An eye-tracking study of feature-based choice in one-shot games

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Appendices

Appendix A: Experimental procedure and instructions

The experiment was conducted at the EPL lab (Experimental Psychology Laboratory) of the University of Trento. As we are only interested in the row players' behavior, we collected eye-tracking data for row players only, and matched each row player with a column player drawn at random from the pool of subjects participating in the experiment in Di Guida and Devetag (2013).

For the eye-track record, a head mounted, video-based eye tracker, model "EyeLink", version 1.11 was used. The software for the decision tasks was written in Matlab, using the Psychophysical Toolbox version 2.5.4 and the Eye-Link Toolbox version 1.4.4 to interface it with the eye-tracker hardware. During the calibration procedure, subjects were asked to fix nine points located in different parts of the screen, to allow the experimenter to record current eye and head position. The calibration was followed by a validation phase, identical to the calibration one, aimed to verify whether the recorded positions were sufficiently accurate. If necessary, both calibration and validation were repeated. Before the beginning of each trial a drift correction was performed.

In order not to increase pupil dilatation during the experiment, the matrix was designed with white lines on a black background. To minimize noise, information displayed on the monitor was limited to payoffs only. Strategy labels were eliminated, as it was straightforward for subjects to remember (once explained) that players' actions were labeled according to the order in which they appeared, from top to bottom and from left to right. In addition, payoffs were positioned as far as possible from each other, with row and column players´ payoffs at different latitudes. This made the classification of eye movements easier and less ambiguous. To further avoid confusion, the two players' payoffs were presented in different colors. Finally, no time constraints were imposed on subjects to choose their strategies.

To begin the trial, a fixation point coincident with the last point of the drift correction had to be fixed for 300 ms (last point of the validation phase for the first trial of each block). The fixation point was located at the bottom of the screen, outside the area covered by the matrix, to minimize biases related to the starting fixation point.

The games were then presented in three blocks of ten games each, to allow subjects to take a short break and to re-calibrate cameras if necessary. After the eye-tracking machinery was calibrated, subjects played four practice games. The order in which the 30 matrices of interest were displayed was random and differed across subjects.

Once the experiment was concluded, subjects had to complete a series of questionnaires aimed at measuring cognitive abilities, personality traits, and degree of risk aversion.

After completing the questionnaire, subjects were presented two urns: the first containing 30 tags, each corresponding to one of the matrices played, the second containing 20 tags, one for each possible opponent. They were then asked to draw 3 tags from each urn, to select both the games and the opponents that would determine their earnings.

INSTRUCTIONS

The following is a translation of the original instructions in Italian. Original instructions are available upon request.

INSTRUCTIONS

Dear student, you are about to participate in an experiment on interactive decision-making. Your privacy is guaranteed: results will be used and published anonymously. All your earnings during the experiment will be expressed in ***Experimental Currency Units*** (ECUs). Your earnings will depend on your performance in the experiment, according to the rules which we will explain to you shortly. You will be paid privately and in cash at the end of the experimental session. Other participants will not be informed about your earnings. After the experiment you are asked to complete a short questionnaire. The maximum you can earn in the experiment is 14 Euros, the minimum 7.

THE EXPERIMENTAL STRUCTURE

The experiment consists of 30 rounds; in each round you will face an interactive decision making situation. In each round you will have to choose **one among three options**: the word "interactive" means that the outcome of your decision will be determined by your choice and by the choice of another participant, randomly chosen at the end of the experimental session.

The structure of each interactive decision problem, henceforth GAME, will be represented by a table like the one below:

C R	C R	C R
C R	C R	C R
C R	C R	C R

where letters will be substituted by numbers, indicating an amount of ECUs. The table has three rows and three columns.

You and the participant with whom you are paired will play the roles, respectively, of ROW PLAYER and COLUMN PLAYER.

The available choices of the ROW PLAYER (for you) are represented by the ROWS of the table (the first row on top, the second row in the middle, the third at the bottom), and the available choices of the COLUMN PLAYER are represented by the COLUMNS of the table (the first column on the left, the second column in the center, the third column on the right).

Each possible combination of choices of row and column player (i.e., each possible combination of rows and columns of the table) identifies one cell in the matrix. Each cell reports two numerical values. These values indicate the earnings (in Experimental Currency Units) of each participant associated with that combination of choices. Conventionally, the number on the bottom of the cell represents the earnings of the ROW PLAYER (your earning), while the number on the top represents the earnings of the COLUMN PLAYER.

For example: in the table below, if YOU choose the top row and the OTHER PLAYER chooses the column in the middle, then your earnings will be those in the cell at the inter- section between the selected row and column.

In this example YOU earn 4 ECUs and the OTHER PLAYER 7 ECU.

4 6	7 4	3 5
4 3	6 5	5 3
6 5	4 6	7 4

Bear in mind that you cannot directly choose the cell of the table, but only one of the rows (the other participant with whom you are matched will choose one column). Only the combination of both choices will select one and only one cell, corresponding to your earnings and to those of the other participant.

INFORMATION

In each of the 30 rounds, the screen will show the decisional table for that round, and you will be asked to make a decision knowing your gain will depend only on that choice and the choice of the person matched with you.

Please remember that you cannot choose a single cell, but only the row that you prefer, given your considerations.

To help you with your choice, the ECUs of the row player (yours) are positioned in the bottom-left corner of each cell and will be in yellow, while the ECUs of the column player will be in the top right corner of the cell and will be in red.

To select your choice you will have to press key 1 for row 1 (the row on the top of the matrix), 2 for row 2 (the row in the middle of the matrix), and 3 for row 3 (the row on the bottom of the matrix).

You will face 30 decisional matrices, corresponding to 30 different interactive situations. The matrices are divided in 3 blocks of 10 matrices each. After each block there will be a short procedure to verify the correct focus of the eye-link equipment.

There is no relation among your choices in the different games, each game is independent from the others.

There is no time limit. We only ask you to try, if possible, to take no longer than one minute for each game.

At the end of the 30th round, the first part of the experiment will be completed, and your earnings for this part will be determined.

PAYMENTS

Each matrix is identified by a code. Some tags have been placed in a box, each showing the code of one of the matrices. The experimenter will ask you to pick 3 of these tags from the box. You will be paid according to the earnings obtained in the tables corresponding to the extracted codes. In a second box 20 tags have been placed, corresponding to 20 subjects that have participated in the experiment as column player. You will have to draw 3 tags from this box too.

Your earnings will be determined by your choices and by the choices of the three people selected, in the three matrices you have drawn. Each matrix will be associated with one column player only, to have exactly 3 outcomes.

Since each of the 30 decisional tables of the experiment has a positive probability of being selected for payment, we ask you to devote the same attention to all of them.

Before the experiment starts, we will ask you to answer a simple anonymous questionnaire, in order to test whether instructions have been clearly understood or whether clarifications are needed. If there are incorrect answers, the relevant part of the instructions will be repeated. After the questionnaire phase is completed, the experiment proper will start.

At the end of the experiment, the experimenter will communicate the exchange rate between Euros and ECUs, you will have to complete a questionnaire, and you will be paid privately and in cash.

Thank you for your kind participation!

Appendix B: Questionnaire

Dear Participant,

the following questionnaire has the sole purpose of verifying your understanding of the rules of this experiment. We ask you to answer the following questions. If you are uncertain about how to respond, please consult the instructions sheet. Your answers to these questions will not affect your earnings in the experiment.

Thank you for your cooperation!

2 3	4 2	9 1
6 4	5 4	6 7
3 2	2 1	8 2

Suppose you are assigned the role of ROW PLAYER:

- If the COLUMN PLAYER chooses the central column and you choose the top row, how many ECUs will you earn? ..... And how many will the other player earn? .....
- If you choose the central row, and COLUMN PLAYER chooses the column on the right, how many ECUs will that person earn? ..... And how many ECUs will you earn? .....
- If the other player chooses the column on the left, your earnings will be:
    - If you choose the top row: .....
    - If you choose the central row: .....
    - If you choose the bottom row: .....

Suppose you are assigned the role of COLUMN PLAYER

- If the ROW PLAYER chooses the central row and you choose the left column, how many ECUs will you earn? ..... And how many will the other player earn? .....
- If the other player chooses the top row, your earnings will be:
    - If you choose the column on the left: .....
    - If you choose the central column: .....

- If you choose the column on the right: .....

- Your role (as ROW or COLUMN PLAYER) in the rounds of the experiment will change:

  TRUE or FALSE

- The participant with whom you are paired will be determined randomly in each round, and you will never be matched more than once with the same participant.

  TRUE or FALSE

- After you have taken your decision on a table, you will be able to observe the choice of the participant with whom you were paired.

  TRUE or FALSE

Appendix C: Risk attitudes and personality measures

We present here the questionnaires on cognitive abilities and personality traits that have been presented to experimental subjects after the conclusion of the experiment, briefly summarizing the goal of each of these tests. After the experiment, the tests were not presented as a unique questionnaire, since some of them required a direct interaction with the experimenter. Therefore, we prefer to discuss each test separately, rather than report the exact format that was presented to subjects. Besides the tests presented in this appendix, subjects were presented the "Holt and Laury Risk Aversion test".

Test of the Theory of Mind

In Psychology, Theory of Mind (TOM) indicates not only the ability to predict and comprehend the mental states of other intelligent beings, but also the ability to understand that others can have state of minds that are different from one's own.

The term Theory of Mind has been proposed for the first time by Premack and Woodruff (1978) in a study on chimpanzees, and since then this stream of research has received increasing attention, concerning in particular the role of TOM in developmental age (Wimmer and Perner 1983; Fodor 1992) and in individuals with cognitive dysfunctions (like autism, Baron-Cohen 1995).

Tests for TOM are designed to discriminate subjects with normal cognitive capacities from those with cognitive dysfunctions. No tests have been designed to discriminate among different levels of TOM ability in subjects with normal cognitive capacities.

Of the several tests of TOM proposed in the literature, we decided to use the one known as *Reading the Mind in the Eyes test* (Baron-Cohen et al. 2001; Baron-Cohen 2004). This test is the least trivial for subjects with normal cognitive capacities. The test was aimed to test the existence of correlations between an agents' TOM ability and her ability to locate equilibria in the game due to an increased capacity to develop correct beliefs on the opponent's behavior, assuming this latter capacity is correlated with TOM ability.

We used the version presented in Baron-Cohen (2004), translated from English into Italian and validated before publication.

In this test, experimental subjects are presented with 36 pictures of the eye-region of faces of different persons; for each picture, subjects have to select, from a list of four possible states of mind, the one that best describes the state of mind of the person portrayed.

Working Memory test, Wechsler Digit Span test, and Cognitive Reflection test

In order to test the role of memory capacity and cognitive reflection in strategic behavior, we presented three short tests to our experimental subjects: the *Cognitive Reflection* test (Frederick 2005), the

Wechsler Digit Span test for short memory (Walsh and Betz 1990), and a *working memory* test (Unsworth and Engle 2007).

The *Cognitive Reflection* test was proposed by Frederick (2005) and aims to measure a specific type of cognitive ability, i.e. the ability to resist an immediate, intuitive and wrong answer, executed with little deliberation, in favor of the search for the correct answer requiring a more complex reasoning. This is motivated by the distinction of two cognitive systems in the human mind: System 1 gives spontaneous reactions and does not require explicit reasoning (as in recognizing a known face), while System 2 requires effort and concentration (as in solving a complex mathematical equation) (Epstein 1994; Frederick 2005).

The cognitive abilities measured by this test are particularly relevant for the situations faced by subjects in this experiment, as our payoff matrices included both ”intuitive” choice options (like the attractor strategy) and options (such as the equilibrium strategy) requiring sophisticated reasoning to be detected.

The test consists of three simple questions, for each of which an impulsive – and wrong - answer comes naturally to the mind of the reader. The questions are the following (Frederick 2005):

1. A bat and a ball cost 1.10 in total. The bat costs 1.00 more than the ball. How much does the ball cost?
2. If it takes 5 machines 5 minutes to make 5 widgets, how long would it take 100 machines to make 100 widgets?
3. In a lake, there is a patch of lily pads. Every day, the patch doubles in size. If it takes 48 days for the patch to cover the entire lake, how long would it take for the patch to cover half of the lake?

The score of the test corresponds to the number of correct answers given.

The *Wechsler Digit Span* test is part of a more complex test called *Wechsler Memory Scale* developed by David Wechsler (1987) to measure human memory capacity.

We focused on the *Digit Span,* as we were interested only on a test of short-term memory (defined as the ability to store a small amount of information and recall it after a short time). Although the overall reliability of the *Wechsler Memory Scale* has been more recently reconsidered (Elwood 1991), the reliability of its single components (such as the Digit Span) has been confirmed and has been used in recent economic experiments (Devetag and Warglien 2008; Rydval, Ortmann, and Ostatnicky 2009).

In this test, subjects are asked to repeat a sequence of digits immediately after the experimenter has finished reading it. The first sequence contains three numbers, and successive strings are of increasing length; the test stops when the subject commits an error in recalling a sequence. The whole test is then repeated. The number of digits of the longest string that has been correctly recalled by the subject corresponds to the score obtained in the test.

The strings of numbers were the same for all subjects.

The working-memory test used in this experiment is called *Immediate Free Recall* and refers to a large literature on working memory that defines it as the ability of temporarily storing and manipulating information. Given the definition of short-term memory that we gave before, working-memory is defined as the ability to manipulate and organize information stored in short-term memory.
Despite the plausibility of this distinction, several scholars do not consider the two processes as distinct, and include short-term memory into working-memory (Unsworth and Engle 2007).
Since the topic is still debated, we decided to administer a test called *Immediate Free Recall*, one of the few working-memory tests that can be done using paper and pencil.
In the test, the experimenter reads aloud ten words (each every 1 or 2 seconds). Once finished, the subject writes down as many words as she can remember. In this experiment (unlike the *Wechsler Digit Span* test) the order in which the words are recalled is not relevant.
We selected a list of ten words randomly sampling from the "Toronto Noun Pool" (to be found at http://memory.psych.upenn.edu/WordPools) of the University of Pennsylvania. The list was the same for all experimental subjects.

Premeditation, Sensation Seeking, Need for Cognition, Perseverance, and Math Anxiety

These five scales aim to measure different personality traits that are relevant from an economic perspective; for example, an individual with low confidence in his mathematical abilities will probably not be able to locate the equilibrium of a game, while an individual prone to sensation seeking will probably be more risk seeking. These tests have already been successfully used in recent economic experiments (e.g., Rydval, Ortmann, and Ostatnicky 2009).

The *Premeditation* scale measures individuals' propensity to control their impulsive instincts and reason carefully when carrying out a particular task, *Need for Cognition* measures subjects' intrinsic motivation and level of commitment, while *Perseverance* measures (as the name suggests) the natural tendency of an individual to persist in a demanding task. We assumed these three scales could be positively correlated with the ability to locate the equilibrium of a game, or negatively correlated with the tendency to look for safe or "obvious" solutions (strategies giving a constant payoff, or attractors). In all scales, a low number indicates a high level of premeditation, commitment, and perseverance.
Sensation Seeking measures the natural tendency of an individual to look for exciting situations and can be considered a measure of risk propensity. In the experiment, sensation seekers might choose the strategy giving the highest possible payoff (maximaxi or Optimistic) regardless of the risk involved in the choice. In this scale, a low score indicates a high level of sensation seeking.

Math Anxiety measures the feelings that an agent has when dealing with mathematical tasks and might be correlated with the ability to locate the equilibrium of the game. A low score indicates a relaxed feeling towards mathematics.

These scales have the common drawback of being self-reports. This implies that there is no control on the attention and effort exerted in answering the questions; in addition, subjects answer according to their own opinion about themselves (which could be an inaccurate evaluation of their capacities or propensities). For example, a person might result as having a high score of *Sensation Seeking* because she might be overconfident but not really willing to act in accordance with her own self-image.

In the experiment, we presented to the subjects a questionnaire of 55 questions covering all the scales. For each question, subjects had to choose the preferred answer among "True, Quite True, Quite False, False".

	Wechsler digit span test	H&L	Working memory	Cognitive Reflection Test	Theory of Mind	Premeditation	Sensation Seeking	Need For Cognition	Perseverance	Math Anxiety	Strategic IQ
Average Time	0.42	-0.01	0.14	0.39	0.10	-0.01	0.20	0.27	0.18	0.16	0.51
Gender	-0.31	0.10	-0.08	-0.31	-0.02	-0.14	0.07	0.24	-0.25	0.14	-0.40
Wechsler digit span test		-0.26	0.21	0.48	0.10	0.18	0.25	-0.09	0.43	-0.16	0.46
H&L	-0.26		-0.11	-0.04	-0.13	-0.06	-0.15	0.16	-0.05	0.35	-0.14
Working memory	0.21	-0.11		0.14	0.24	0.04	0.31	-0.25	0.19	0.09	0.19
Cognitive Reflection Test	0.48	-0.04	0.14		0.19	-0.05	0.26	-0.13	0.06	-0.28	0.61
Theory of Mind	0.10	-0.13	0.24	0.19		-0.10	0.32	-0.20	-0.12	-0.16	0.08
Premeditation	0.18	-0.06	0.04	-0.05	-0.10		-0.33	0.06	0.18	0.06	0.09
Sensation Seeking	0.25	-0.15	0.31	0.26	0.32	-0.33		-0.10	-0.09	-0.23	0.20
Need For Cognition	-0.09	0.16	-0.25	-0.13	-0.20	0.06	-0.10		0.26	0.52	-0.09
Perseverance	0.43	-0.05	0.19	0.06	-0.12	0.18	-0.09	0.26		0.36	0.19
Math Anxiety	-0.16	0.35	0.09	-0.28	-0.16	0.06	-0.23	0.52	0.36		-0.21
EQ choices	0.37	-0.43	0.26	0.43	0.13	0.31	0.18	-0.18	0.19	-0.31	0.80
A choices	-0.09	0.19	-0.17	-0.16	-0.09	0.22	-0.35	0.20	0.03	0.40	-0.06
HA choices	-0.25	0.19	0.05	-0.17	0.16	-0.36	0.26	0.01	-0.21	-0.09	-0.35
RPr	0.09	0.37	0.14	0.03	0.02	-0.43	0.27	0.09	0.01	0.23	0.07
CPr	0.35	-0.03	0.07	0.19	-0.01	0.04	-0.07	0.32	0.32	0.39	0.37
RPc	0.54	-0.06	0.24	0.36	0.01	-0.11	0.27	-0.13	0.33	0.04	0.46
CPc	0.53	-0.28	0.25	0.49	0.07	0.08	0.07	0.03	0.32	-0.02	0.71
INF	0.24	-0.09	0.04	0.25	0.19	0.20	0.05	0.34	0.18	0.15	0.43
(R1,C1) Cell	0.27	0.07	0.11	0.33	0.13	-0.04	0.13	0.23	0.04	0.20	0.33
(R1,C2) Cell	0.34	0.11	0.19	0.31	0.11	-0.17	0.20	0.24	0.14	0.24	0.39
(R1,C3) Cell	0.46	-0.16	0.21	0.43	0.14	-0.01	0.24	0.23	0.26	0.00	0.66
(R2,C1) Cell	0.41	-0.03	0.18	0.36	0.02	-0.03	0.15	0.26	0.17	0.22	0.47
(R2,C2) Cell	0.44	0.08	0.14	0.25	0.08	-0.02	0.20	0.18	0.24	0.22	0.39
(R2,C3) Cell	0.43	-0.18	0.15	0.38	0.11	0.08	0.18	0.24	0.27	0.08	0.63
(R3,C1) Cell	0.45	0.04	0.25	0.46	0.10	-0.09	0.25	0.09	0.15	0.05	0.49
(R3,C2) Cell	0.42	0.11	0.16	0.24	0.14	-0.18	0.29	0.11	0.21	0.11	0.36
(R3,C3) Cell	0.51	-0.25	0.19	0.43	0.21	0.11	0.26	0.11	0.30	-0.03	0.74
AOI 1	0.13	0.20	0.04	0.20	0.05	-0.13	0.15	0.28	-0.07	0.23	0.15
AOI 2	0.22	0.20	0.13	0.14	0.11	-0.32	0.27	0.21	0.06	0.24	0.18
AOI 3	0.33	-0.06	0.20	0.35	0.17	-0.18	0.30	0.25	0.17	0.04	0.52
AOI 4	0.20	0.21	0.13	0.28	0.02	-0.17	0.22	0.31	0.01	0.25	0.20
AOI 5	0.23	0.31	0.05	0.08	0.01	-0.18	0.23	0.20	0.11	0.29	0.14
AOI 6	0.42	-0.09	0.16	0.36	0.14	-0.04	0.33	0.23	0.19	0.06	0.56
AOI 7	0.23	0.20	0.08	0.27	0.03	-0.13	0.20	0.11	0.04	0.08	0.21
AOI 8	0.21	0.26	0.09	0.08	0.10	-0.29	0.28	0.08	0.09	0.18	0.11
AOI 9	0.45	-0.17	0.15	0.23	0.17	-0.03	0.30	0.06	0.26	0.01	0.58
AOI 10	0.37	-0.13	0.15	0.38	0.17	0.14	0.08	0.18	0.19	0.14	0.48
AOI 11	0.42	-0.09	0.18	0.40	0.12	0.07	0.12	0.18	0.23	0.16	0.56
AOI 12	0.48	-0.26	0.19	0.45	0.12	0.12	0.18	0.15	0.26	-0.02	0.68
AOI 13	0.43	-0.16	0.18	0.33	0.07	0.07	0.09	0.21	0.23	0.16	0.51
AOI 14	0.46	-0.12	0.14	0.31	0.07	0.13	0.10	0.16	0.29	0.16	0.55
AOI 15	0.42	-0.25	0.16	0.39	0.08	0.10	0.14	0.20	0.28	0.03	0.64
AOI 16	0.43	-0.17	0.21	0.42	0.14	0.07	0.17	0.14	0.23	0.08	0.61
AOI 17	0.49	-0.10	0.15	0.37	0.17	0.09	0.17	0.14	0.29	0.08	0.58
AOI 18	0.47	-0.26	0.17	0.43	0.19	0.13	0.18	0.14	0.29	-0.03	0.69

Table 1 Correlation between variables testing personality traits, choices (only the main categories were considered), transitions, number of fixations (by cell and by AOI) and strategic IQ. Shaded coefficients are statistically significant at the 5 per cent level according to a Spearman correlation test