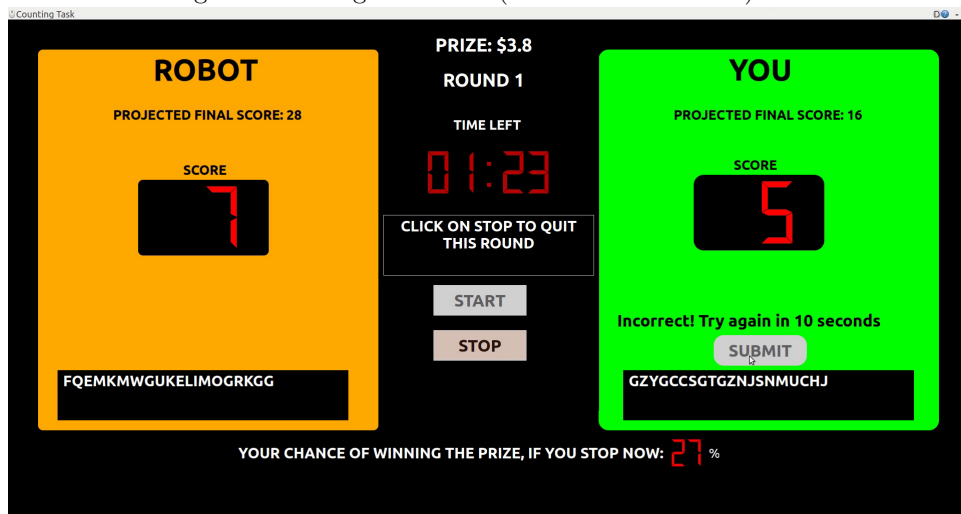Figure 2: After clicking on 'START'

Figure 3: During the round (incorrect submission)

Figure 4: During the round (correct submission)

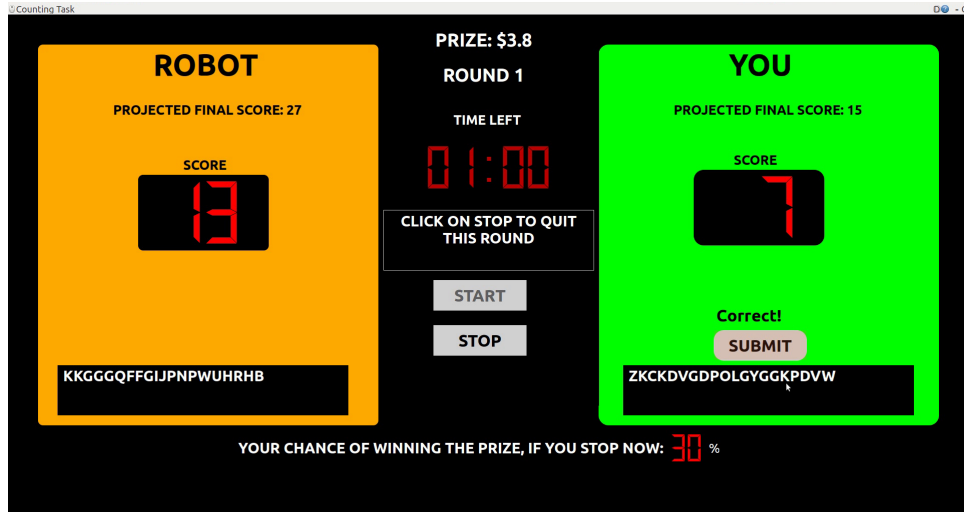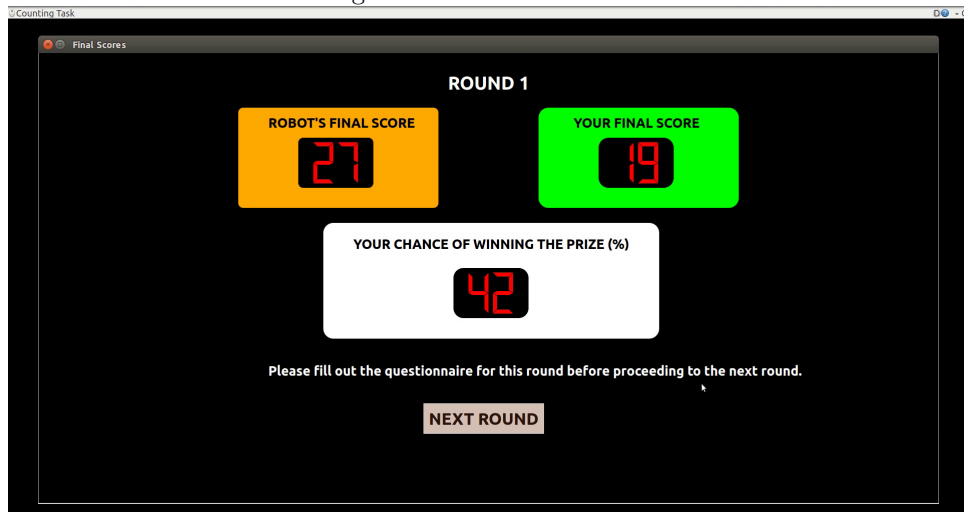Figure 5: End of round

B   Recruitment Page, Consent Form and Instructions

Figure 6: Screenshot of the SONA recruitment page

Study Name	Decision Making with a Robot
Study Type	**Standard (lab) study** This is a standard lab study. To participate, sign up, and go to the specified location at the chosen time.
Pay	10 Dollars
Duration	50 minutes
Abstract	We are seeking participants for an experimental study on decision making.
Description	Participants will make decisions in the presence of a robotic arm. The task will be quite strenuous, so if you choose to participate, please select a sign-up slot in which you are well-rested and alert. The interactions will be logged and recorded. The study will last approximately 50 minutes. Participants will receive $10 for their time. The payment will be made on the day following the study.
Researchers	BSL Admin ✉
	Ori Heffetz ✉
	Guy Hoffman ✉
	Alap Ravindra Kshirsagar ✉
Principal Investigator	Principal Investigator
Deadlines	Sign-Up: 24 hour(s) before the appointment Cancellation: 24 hour(s) before the appointment

[Consent form and instructions start on the next page]

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Consent Form

We are asking you to participate in a research study on people's decision making. We will describe this study to you and answer any of your questions.

This study is being conducted by Alap Kshirsagar, Sibley School of Mechanical and Aerospace Engineering, Cornell University. The Faculty Advisor for this study is Guy Hoffman. Ori Heffetz, another faculty member, is also a member of the research team.

The purpose of this research is to investigate how people make decisions. We will ask you to compete with a robotic arm by performing a task that involves counting letters and arranging blocks. The experiment will last approximately 50 minutes.

We do not anticipate any risks from participating in this research. You can choose to quit at any time.

Compensation for participation
You will receive $10 for your time. In addition to this, based on your performance you have a chance to win more money, as explained in the experiment.

Audio/Video Recording
During the experiment, we will log your task-progress. The data will not have any personally identifiable information.

Privacy/Confidentiality/Data Security
You will be assigned subject numbers for purposes of recording and analysis of data. All information which could link the subject number to a participant will be in a locked file under the Investigator's control only. No identifiers will be published, subjects will be referred only using the subject number in subsequent publications and presentations.

Data Sharing
De-identified data from this study may be shared with the research community at large to advance science and health. We will remove or code any personal information that could identify you before files are shared with other researchers to ensure that, by current scientific standards and known methods, no one will be able to identify you from the information we share. Despite these measures, we cannot guarantee the anonymity of your personal data.

Taking part is voluntary
Your involvement is voluntary, you may refuse to participate before the study begins, discontinue at any time, or skip any questions/procedures that may make you feel uncomfortable, with no penalty to you, and no effect on the compensation earned before withdrawing, or your academic standing, record, or relationship with the university or other organization or service that may be involved with the research.

Follow up studies

May we contact you again to request your participation in a follow up study? (Yes/No)

If you have questions

Please ask any questions you have now. If you have questions later, you may contact Alap Kshirsagar at ak2458@cornell.edu. If you have any questions or concerns regarding your rights as a subject in this study, you may contact the Institutional Review Board (IRB) for Human Participants at 607-255-5138 or access their website at http://www.irb.cornell.edu. You may also report your concerns or complaints anonymously through Ethicspoint online at www.hotline.cornell.edu or by calling toll free at 1-866-293-3077. Ethicspoint is an independent organization that serves as a liaison between the University and the person bringing the complaint so that anonymity can be ensured.

Statement of Consent:

I have read the above information, and have received answers to any questions I asked. I consent to take part in the study.

Your Signature   Date

Your Name (printed)

Signature of person obtaining consent   Date

Printed name of person obtaining consent

This consent form will be kept by the researcher for five years beyond the end of the study.

Instructions:

Thank you for participating in this session. Please read these instructions carefully.

Please turn off your mobile phones or keep them on silent mode (not vibrate).

In this session, you will compete, for real monetary prizes, with the robotic arm in front of you. You will compete in several rounds. Each round will result in a chance of winning a monetary prize. This chance will determine a lottery that will happen tomorrow, when you return to the lab. Each round has its own prize and its own separate lottery draw.

Everything written in these instructions is true. For example, when we mention a monetary prize, the prize is real. When you return to the lab for payment tomorrow, if you win the lottery related to a certain prize, you will actually receive that prize, in cash.

If you have any questions while reading these instructions, please make sure to ask the experimenter.

On the screen you will see information related to the task you and the robot compete on. Below is a screenshot of what you see on the screen. We will explain soon what you see here.
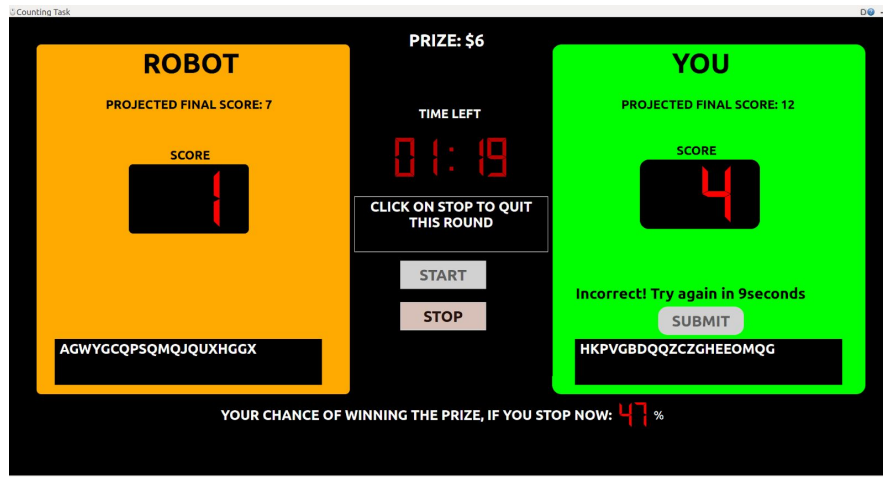
Here is an image of what the bins used for the task look like (we will explain this soon too):
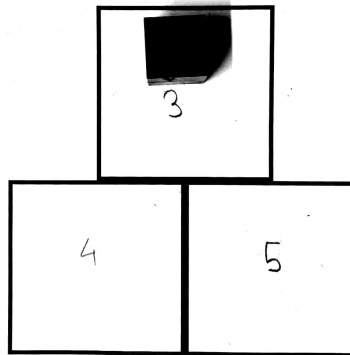
You and the robot will work on identical tasks as described below:

1) You and the robot each receive a randomly generated text. Your text is displayed on the bottom of the "YOU" side of the screen in a black box, and the robot's text is displayed at the bottom of the "ROBOT" side of the screen. Please locate the text now.

2) You (and the robot) have to count the number of G letters in your texts. There will be either 3,4, or 5 G letters in the text. In the example above, your text contains the letter G three (3) times, and the robot's text contains four (4) occurrences.

3) You (and the robot) have to place the block in the corresponding bin. In the example above, you have to place the block in the bin labeled "3". (The robot will place the block in the bin labeled "4")

4) Once you've arranged your block, click the 'Submit' button on the screen above the text, to validate your block arrangement. The mounted camera will then analyze your block arrangement.

- If your block is placed in the **correct location**, your 'Score' will increase by 1 point, and your next text will appear on the screen.

- If your block is placed in the **incorrect location**, you will get no points, and the 'Submit' button will become disabled for 10 seconds. After 10 seconds, the 'Submit' button will be enabled again, and you can try again. (Of course, you can recount the letters and rearrange the block while the 'Submit' button is disabled; you just cannot click 'Submit' until the button is enabled again.)

The competition will have a practice round, followed by several paying rounds. Each round will last two (2) minutes. Different rounds are for different amounts of money. The robot will follow a pre-programed algorithm in each round. The robot may have different speeds in different rounds, but its speed is not affected in any way by your performance and speed. The 'Projected Final Score' of the Robot on a new round's screen reflects the robot's speed in that round.

You do not have to compete for the full two minutes and can choose to move to the next round at any time during these two minutes. In other words, you can analyze as many texts as you want up to two minutes, or click the 'Stop' button if you do not want to continue. This will start the next round.

Points to Note: You and the robot are doing the same task, but texts will be different. If you click 'Stop' before the two minutes are up, the assumption is that the robot would have continued until the end of the two-minute round, with the same average performance it had until the moment when you clicked 'Stop', and would therefore have achieved the robot's projected final score.
Please let the experimenter know at this point if there any questions about the task description.

We now explain what you see on the screen above the texts.

[On each side - bottom to top]
1. SCORE (ROBOT / YOU) : Points accumulated so far
2. PROJECTED FINAL SCORE (ROBOT / YOU) : Total points expected at the end of the 2-minute round. This value is calculated based on the average speed so far: the computer calculates how many points per second you've made so far, and multiplies this number by the total time of round. Of course, this number assumes a constant average speed for you, and may change if you speed up or slow down. The calculation is as follows:

$$PROJECTED\ FINAL\ SCORE\ =\ \frac{SCORE}{TIME\ ELAPSED\ (in\ seconds)} * 120$$

[In the center - top to bottom]
3. PRIZE: The monetary prize for this round. Note that this prize will be paid out based on a lottery happening tomorrow, when you return to the lab. The lottery is related to the points you collect, as described in the next section.
4. TIME LEFT: Time left in the round

5. START: Click here to begin the round
6. STOP: Click here to end the round
7. YOUR CHANCE OF WINNING THE PRIZE, IF YOU STOP NOW: If you choose to stop the round, the robot's final score will be made equal to its projected final score and your final score will be made equal to your score (not your projected final score), at that instant. The calculation of this number is as follows:

$$Your\ chance\ of\ winning,\ if\ you\ stop\ now\ (\%) = 50 + (Your\ Score - Robot's\ Projected\ Final\ Score)$$

Every 5 seconds, you will hear this number in a robotic voice.

Prize Scheme:

Your chance of winning the prize for each round depends on the difference between the robot's final score and your final score. If the scores are the same, you and the robot each have 50% chance of winning the prize. If the scores are not the same, the chance of winning for whoever has the higher points score increases by 1 percentage point for every increase of 1 in the difference between the scores, while the chance of winning for whoever has the lower score correspondingly decreases by 1 percentage point.

That means that your chance of winning the price increases by 1% for every increase of 1 point in your final score, and decreases by 1% for every increase of 1 point in the robot's final score.

$$Your\ chance\ of\ winning(\%) = 50 + (Your\ Final\ Score - Robot's\ Final\ Score)$$

For example:

Your Final Score	Robot's Final Score	Your Final Score minus Robot's Final Score	Your Chance of Winning the Prize	Robot's Chance of Winning the Prize
10	10	0	50%	50%
5	2	3	53%	47%
25	10	15	65%	35%
10	25	-15	35%	65%
0	40	-40	10%	90%

Points to note: Your chance of winning the prize depends on the difference between the robot's final score and your final score. Assuming the robot's final score will equal its projected final score, your chance of winning the prize increases by 1% for every additional point that you score. (Remember that if you choose to quit a round early, then the robot's final score will be made equal to its projected final score for that round.)

The lottery for each paying round will happen tomorrow when you visit the lab again. We will use a public website (http://www.roll-dice-online.com/) for this purpose. For each paying round, we will roll a 100-sided die on that website, meaning the website randomly chooses a number between 1 and 100. If the result of the die roll is less than or equal to your chance of winning the prize, then you will win the prize for that round. For example, if your chance of winning the prize is 80%, then you will win the prize for any number between 1 and 80, and not win the prize for any number between 81 and 100. Please be assured that you will be paid in a fair way.

Here is a screenshot of the website we will use tomorrow:

Please let the experimenter know at this point if there are any questions about the prize scheme.

Comprehension Quiz

To make sure you understand the prize scheme correctly, please fill out the following brief comprehension quiz.

Please let the experimenter know when you are done filling out the quiz.

Lottery Resolution Demonstration

To make sure you are familiar with the lottery-resolution procedure that will be followed tomorrow when you return to the lab, please complete the following demonstrations.

Please let the experimenter know when you are finished with the demonstrations.

Questionnaires

After each round, you will be asked to fill out a short questionnaire.

Also, at the end of all paying rounds, you will be asked to fill out another questionnaire.

Practice Round

To familiarize yourself with the competition task and reward scheme, you will now participate in a practice round. The task description for the practice round is same as that for the actual competition. The practice round will last for 2 minutes. There is no monetary prize for the practice round.

Are there any final questions?

Comprehension Quiz:

Please answer these questions based on the information provided to you. These questions are designed to test whether you understand the reward scheme for this competition.

Your Score	Robot's Projected Final Score	Difference between Your Score and Robot's Projected Final Score	Your Chance of Winning the Prize, if You Stop Now.
5	5		
5	25		
5	45		
25	5		
25	25		
25	45		
45	5		
45	25		
45	45		

Q1: If the Robot's 'Projected Final Score' is 10 and your 'Score' increases from 20 to 21, what is the increase in your chance of winning the prize?

Q2: If the Robot's 'Projected Final Score' is 20 and your 'Score' increases from 20 to 21, what is the increase in your chance of winning the prize?

Q3: Is it true that your chance of winning the prize increases by 1% for every 1 point increase in your 'Score', for any given robot's 'Projected Final Score'?

Die-Rolling Demonstration:

Please go to the website http://www.roll-dice-online.com/ for a demonstration of the die-rolling procedure that will be followed when you return to the lab tomorrow.

Set the parameters as follows:
- Number of sides = 100
- Number of dice to roll = 1
- Number of rolls = 1.

Hypothetical Round 1: Prize = $1, Your score = 15, Robot's score = 10
- Imagine that in one of today's rounds, the prize were $1, your score were 15, and the robot's score were 10.
- In that case, your chance of winning that round's prize tomorrow would be ___%.
- Imagine that you came back to the lab tomorrow to roll the die for that round. Please click 'Roll dice.' What number came up? ___
- With that die-roll outcome, would you win the $1, or would the robot win? I \ ROBOT.
- If the answer is "I" please write "I" in the leftmost square in the table below. If the answer is "ROBOT," please write "R" in the square.
- Now repeat this process 9 more times (overall 10 die rolls) to get a feel for the uncertainty of winning the prize. After each roll, determine in your head who would win the prize, and fill the leftmost empty square with an "I" or "R" accordingly.

Hypothetical Round 2: Prize = $1, Your score = 9, Robot's score = 38
- In that case, your chance of winning that round's prize tomorrow would be ___%.
- Now repeat the process above (with another 10 die rolls) and fill the table below with "I"s and "R"s accordingly.

Hypothetical Round 3: Prize = $1, Your score = 26, Robot's score = 5
- In that case, your chance of winning that round's prize tomorrow would be ___%.
- Now repeat the process above (with another 10 die rolls) and fill the table below with "I"s and "R"s accordingly.

Questionnaires

(To be filled at the end of each round)

Round Number ____

Please rate how much you like the robot on the following scale (circle the number):

Dislike 1 2 3 4 5 Like

Please rate how much you consider the robot to be competent on the following scale:

Incompetent 1 2 3 4 5 Competent

Please rate how true the following sentence is for you with respect to this task:

I feel confident in my ability to do this word-counting task well.

1	2	3	4	5	6	7
Not at all true			Somewhat true			very true

Round Number ____

Please rate how much you like the robot on the following scale (circle the number):

Dislike 1 2 3 4 5 Like

Please rate how much you consider the robot to be competent on the following scale:

Incompetent 1 2 3 4 5 Competent

Please rate how true the following sentence is for you with respect to this task:

I feel confident in my ability to do this word-counting task well.

1	2	3	4	5	6	7
Not at all true			Somewhat true			very true

Round Number ____

Please rate how much you like the robot on the following scale (circle the number):

Dislike 1 2 3 4 5 Like

Please rate how much you consider the robot to be competent on the following scale:

Incompetent 1 2 3 4 5 Competent

Please rate how true the following sentence is for you with respect to this task:

I feel confident in my ability to do this word-counting task well.

1	2	3	4	5	6	7
Not at all true			Somewhat true			very true

(To be filled at the end of the competition)
PLEASE MARK THE APPROPRIATE COLUMN WITH AN "X"
*

	Not At All True	Hardly True	Moderately True	Exactly True
1. I can always manage to solve difficult problems if I try hard enough				
2. If someone opposes me, I can find the means and ways to get what I want.				
3. It is easy for me to stick to my aims and accomplish my goals.				
4. I am confident that I could deal efficiently with unexpected events.				
5. Thanks to my resourcefulness, I know how to handle unforeseen situations.				
6. I can solve most problems if I invest the necessary effort.				
7. I can remain calm when facing difficulties because I can rely on my coping abilities.				
8. When I am confronted with a problem, I can usually find several solutions.				
9. If I am in trouble, I can usually think of a solution				
10. I can usually handle whatever comes my way				

(To be filled at the end of the competition)
PLEASE MARK THE APPROPRIATE COLUMN WITH AN "X"

	Very untrue of me	Untrue of me	Somewhat untrue of me	Neutral	Somewhat true of me	True of me	Very true of me
	1	2	3	4	5	6	7
1. I put money ahead of pleasure							
2. I firmly believe that money can solve all of my problems							
3. I would do practically anything legal for money if it were enough							
4. I believe that a person's salary is very revealing in assessing their intelligence							
5. I worry about my finances much of the time							
6. I enjoy working in situations involving competition with others							
7. I feel that winning is important in both work and games							
8. It is important to me to perform better than others on a task							
9. It annoys me when other people perform better than I do							
10. I try harder when I'm in competition with other people							

Please write a few sentences about your experience of competing with this robot.

Finally, if you have any comments or thoughts you would like to share with us, please write them here. We are especially curious to know: how did you decide in each round how strongly to compete?