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Feature-based Choice and Similarity in Normal-form Games: An Experimental Study

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Feature-based Choice and Similarity Perception in Normal-form Games: An Experimental Study

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Abstract

In this paper, we test the effect of descriptive “features” on initial strategic behavior in normal form games, where the term “descriptive” indicates all those features which can be modified without altering the (Nash) equilibrium structure of a game. Our experimental subjects behaved according to some simple heuristics based on descriptive features, and we observed that these heuristics were stable even across strategically different games. These findings indicate the need to incorporate descriptive features into models describing strategic sophistication in normal form games. Analysis of choice patterns and individual response times indicates that non-equilibrium choices may derive from incorrect and simplified mental representations of the game structure, rather than from beliefs in other players' irrationality. Of the five stationary concepts analyzed (Nash equilibrium, QRE, action sampling, cognitive hierarchy, and payoff sampling), QRE turned out to be the best in fitting the data.

Keywords: normal form games, one-shot games, response times, dominance, similarity, categorization, focal points

JEL classification codes: C72, C91, C92

1. Introduction

According to standard game theory, a game equilibrium structure is all that is required to predict the behavior of a rational player. This basic tenet has two immediate and closely related consequences: first, games which differ along a set of superficial or “descriptive” dimensions (e.g., payoff levels, payoff symmetry, magnitude of payoff differences, labeling of strategies, position of outcomes in the matrix) but the equilibrium structure of which is identical. should trigger identical behaviors. Second, games which are similar along the same set of descriptive dimensions but which have differing equilibria, should trigger different behaviors. Accordingly, standard game theory has developed a taxonomy of games based on equilibrium notions and refinements, implicitly discarding any other element as irrelevant.

There is now plenty of experimental evidence against this primary assumption: a plethora of experimental studies on single-shot games in normal form has shown not only that players’ initial behavior is more often *out of equilibrium* (at least out of Nash Equilibrium) than *in equilibrium*, but also that strategizing responds to several *features* which are theoretically irrelevant (e.g., Bosch-Domènech and Vriend, 2008; Cooper and Van Huyck, 2003; Costa-Gomes et al., 2001; Crawford et al., 2008; Goeree and Holt, 2001, 2004). In turn, experimental results have stimulated the development of several new equilibrium concepts, in which behavior is explained either by the “trembling hand” effect (as in the Quantal response equilibrium; McKelvey and Palfrey, 1995), behavioral assumptions (Impulse Balance Equilibrium; Selten and Chmura, 2008; Cognitive Hierarchy, Camerer et al., 2004) or bounded rationality, intended as a limited capacity to process information (Payoff-sampling equilibrium, Osborne and Rubinstein, 1998; Action-sampling equilibrium, Selten and Chmura, 2008).

However, even new stationary concepts fall short of capturing the level of heterogeneity and some apparently “irrational” behaviors observed in laboratory experiments. In particular, behavioral models estimated with large data sets (Weizsäcker, 2003) and experiments which track down individual reasoning processes (Devetag and Warglien, 2008; Rydval et al., 2009) or test consistency between choices and beliefs (Costa-Gomes and Weizsäcker, 2008; Stahl and Haruvy, 2008) indicate that players reason through incomplete models of the strategic situation to hand, either ignoring their opponents’ incentives or treating them as mirror images of their own. Hence, more research is needed to investigate what drives choices in one-shot games, as many strategic situations experienced by people are unique, and it is only very seldom that repeated interactions on the same identical game with transparent feedback occur in the real world.

We hypothesize that players' behavior in single-shot games in normal form conforms to very simple choice principles, either non-strategic (in the sense that they do not seem to take opponents' incentives into account) or strategic in a naive sense (see later). Consequently, players' behavior may be influenced by manipulating a small set of game features which do not alter the game Nash equilibria in pure strategies. More specifically, we argue that players in reasonably complex single-shot games, with no opportunity for learning and no feedback, at first look for "obvious" and "natural" solutions to the strategic problem they face: one such natural solution is picking a strategy which is both attractive and safe, i.e., one with high payoff sum and low payoff variance. Alternatively, an equally "natural" solution is selecting the strategy corresponding to a very attractive outcome, which we call *focal point*. The first behavior is compatible with the "level 1" type commonly used in behavioral models of k-level thinking (Camerer et al., 2004; Costa-Gomes et al., 2001; Stahl and Wilson, 1995) and may derive either from diffuse priors on the opponent's play or from a tendency to ignore opponents' incentives entirely (Costa-Gomes and Weizsäcker, 2008; Weizsäcker, 2003). However, unlike the above-mentioned models, we assume that payoff variance (taken as an intuitive measure of the risk involved in choosing a strategy) plays an important role in determining level 1 type behaviors. To the best of our knowledge, we are the first to test the role of strategy payoff variance in influencing behavior. The second solution is strategic because it relies on forms of team reasoning or Schelling salience (Mehta et al., 1994; Sugden, 1993) which have been identified in experiments on matching games and which have shown themselves to be very effective in promoting coordination. However, we call this strategic approach "naive", in that focal points - as we define them - are not equilibria. Therefore, the choice of a focal point by a player relies on that player ignoring some structural elements of the game.

Only in the absence of features which may trigger the choice principles described above can players start to reason strategically in a standard game-theoretical sense, and find their way to equilibrium play.

We hypothesize that games which share features such as the presence of a safe-and-attractive strategy and focal point may trigger similar behaviors (at both aggregate and individual levels), although they may have very different inner strategic structures; conversely, games which differ feature-wise but which present the same equilibria may trigger very different behaviors. Theories of cross-game similarity are crucial when modeling important phenomena such as cross-game transfer and generalization. It is widely acknowledged that the games we play in real life are at most similar to each other but never identical (unlike the typical "Groundhog day" lab situation) and, as many of our decision processes are case-based or analogy-based (Gilboa and Schmeidler, 1995; Jehiel, 2005), it becomes essential to understand when players perceive two games as being similar.

Surprisingly, there are very few studies investigating cross-game similarity perception. Among these, Knez and Camerer (2000) test transfer of precedent between a PD and a weak link game, and introduce the distinction between surface (or descriptive) and structural similarity. In their design, transfer of precedent is triggered only in the presence of descriptive similarity features between the two games (such as action labeling). Ranking et al. (2000) tested coordination behavior in perturbed environments by having subjects play a series of stag hunt games with randomly perturbed payoffs and action labels, and found that, when descriptive similarity is impeded, convergence to the payoff-dominant equilibrium is more frequent. Hence, understanding what features are relevant in eliciting similarity perception between games is crucial for modeling both repeated behaviors in ever-changing environments and phenomena of generalization from experience.

In order to test our hypotheses, we used 30 3x3 games in normal form belonging to five well-known game types. For each type, we chose six different versions by manipulating two features: the presence vs. absence of a *focal point* (defined below) and the creation of three levels of payoff variance for the strategy presenting the highest average payoff for the row player. Our definition of a focal point differs both from that of Schelling (1963) and from those previously used in all experimental games (Bosch-Domènec and Vriend, 2008; Crawford et al., 2008; Metha et al., 1994; Sugden, 1995), as we define as “focal” any outcome which is Pareto-efficient and yields identical payoffs to the players. It follows that, in our games, focal points need not be equilibria. We also test the effect of payoff magnitude and position of the cell in the matrix in determining the attractiveness of a focal point.

Our manipulations (mostly “economic” in nature, implying exclusively changes in payoffs and, for one game only, changes in the position of the focal point in the matrix) influence behavior significantly. We also show that players respond similarly to games which are “similar” in terms of the above features, even when they belong to very different strategic types. Hence, a taxonomy of games based on descriptive features (e.g., an outcome with symmetric, high payoffs, a strategy with high expected value and low variance, etc.) turns out to be more useful in predicting initial behavior than a categorization based on a game equilibrium structure.

Analysis of response times showed that players who chose the equilibrium strategy on average took longer to choose, indicating that out of equilibrium behavior does not derive from beliefs in opponents' irrationality.

Lastly, we tested the predictive power of a set of non-standard equilibrium concepts, of which QRE is the best estimator.

Our findings are connected with previous studies in several ways: first, they provide evidence of behavior in single-shot normal form games which cannot be explained by any equilibrium concept, or any behavioral model which assumes a distribution of player types and level-k thinking. In this, , they point to the role of strategy variance as an important determinant of choice. Second, they extend the notion of a “focal point” well beyond equilibrium outcomes in symmetric games, showing that focality may be a much more general property of game outcomes, both symmetric and asymmetric.

More generally, our results show that mild payoff changes induce quantitatively important changes in behavior, suggesting that choices in these games respond systematically and predictably to features other than a game equilibrium structure. We argue that these findings constitute the basis for a complete theory of similarity which takes into account both structural and descriptive dimensions to describe players’ cross-game similarity perceptions, the latter being more prominent than the former when initial or single-shot behavior is concerned.

Our results are in line with previous studies of mental models of games (Devetag and Warglien, 2008), and add insights to the so-called “pre-game theory” (Camerer, 2003), i.e., they contribute to our understanding of strategic interaction situations as these are perceived and interpreted by the players involved. .

The rest of the paper is organized as follows: section 2 presents the games used in the experiment; section 3 describes the experimental design and its implementation, and presents our behavioral hypotheses. Section 4 presents results: we first discuss aggregate results (section 4.1), and then analyze individual response times (section 4.2). In section 4.3, we test the predictive power of a series of non-standard equilibrium concepts (QRE, payoff sampling, action sampling and cognitive hierarchy). Section 5 offers some concluding remarks.

2.The games

As we are interested in initial behavior only, we implemented a random rematching scheme in our design, with no feedback, to avoid learning and “repeated game effects” as much as possible.

The payoff matrices used in the experiment are listed in Table 1.

We selected 5 3x3 game types and created 6 versions of each game. In some cases, new Nash equilibria emerged together with the original ones, which always remained.

The chosen basic games were: a game with a strictly dominant strategy for the column player (henceforth, DomCol game); a game without pure strategy Nash Equilibria (noNE), a game with a

single pure strategy Nash Equilibrium but not solvable through iterated elimination of dominated strategies (UniqNE), a Prisoners' Dilemma (PD), and a Weak Link coordination game (WL).

For each game, we identified the strategy with the highest average payoff (HA), the equilibrium strategy (EQ, whenever a pure strategy Nash Equilibrium is present), and a strategy leading to a Focal Point (FP). A Focal Point is any cell containing Pareto-efficient and symmetric payoffs, located at the center of the matrix, except in the Weak Link game, where all symmetric cells were positioned along the main diagonal from the highest to the lowest payoff. Except in the Weak Link game, our Focal Points were not equilibria.

We also tested the relative contribution of Pareto efficiency, cell position, payoff magnitude, and payoff symmetry to an outcome focality.

Our analysis almost entirely covers the behavior of the row players, since most of our games are not symmetric. Therefore, all descriptions of strategies and matrices deal with the row player's perspective, unless otherwise specified.

Our main goal was to examine how the presence or absence of Focal Points affected subjects' perception of cross-game similarity and strategic behavior, as well as the effect of increasing the variance of the HA strategy (three levels of variance were introduced: low, medium, high).

For this purpose, and in order to identify both their separate and joint effects, we created a matrix for every possible combination of features. Six matrices were created for each basic game: FP and HA with low variance; FP and HA with medium variance; FP and HA with high variance; no FP or HA with low variance; no FP or HA with medium variance; no FP or HA with high variance.

For ease of discussion, we called each matrix by the acronym identifying the game type, and by two acronyms identifying its features: "FP" means a matrix with a focal point, "XFP" a matrix without focal point, and "L", "M" and "H" the three levels of variance of the strategy with the highest payoff sum.

All the differing versions of the same game were created, changing the content of cells as little as possible and always maintaining the same equilibrium structure. In a few cases, these changes added new Nash equilibria in mixed strategies. In extreme cases, two matrices differed by only a single cell.

Except in one matrix (WL_FP_L), the average payoff of the HA strategy was kept unchanged in the different versions of the same game, and only the payoff distribution was modified so as to change the value of payoff variance.

Matrices without FP were obtained by breaking the symmetry of payoffs and altering some "relevant attributes" of the FP outcome (see Hypothesis 4).

In the case of the weak link game, this was not possible without altering the game structure, so we obtained matrices without FP by moving the FP from the top-left cell to a less “focal” position.

In order to measure the impact of every feature, we kept our three strategies of interest separate whenever possible. For example, in the DomCol game, Row 1 identifies the HA strategy, Row 2 the FP strategy, and Row 3 the EQ strategy. This was not possible for the Prisoner's Dilemma, where the EQ and HA strategies coincide, and in this case a single row was therefore simultaneously the EQ and the HA strategy.

To avoid spurious effects due to the position of the strategy in the matrix, we always kept the position of every strategy fixed in the different versions of the same game, the only exception being the WL game.

The labels for the strategies used from now on are: EQ for the equilibrium strategy, FP for the strategy leading to the FP, XFP for the strategy in which the Focal Point has been removed, and HA for the strategy with the highest average payoff. COS is a strategy which gives a constant payoff (present only in the WL game) and DOM is a dominated (albeit weakly) strategy. Lastly, QES is a quasi-equilibrium strategy, in the sense explained in section 4 (see discussion of results).

3. Experimental design and behavioral predictions

3.1 Experimental design and implementation

The experiment was conducted at the Computable and Experimental Economics Lab (CEEL) of the University of Trento, in 5 different sessions, each having 16 subjects. In each session, 12 subjects were randomly assigned the role of row player and 4 the role of column player, for a total of 60 observations for row players and 20 for column players. Roles were fixed throughout the experiment. This asymmetry was chosen (see section 2) as we were interested only in the behavior of row players. Subjects made their choices as row or column players in the 30 matrices, and were re-matched randomly at every round with a player of the opposite role. All games were also presented from the viewpoint of the row player. No feedback regarding opponents' choice or the obtained payoff was revealed until the end of the experiment.

On entering the lab, subjects were assigned randomly to a pc cubicle and to the role of row or column player. They were given a paper copy of the instructions, which was also read aloud by the experimenter. Control questions were administered before starting the experiment, to ensure that the rules of the experiment had been understood. Particular care was taken to make sure that subjects understood how to read a payoff matrix. In the case of incorrect answers, instructions were repeated (for a translated copy of the instructions and control questions, see appendices A, B, and Figure 1).

The experiment was computerized with a Z-Tree based software (Fischbacher, 2007), especially developed for the purpose. The matrices were presented one at a time in random order, which differed from subject to subject.

In each round, subjects had to select their preferred strategy by typing the corresponding row number (Figure 1 shows a sample of the software interface).

All players' strategies were recorded and matched randomly, but no feedback was given until the end of the experiment.

Although subjects could take as much time as they needed, but were asked to take no more than 30 seconds. Nonetheless, on several occasions subjects used more than 60 seconds to make their decision, showing that the suggestion was not perceived as mandatory.

The final payment was determined by the outcomes of 5 matrices, picked at random. The exchange rate was announced at the end (and had been made explicit to subjects in the instructions). After the last matrix had been displayed, one subject, selected randomly, was asked to verify that a few tags in a jar each reported the numeric code of one of the matrices played. Subsequently, another randomly selected subject was asked to take 5 tags out of the jar, an action which determined which matrices would be used to calculate subject payments. Then all subjects were paid, according to the choices their assigned opponent had made in those 5 matrices.

After the experiment and selection of payment matrices, some personality tests were administered to subjects, together with general demographic questions. Before leaving the lab, subjects entered the Holt and Laury lottery (Holt and Laury, 2002), with real payments (for a translated copy of the test, see Appendix C). Hence, players' final payments were the sum of their earnings from the 5 matrices selected and their winnings from the lottery. The experimental session did not last more than 1.5 hours and subjects earned an average of 14 Euros for completing it. The minimum earning was 10 Euros and the maximum 17.50 Euros.

3.2 Behavioral predictions

We formulate the following research hypotheses, around which presentation of results will be organized:

Hypothesis 1 (importance of FP): for each game type and each variance level of HA, choice distributions in matrices with FP differ from choice distributions in the corresponding matrices without FP.

Hypothesis 2 (importance of FP and HA over EQ): when the variance of HA is low, strategies FP and HA capture the majority of choices in games with a FP, and strategy HA captures the majority of choices in games without a FP.

Hypothesis 3 (effect of variance): all other features remaining fixed, when the variance of HA increases, its share decreases.

Hypothesis 4 (nature of focality): the share of the FP strategy increases with the number of attributes defining a FP.

Attributes of FP:

1. payoff magnitude (“significantly” greater than other payoffs for the row player)
2. symmetry of payoffs
3. centrality of the cell (or positioned in the main diagonal in WL game)
4. Pareto-efficiency

Hypothesis 5 (feature-based weak similarity hypothesis): a “key feature” has a similar effect in strategically different games by influencing choice behavior in the same direction.

Hypothesis 6 (feature-based strong similarity hypothesis): all other features remaining fixed, the choice distributions in matrices which are strategically different but similar with respect to key features are closer - statistically - than the choice distributions of matrices which are strategically equivalent but differ with respect to key features.

Hypothesis 7 (FP response times): matrices with FP trigger intuitive reasoning, whereas matrices without FP trigger analytical reasoning: this difference appears in longer average response times for matrices without FP, other things being equal.

4. Results and Discussion

We first present an overview of aggregate data and discuss each of the previously stated hypotheses in sequence. We then present the results of response time analysis and equilibrium analysis separately.

4.1 Analysis of aggregate choices

A data overview is given in Figures 2 to 4, which show observed frequencies, the 30 games being grouped together, although the matrix rows are analyzed separately. Each figure shows two lines, one the frequencies of games with FP, and one without. Since in the version with and without the FP of the WL game the cells were the same but the position in the matrix was changed, Figures 2-4 group cells according to type, and not according to the row in which they were positioned.

Several considerations may be made from an initial examination of the data: first, the choice distributions in the 6 versions of the same game look markedly different, showing that the presence vs. absence of key features influences choices to a great extent. Second, some patterns are clear-cut: specifically, the difference in observed frequencies between the same matrix with and without FP is evident in most cases, as are the low share of the EQ strategy (except for the PD) and the effect of increasing the variance of HA. In particular, for each game, differences in the choice distributions of matrices “FP, HA low var” and “XFP, HA high var” – the two extreme cases – are statistically significant in all games at least at a p level of 0.01, according to a chi-square test.

We now examine each of our hypotheses.

Hypothesis 1 (relevance of FP) XFP is the strategy (i.e., matrix row) corresponding to FP in the matrices in which the focal point has been removed. In our data, the share of FP is always higher (and equal in only one case) than the share of XFP (see Figure 3). The frequencies of FP, XFP and the corresponding p-values are listed in Table 2. In the first three game categories – DomCol, noNE and UniqNE – the average difference in share between FP and XFP is 38%. In the case of PD and WL, it falls to 6.5%, and is 25.4% overall.

We made pairwise comparisons of the choice distributions with a chi-square test. The hypothesis was confirmed for games DomCol, noNE and UniqNE and the difference was statistically significant in all 9 comparisons (p-value < 0.01). In PD too, the frequencies of XFP were always smaller than or equal to the corresponding frequencies of FP, but the difference was statistically significant only in the pair with HA medium variance (chi-square test p-value < 0.1; binomial test p-value < 0.5, one-tailed). There are two reasons for this difference: first and most importantly, the FP in game PD is weak (according to the attributes of Hypothesis 4): consequently, the related strategy is chosen by fewer subjects than in any other game. Second, in the PD, the FP is eliminated only by breaking the symmetry, with a minimal change in payoff magnitude for the column player and no changes in the payoff of the row player.

In WL too, FP frequencies are higher than those of XFP, although the differences are not statistically significant. One reason (explored in depth when discussing Hypothesis 4) is that, in the WL, XFP is obtained by simply shifting the cell position without altering its content. This change apparently does not affect cell focality. We note that the frequency WL HA high variance is obtained by summing the frequencies of FP and HA, since - for structural reasons - two identical focal points appear in that matrix, one for each of these strategies.

As regards the importance of the focal point, the behavior of the column players is particularly interesting. The DomCol game presents a strictly dominant strategy for the column player, whereas both noNE and UniqNE present a strategy yielding the highest payoff in 2 out of 3 cells and a slightly lower payoff in the third cell: hence, a large share of FP on the part of column players indicates that its importance is considerable, in view of the available alternatives. The frequencies of FP, XFP and of the (quasi)-dominant strategies for column players are listed in Table 3. When the FP is present, 100% of column players choose FP or the (Q)EQ strategy, but very few of them violate strict (or quasi) dominance when the focal point is absent, as shown by the values of the EQ shares shown in brackets; hence, players do seem to understand the game and show compliance with the basic principles of individual rationality. The choice of the FP strategy on the part of these players cannot therefore be attributed to error or confusion. Since several strategies have frequency 0, the chi-square test cannot be applied. We therefore only use the binomial, one-tailed test. The average difference between FP and XFP is 32.8%, and in all but one case it is significant, with p-values of less than 0.05. Altogether, these results confirm our hypothesis and show that, when the difference between FP and XFP outcomes is evident, the effect on subjects' choice behavior is both quantitatively and statistically significant.

Hypothesis 2 (importance of FP and HA over EQ)

We expect that, when some key features are present, players will be attracted to them more than to the equilibrium strategy. In players' perception, key features provide “salient” and “obvious” solutions to the game. Only when these features are absent do players reason through the game more strategically and in some cases recognize the equilibrium strategy.

Table 4 summarizes our findings regarding Hypothesis 2.

As hypothesized, when both key features are strong (FP, HA with low variance), these strategies capture the large majority of players' choices and, when FP is eliminated, HA increases its attractive power, leading to almost the same frequencies as in the previous case. The case of DomCol is emblematic, as in DomCol_FP_L only 17% of players choose the Equilibrium Strategy,

even though it is the best response for a column player choosing a strictly dominant strategy, and in DomCol_L (where FP was removed), HA is selected by 80% of players.

Looking at Table 4, it is noteworthy that the noNE pattern is similar to those of DomCol and UniqNE, although noNE does not have any pure strategy Nash equilibria. This finding is consistent with a “similarity judgment” approach (Leland, 1994; Rubinstein, 1988), according to which strategy C3 of noNE may be considered as “almost-dominant”, since it yields the highest payoff in 2 out of 3 cases, and a not significantly lower payoff in the third case. Since choosing R3 is the best response for a column player choosing an “almost-dominant” strategy, (R3, C3) may be considered a “quasi-equilibrium” in pure strategies. This hypothesis is also supported by the behavior of the column players, as the frequencies of their choices in DomCol and noNE are very similar, as shown in Table 3.

PD and WL strongly support our hypothesis: less than 5% of players fall outside the FP+HA combination, although in the PD HA=EQ by construction, and in WL the remaining strategy is weakly dominated.

The only case which apparently contradicts our hypothesis is WL_L, in which 48% of subjects choose HA and another 48% XFP. However, it has already been specified (and will be clarified when discussing Hypothesis 3) that, in the WL game, the XFP outcome was created by simply locating the cell outside the main diagonal, with no change in payoffs. This is preliminary evidence showing that moving a FP cell from a central position does not reduce its focality, and therefore that frequencies must be interpreted as 96% of players choosing HA+FP, still in line with our hypothesis.

Hypothesis 3 (effect of variance)

It is reasonable to assume that a certain number of players will select the strategy with the highest expected value, assuming, more or less implicitly, that their opponents' choices are equally likely. This behavior is relatively well-known for normal form games and has been defined as “Level-1” or “Naive” (Camerer et al. 2004; Costa-Gomes et al., 2001; Stahl and Wilson, 1995). What has not been taken into account so far is the role played by perceived risk in influencing “Level-1” types of reasoning. According to the literature, what matters for “Level-1” players is a strategy-expected value. Instead, in line with previous findings (Warglien et al., 1999), we assume that the attractiveness of the highest expected value strategy is also a function of its safety: therefore, the higher the variance, the lower the attractiveness, *ceteris paribus*. To the best of our knowledge, no previous study has systematically investigated the role of perceived risk, as measured by payoff

variance, in determining the fraction of players who exhibit behavior compatible with a Level 1 type.

We first present the results for games DomCol, noNE, UniqNE and PD, and separately those for the WL. Table 5 reports data for the first four games.

Table 5 shows that the share of HA always decreases monotonically when the variance of HA increases from low, to medium, to high, except in two cases, in which it stays constant from medium to high (noNE without FP and PD with FP). We tested differences between matrices with HA-low variance and those with HA-high variance by both a chi-square and a binomial one-tailed test. For games DomCol, noNE, and UniqNE, both tests revealed that the differences were statistically significant ($p \leq 0.1$; except in two cases, in which $p \leq 0.5$). Those for the PD without FP are similarly likewise significant (p-value < 0.01). The PD with FP is the only case in which the difference is not significant, although the trend is the same as in the other games.

The case of PD is particularly intriguing, since HA corresponds to EQ by construction, and is weakly dominant. Hence, we note that increasing the strategy variance without affecting its dominance induces a shift in behavior.

On average, the frequency of HA passes from 68% (low variance case) to 43% (high variance case).

A different approach must be used for the WL game. Here, the effect of variance cannot be observed directly, but it must be inferred from the share of strategy COS (the strategy giving a constant payoff). Due to equilibrium constraints, while in HA low var and HA middle var, strategies HA and FP are distinct, in HA high var two focal points appear: one in the former FP strategy and another in HA. Therefore, instead of testing whether increasing the variance of HA reduces its share, we verify whether it increases the share of COS. In WL with FP, the frequency of COS strategy passes from 2% in the low var matrix, to 8% in the middle var matrix, to 18% in the high var matrix. Instead, in WL without FP, the frequency rises from 3% to 12%, to 23%. In both cases, chi-square and binomial tests showed that the differences between low and high var matrices were statistically significant ($p < 0.01$). We conclude that, in WL too, our hypothesis is confirmed.

Hypothesis 4 (nature of focality)

While Hypothesis 2 simply postulated that the presence of focal points induces changes in behavior, hypothesis 4 measures the relative contribution of a series of attributes to an outcome focality.

The point is significant, because it extends the notion of focal point and its properties well beyond the domain of equilibrium outcomes in (symmetric) coordination games.

It has already been shown that the share of FP is always higher than that of XFP, but we must ask why some of the differences are more remarkable than others.

There are 4 attributes of a game outcome which we judge to be relevant in determining focality:

1. payoff magnitude (“significantly” greater than the other payoffs)
2. symmetry of payoffs
3. centrality of the cell (or positioned in the main diagonal in WL)
4. Pareto-efficiency

“Payoff magnitude” refers to the magnitude of a cell payoff, when compared with the other payoffs which the same player can get elsewhere in the matrix. For example, in DomCol_FP_L, the payoff of the focal point is “significantly” greater than the other payoffs, giving 80 ECUs (Experimental Currency Units) against 40 of the second-highest payoff. Conversely, in PD, the payoff of the focal point is not significantly greater, as in PD_FP_L there are 4 other cells which can give the row player the same payoff as the FP cell (35 ECUs).

“Symmetry of payoffs” indicates that the payoffs of the two players are identical within the cell.

“Centrality of the cell” refers to the position of the cell in the matrix. The FP was always located at the center of the matrix, except in the WL, where (due to the presence of three symmetric cells with increasing magnitude) the symmetric cells were positioned on the main diagonal in order of decreasing payoff magnitude.

The choice of “Pareto Efficiency” (henceforth PE) as an attribute instead of “Nash Equilibrium” differentiates our definition of a focal point from previous definitions used in the literature. We assume that players do not initially reason strategically in a game-theoretical sense: therefore, we consider that it is more important for the focality of an outcome to be Pareto-efficient rather than an equilibrium.

A FP is an outcome (a cell) and not a strategy. Since only choices of strategies are observed and motivations for choices are not observed, the strategies yielding a FP were built in such a way that outcomes other than the FP look particularly unattractive. In all games, one of the two remaining cells gives the lowest possible payoff to row players, and in all games except the WL the remaining cell yields the second lowest payoff. In addition, one of these two cells gives the highest possible payoff to column players; hence, subjects should avoid picking FP if they imagine that column players might go for their highest payoffs (which in our games coincides with the equilibrium strategy for column players).

In these games, two types of FP were constructed. The first is a FP for games DomCol, noNE, UniqNE, and WL, which satisfies the attributes of “payoff magnitude”, “symmetry of payoffs”, “centrality of the cell”, and “PE”. The second is the FP for PD, which satisfies “symmetry of payoffs”, “centrality of the cell” and “PE”, but not “payoff magnitude”.

Three types of XFP outcomes were also constructed: the first is XFP for games DomCol, noNE, and UniqNE, obtained by breaking the symmetry of payoffs and reducing their magnitude, so that the cell satisfies only the attribute of “centrality” and “PE”. The second XFP is that of WL, which is obtained simply by shifting the strategies so as to have all cells with symmetric payoffs outside the main diagonal. Therefore, this XFP outcome satisfies the attributes of “payoff magnitude”, “symmetry of payoffs” and “PE”. The last XFP type is that of the PD, which is obtained by simply reducing the payoff of column players. Since both payoffs were already relatively small, the payoff decrease in this case is slight. This XFP satisfies “centrality of the cell” and “PE” (in 2 out of 3 matrices).

Table 6 lists attributes and choice shares for a sample of payoff matrices. The data clearly show that some of these attributes are an important source of focality whereas others are not.

Let us first analyze PD_FP_L, in which the FP strategy is not particularly successful, being chosen only by 10% of players. As the difference with PD_XFP_L is not significant, we infer that the joint presence of “symmetry of payoffs”, “centrality of the cell” and “PE” is not sufficient to trigger focality.

We then analyze games DomCol, noNE, and UniqNE, treating them jointly, since their FP and XFP cells share the same attributes. The FP strategy in these games is highly attractive, reaching a share ranging from 32% to 47% in the low var case. In addition, in all versions, the differences between FP and XFP are always significant, suggesting that “symmetry of payoffs” and “payoff magnitude” (the attributes removed in XFP) are a key source of focality. Instead, since XFP is rarely selected, it appears that “PE” and “centrality of the cell” are two attributes of minor or no importance, as already indicated by the PD data.

In WL, FP has the strongest attractive power and, when the matrices with the same features are compared, it reaches the highest frequencies. Although the share of FP is always higher than that of XFP, the difference is never significant, again indicating that “centrality of the cell” plays a minor role in determining focality.

Lastly, we consider the separate effects of “symmetry of payoffs” and “payoff magnitude”: although the two attributes show considerable attractive power when together, neither seems to create a focal point when alone. In PD_XFP_L, only 3% of subjects chose strategy DOM, although it contains a symmetric cell yielding an “acceptable” gain to both players. Similarly, in

DomCol_XFP_L, only 2% of row players chose strategy XFP, which yields the highest (although not symmetric) gain compared with other matrix cells.

Altogether, these results suggest that cell focality in a non-symmetric game is mainly due to the joint effect of “payoff magnitude” and “symmetry of payoffs”, whereas “centrality of the cell” and “PE” play a minor role. The two attributes, when present in isolation, lose much of their attractive power. This finding is consistent with the results of -Biel (2009), in which introducing cells with symmetric payoffs in normal form games turned out to be irrelevant in modifying players’ strategic behavior.

So far we have stated that the attractiveness of FP is due to its structure, meaning that its features make it a “natural” cooperative choice in the absence of communication or feedback. An alternative explanation may be that FP is chosen because it is the outcome yielding the highest payoff sum. Fairness-based explanations of out-of-equilibrium play are widespread, and behavioral models such as that of Costa-Gomes et al. (2001) include an “Altruistic” type, who systematically opts for the cell with the highest payoff sum. In order to test whether players select FP for this reason, in the following we analyze the relative attractiveness of the “fair” cell, defined as the one with the highest payoff sum.

In matrices with FP, FP is always the fair cell. In PD_FP_L, PD_FP_H and WL_FP_H, another cell yields the same payoff sum as FP (in strategies EQ/HA, EQ/HA, and HA). In all matrices with FP, the strategies corresponding to the fair outcomes are chosen by a share ranging from 32% to 87%. The only exception is PD_FP_M, in which the strategy leading to the only fair cell – FP – is only chosen by 17% of subjects, the first evidence of the scarce importance of payoff sum by cell as a criterion of choice

Let us now examine fair cells in matrices without FP. The cases of PD and WL are not informative: in PD, fair cells are always selected by the EQ/HA strategy, and another fair cell appears in XFP as well in PD_XFP_M and PD_XFP_H. In the WL, the FP is not really removed, but it is only shifted to a different position and this change does not affect its salience. We therefore analyze the case of games DomCol, noNE, and UniqNE.

Here, XFP is the fair cell in 8 out of 9 matrices, but the share of the corresponding strategy ranges from 0% to a maximum of 7%, and in matrices with FP from 32% to 58%. We interpret this difference as strong support to the hypothesis that the attractiveness of FP is not related to its being the cell with the highest payoff sum, but to the features already singled out.

In particular, the symmetry and magnitude of payoffs make FP an “obvious” choice for both, triggering spontaneous coordination. Clearly, payoff symmetry makes the FP a fair outcome by

definition (as is the result of applying the “equality rule” which Mehta et al. (1994) find as the most frequently used in a series of assignment games), but we argue that subjects select it for reasons which have to do with Schelling salience or team reasoning (Bacharach, 1999; Bardsley et al, 2010; Mehta et al., 1994; Sugden, 1993): that is, out of cognitive processes akin to those which are thought to be triggered by equilibrium focal points in games of pure coordination.

Hypothesis 5 (feature-based weak similarity hypothesis)

Our aim in this study is not simply to show that Nash Equilibrium is a poor predictor of strategic behavior, but that observed differences in choice of strategies between games sharing the same equilibrium structure follow predictable patterns, governed by the presence vs. absence of the descriptive features defined above.

Our data show that Nash Equilibrium cannot explain observed frequencies.. For all our game types, the difference in choice shares between the matrix with all key features and that without key features is always significant, with a p-value of less than 0.01.

A focal point (according to our definition) is one of these uch features, capable of influencing choices regardless of a game equilibrium structure. We have shown that, even when FP is a strictly dominated strategy, it can still attract a significant fraction of players' choices. This effect was observed in several games, with different equilibrium structures, both symmetric and non-symmetric.

Another key feature which influences strategic behavior is HA when it is perceived as a “safe” option (low variance). In this case too, HA determines similar effects in different games, and the importance of the “safety” attribute is revealed by the emergence of an inverse relationship between the share of players choosing HA and its variance level.

Altogether, our results show that some features affect behavior in the same direction, regardless of the game-theoretical properties of the strategic situation to hand. Therefore, it may be hypothesized that strategically different games are perceived as similar when they share some of key features.

The next hypothesis goes further, pointing not only in the direction of effects but also their magnitude.

Hypothesis 6 (feature-based strong similarity hypothesis)

It has been shown above that games with the same equilibrium structure which differ only in key features generate different choice distributions. Here, we propose that games with different

equilibrium structures but the same key features generate choice distributions which are so similar as to be statistically indistinguishable.

This hypothesis refers to strong similarity, since it does not only concern the direction of effects but also their magnitude.

Table 7 lists p-values obtained by comparing games with the same key features and different strategic structures, with p-values < 0.1 shaded in gray. We omit WL because, comparison-wise, its strategic structure is too different.

The data show that, for games DomCol, noNE and UniqNE, in most of the comparisons, frequency distributions do not appear to be significantly different among games sharing the same features.

Hence, whereas frequencies differ significantly when the same game type is compared with and without features (as shown in the previous hypotheses), when the latter remain unaltered but the game structure changes, players' strategic behavior remains statistically invariant, indicating that the difference is not perceived as such in the aggregate.

In further support to our hypothesis, it must be noted that the frequencies of DomCol, noNE and UniqNE are all significantly different (according to a chi-square test) from one another only in the XFP_H case, when all features are removed and hence the real game structure is more clearly visible.

These results may be interpreted in two ways: either the features are so salient as to prevent players from perceiving a game with an inner strategic structure, or they correctly perceive a game with a strategic structure but base their strategic choices on other features (and expect other players to do so as well). Analysis of response times indicates that the first explanation is more valid.

4.2 Analysis of response times and correlations

For insights into choice processes, we now analyze differences in response times.

Figure 5 shows average response times, disaggregated by game class and matrix version.

Some recent studies of gaming behavior employ response time (henceforth RT) as a means to explore subjects' decision-making processes, as opposed to the more invasive and expensive methods based on study of neural activity. Both Rubinsten (2007) and Piovesan and Wengström (2009) analyze the relationship between response times and social preferences. Rubinsten's study finds that fair decisions take a shorter RT than egoistic (more rational) ones, whereas Piovesan and Wengström (2009) seem to find the opposite, although the two experimental designs differ in many respects. In a recent fMRI study on gaming behavior, Kuo et al. (2009) found that subjects took a

much longer time, on average, to choose a strategy in dominance-solvable games than in coordination games, and different areas of the brain were activated when players faced instances of the two classes of games. According to these findings, the authors suggested the existence of two different “strategizing” systems in the brain, one based on analytical reasoning and deliberation and the other on intuition and a “meeting of the minds”.

As proposed by Kuo et al. (2009), we also hypothesize that matrices with a focal point trigger intuitive reasoning and hence require a shorter RT than matrices without a focal point, which are presumed to activate analytical reasoning.

We do not expect the relation between RT and type of game to be as notable as reported by Kuo et al. (2009), as the two game types in their study were indeed strategically different, whereas in our case they only differ in the presence of a focal point, as defined earlier.

Nonetheless, the individual RT for matrices with FP is significantly shorter than that for matrices without FP, according to a paired *t*-test ($p < 0.01$, two-tailed¹). Hence, our data support the hypothesis that matrices without focal point require more cognitive effort. Note that the significance of results holds, although some subjects did not select the focal point strategy in the matrices which contained it, and those who did not presumably employed the same type of analytical reasoning used for games without FP.

The second important finding is the increased RT which can be observed when the variance of the HA strategy increases (from low, to medium, to high). The increasing pattern is clear-cut in Figures 5 and 6, which shows average RT when games are aggregated according to variance level. The figures shows that increasing the variance leads to large increases in RT.

RT averages 17.71 in the low variance case, 20.98 in the mid-variance case, and 23.66 in the high variance case. Pairwise differences of individual RT are significant according to a paired *t*-test, two-tailed ($p = 0$ for all cases: low var-middle var, low var-high var, and middle var-high var²).

We then compared the two “extreme” cases according to these findings, i.e., matrices with focal point and low variance - which should be the fastest to process - and matrices without focal point and with high variance - which should instead require the highest cognitive effort. The difference in RT was indeed remarkable, increasing on average from 17.61 to 24.27 from the first to the second groups. Also in this case, the differences in individual RT were significant (paired *t*-test test, $p = 0$, two-tailed).

¹ The same result was obtained by a non-parametric Wilcoxon signed rank test ($p < 0.01$, two-sided).

² The same result was obtained by a non-parametric Wilcoxon signed rank test ($p = 0$, two-sided).

No significant correlations were found between individual RT, degree of risk aversion, and either number of FP choices or number of HA choices. Instead, a significant correlation was found between individual response times and number of EQ choices. The correlation coefficient is positive and is .273 (Spearman's rho coeff., $p=0.035$, two-tailed) when choices from the modified PD (in which EQ=HA) are included, and is .331 (Spearman's rho coeff., $p=0.01$, two-tailed) when choices from modified PD are excluded, leaving only “pure” EQ choices.

This finding shows that the players who were more likely to choose equilibrium strategy EQ took longer to respond, as found by Kuo et al. (2009). These correlation results also indicate that choices of FP or HA generally derive from imperfect or simplified strategic reasoning, rather than beliefs in other players' irrationality. In fact, if the latter were the case, i.e., if players always correctly identified the equilibrium strategy even when they did not select it, we would not observe higher response times for EQ choosers.

4.3 Equilibrium analysis

In the previous analysis, we used pure strategy Nash equilibria as a benchmark to evaluate observed frequencies. Any manipulation of the descriptive features was always referred to as strategically irrelevant, since it did not erase the starting set of pure strategy Nash equilibria. We now compare the descriptive power of four other stationary concepts, to find which stationary concept best fits our data, and whether any of them can capture effects due to changes in key features.

The stationary concepts tested are: Quantal Response Equilibrium (henceforth QRE; McKelvey and Palfrey, 1995); action sampling equilibrium (Selten and Chmura, 2008); cognitive hierarchy (Camerer et al., 2004); and payoff sampling equilibrium (Osborne and Rubinstein, 1998). Of these, only Nash is non-parametric, whereas the others have one free parameter.

We provide a brief description of parametric stationary concepts: according to QRE (McKelvey and Palfrey, 1995), players make their choices according to relative expected utility and use a quantal choice model. Players also assume that other players apply the same strategy. The possibility of errors in the decision-making process is taken into account.

Action sampling equilibrium is discussed in Selten and Chmura (2008). According to this model, players respond best to a sample (the size of which is the only parameter of the model) of observations of strategies played by their opponents. The parameter is generally set at 7, which is why the model is often considered to be non-parametric. By varying the parameter, we found the value yielding the most accurate fit of our data.

Cognitive hierarchy (Camerer et al., 2004) divides subjects into different strategic categories,

according to their level of sophistication. Each subject is assumed to be more sophisticated than the others, and best responds to others' behavior by assuming that the other players belong to levels from 0 to $k-1$ (where k is the level of sophistication of the subject). Types are distributed according to a Poisson distribution.

Payoff sampling (Osborne and Rubinstein, 1998) is similar to action sampling. In this model, players take one sample of actions for each pure strategy available, and then play the strategy with the highest average payoff. This model too has one parameter, since the samples have the same size.

First, we calculate estimates with sample sizes ranging from 1 to 10 for action sampling, and (due to computability restrictions) from 1 to 9 for payoff sampling. We then compare estimated and observed frequencies by the mean square deviation (MSD) and find the parameter value which minimizes it. We found optimal sample size parameter values of 9 and 1, for action sampling and payoff sampling, respectively. Similarly, we calculate QRE with values of λ in the interval 0.01-3, with steps of 0.01. For QRE, the parameter value which best fits the data is 0.1. For QRE estimates, we used special software: GAMBIT (McKelvey et al., 2010). For the cognitive hierarchy model, the best-fitting parameter was 0.7 (estimate of fitness for values of the parameter ranging from 0.5 to 2, with steps of 0.1).

Figures 7, 8, and 9 show observed and estimated frequencies, divided by row.

In the analysis, together with stationary concepts, we also include the random choice model.

At first sight, Nash and action sampling seem to perform poorly. They generally underestimate the frequency of row 1 (corresponding to strategy HA) and row 2 in matrices with FP. Instead, they overestimate the frequency of row 3, generally corresponding to the equilibrium strategy. Nor do they seem to capture the effects of changes in the variance of HA, whereas Nash cannot capture the effect of FP. Emblematic is the case of DomCol, where both Nash and action sampling give the same estimates in all six versions of the game.

Action sampling often coincides with one of the game Nash Equilibria. When more than one is available, action sampling oscillates between them, and small changes in payoffs can change the expected frequency from 0 to 100%.

Cognitive hierarchy also performs poorly. Although estimates are closer to the observed values, the model does not capture the effects of changes in features, and often maintains estimates invariant in different versions of the same game. In particular, model predictions are not affected in any way by the presence or absence of a focal point.

Payoff sampling clearly performs better than either Nash or action sampling. Even small changes in payoffs affect it, but the reactions are smoother than those observed in action sampling. Nonetheless, the estimates are not precise, and the difference between estimated and observed frequencies often exceeds 20%.

Of all the stationary concepts, QRE seems to be the best estimator.

Figure 10 shows MSD scores for stationary concepts and the uniformly distributed random choice model. Since in several games Nash selected more than one prediction, we chose the one closest to the observed frequencies. However, the results show that NE is the worst predictor.

Figure 10 confirms our observation. There is a clear-cut difference in the accuracy of fit: Nash equilibrium and action sampling equilibrium perform poorly, whereas cognitive hierarchy, payoff sampling and QRE perform significantly better. Random choice falls between the two groups, outperforming Nash and action sampling. However, the trend of the data shown in Figures 7, 8, and 9 indicates that the first is probably the result of a statistical artifact.

Differences in performances were tested by a two-sided t-test³. We compared the observed frequencies for each matrix row with the estimates of the stationary concepts and of the uniformly distributed random choice model.

The statistical analysis confirms our previous results: QRE performs significantly better than Nash, random choice, action sampling, cognitive hierarchy ($p=0$) and payoff sampling ($p\leq 0.1$). The second-best model is payoff sampling, which performs better than Nash and action sampling ($p=0$) and random choice ($p=0.01$) but not cognitive hierarchy. Cognitive hierarchy performs significantly better than Nash ($p=0$), action sampling ($p=0.01$) and random ($p\leq 0.1$). Random choice performs better only than Nash ($p\leq 0.05$), whereas Nash and action sampling are statistically indistinguishable.

Concluding, as suggested by the analysis of aggregate choices, Nash equilibrium performs poorly and captures almost none of the effects of the descriptive features. Of all the other stationary concepts analyzed, QRE is the best estimator. This result is quite interesting, as in previous studies (e.g., Selten and Chmura, 2008) QRE was the second-worst performer, better only than Nash. With the features we take into consideration, QRE is able to capture even minute modifications, avoiding overreactions.

³ Similar results were obtained with a two-sided Wilcoxon signed rank test.

5 Conclusions

We show that initial behavior in normal form games may be explained by a set of very simple behavioral rules which eschew optimization and are triggered by the presence of salient features: two of such features are a “focal point” and a strategy with high expected value and low variance.

More specifically, we show that the attractive power of focal points extends to asymmetric games and non-equilibrium outcomes, and identify two attributes (“payoff symmetry” and “payoff magnitude”) which, when jointly present, are the two factors most frequently responsible for making an outcome focal.

We also show that the presence of a strategy with high expected value and low variance (a “safe”, attractive strategy) is a strong choice attractor.

Together, the strategy yielding the focal point and the safe strategy explain most of players’ choices. Subjects react in similar ways to games with the same features, regardless of their game-theoretical category, and treat formally equivalent games differently when they differ with respect to descriptive features.

Analysis of response times shows that matrices with focal points are faster to process than matrices without them, and that there is a direct relationship between the variance level of the HA strategy and average response times.

Equilibrium choices take longer than other choices, indicating that out-of-equilibrium choices are not due to beliefs in other players’ irrationality, but rather to the use of simplified and/or incorrect mental representations of the strategic situation to hand (Devetag and Warglien, 2008).

Lastly, we explore the predictive power of Nash equilibrium and other non-standard stationary concepts: QRE performs best, followed by payoff sampling equilibrium, random choice and Nash equilibrium. None of the stationary concepts considered, despite their differing ability to capture our data, can fully reproduce the magnitude of feature-based changes in behavior.

Future research will have to proceed in two complementary directions: exploring subjects’ decision-making processes and similarity perceptions in greater depth, through the use of eye-tracking techniques and the elicitation of direct similarity judgments; and developing a comprehensive theory of cross-game similarity, based on experimental results which may help to model and predict cross-game transfer and generalization.

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References

- Bacharach, M., 1999. Interactive Team Reasoning: A Contribution to the Theory of Co-Operation. *Res. Econ.* 53(2), 117-147.
- Bardsley, N., Mehta, J., Starmer, C., Sugden, R., 2010. Explaining Focal Points: Cognitive Hierarchy Theory Versus Team Reasoning. *Econ. J.* 120(543), 40-79.
- Bosch-Domènech, A., Vriend, N. J., 2008. On the Role of Non-Equilibrium Focal Points as Coordination Devices (Working Paper, Queen Mary University of London, No. 621).
- Camerer, C. F., 2003. *Behavioral Game Theory: Experiments in Strategic Interaction*. Princeton: Princeton University Press.
- Camerer, C. F., Ho, T., Chong, J., 2004. A Cognitive Hierarchy Model of Games. *Quart. J. Econ.* 119(3), 861-898.
- Cooper, D. J., Van Huyck, J. B., 2003. Evidence on the Equivalence of the Strategic and Extensive Form Representation of Games. *J. Econ. Theory* 110(2), 290-308.
- Costa-Gomes, M., Crawford, V. P., Broseta, B., 2001. Cognition and Behavior in Normal-Form Games: an Experimental Study. *Econometrica* 69(5), 1193-1235.
- Costa-Gomes, M., Weizsäcker, G., 2008. Stated Beliefs and Play in Normal-Form Games. *Rev. Econ. Stud.* 75(3), 729-762.
- Crawford, V. P., Gneezy, U., Rottenstreich, Y., 2008. The Power of Focal Points Is Limited: Even Minute Payoff Asymmetry May Yield Large Coordination Failures. *Amer. Econ. Rev.* 98(4), 1443-1458.
- Devetag, G., Warglien, M., 2008. Playing the Wrong Game: An Experimental Analysis of Relational Complexity and Strategic Misrepresentation. *Games Econ. Behav.* 62(2), 364-382.
- Fischbacher, U., 2007. Z-Tree: Zurich Toolbox for Ready-made Economic Experiments. *Exper. Econ.* 10(2), 171-178.
- Gilboa, I., Schmeidler, D., 1995. Case-Based Decision Theory. *Quart. J. Econ.* 110(3), 605-639.
- Goeree, J. K., Holt, C. A., 2001. Ten Little Treasures of Game Theory and Ten Intuitive Contradictions. *Amer. Econ. Rev.* 91(5), 1402-1422.
- Goeree, J. K., Holt, C. A., 2004. A model of noisy introspection. *Games Econ. Behav.* 46(2), 365-382.
- Holt, C. A., Laury, S. K., 2002. Risk Aversion and Incentive Effects. *Amer. Econ. Rev.* 92(5), 1644-1655.
- Jehiel, P., 2005. Analogy-Based Expectation Equilibrium. *J. Econ. Theory* 123(2), 81-104.

- Knez, M., Camerer, C., 2000. Increasing Cooperation in Prisoner's Dilemmas by Establishing a Precedent of Efficiency in Coordination Games. *Organizational Behavior and Human Decision Processes* 82(2), 194-216.
- Kuo, W., Sjöström, T., Chen, Y., Wang, Y., Huang, C., 2009. Intuition and Deliberation: Two Systems for Strategizing in the Brain. *Science* 324(5926), 519-522.
- Leland, J. W., 1994. Generalized Similarity Judgments: An Alternative Explanation for Choice Anomalies. *J. Risk Uncertainty*. 9(2), 151-172.
- McKelvey, Richard D., McLennan, A. M., Turocy, T. L., 2010. *Gambit: Software Tools for Game Theory*, Version 0.2010.09.01. <http://www.gambit-project.org>.
- McKelvey, R. D., & Palfrey, T. R., 1995. Quantal Response Equilibrium for Normal Form Games. *Games Econ. Behav.* 10(1), 6-38.
- Mehta, J., Starmer, C., Sugden, R., 1994. The Nature of Salience: An Experimental Investigation of Pure Coordination Games. *Amer. Econ. Rev.* 84(3), 658-673.
- Osborne, M. J., Rubinstein, A., 1998. Games with Procedurally Rational Players. *Amer. Econ. Rev.* 88(4), 834-847.
- Piovesan, M., Wengström, E., 2009. Fast or fair? A study of response times. *Econ. Letters* 105(2), 193–196.
- Rankin, F. W., Van Huyck, J. B., Battalio, R. C., 2000. Strategic Similarity and Emergent Conventions: Evidence from Similar Stag Hunt Games. *Games Econ. Behav.* 32(2), 315-337.
- Rey-Biel, P., 2009. Equilibrium Play and Best Response to (Stated) Beliefs in Normal Form Games. *Games Econ. Behav.* 65(2) 572-585.
- Rubinstein, A., 1988. Similarity and Decision-Making under Risk (Is There a Utility Theory Resolution to the Allais Paradox?). *J. Econ. Theory* 46(1), 145-153.
- Rubinstein, A., 2007. Instinctive and Cognitive Reasoning: A Study of Response Times. *Econ. J.* 117(523), 1243-1259.
- Rydval, O., Ortmann, A., Ostadnický, M., 2009. Three Very Simple Games and What It Takes to Solve Them. *J. Econ. Behav. Organ.* 72(1), 589-601.
- Schelling, T. C., 1963. *The Strategy of Conflict*. New York: Oxford University Press.
- Selten, R., Chmura, T., 2008. Stationary Concepts for Experimental 2x2-Games. *Amer. Econ. Rev.* 98(3), 938-966.
- Stahl, D. O., Haruvy, E., 2008. Level-n Bounded Rationality and Dominated Strategies in Normal-Form Games. *J. Econ. Behav. Organ.* 66(2), 226-232.
- Stahl, D. O., Wilson, P. W., 1995. On Players' Models of Other Players: Theory and Experimental Evidence. *Games Econ. Behav.* 10(1), 218-254.

- Sugden, R., 1993. Thinking as a Team: Towards an Explanation of Nonselfish Behavior. *Social Philosophy and Policy*, 10(1), 69-89.
- Sugden, R., 1995. A Theory of Focal Points. *Econ. J.* 105(430), 533-550.
- Warglien, M., Devetag, G., Legrenzi, P., 1999. I Modelli Mentali dei Giochi: Focalizzazione e Rappresentazioni Selettive. *Sistemi Intelligenti*, XI(1), 85-111.
- Weizsäcker, G., 2003. Ignoring the Rationality of Others: Evidence from Experimental Normal-Form Games. *Games Econ. Behav.* 44(1), 145-171.

Figures



Fig. 1: Game interface (printed and presented to participants as an example of the type of graphical interface they would face during the experiment)

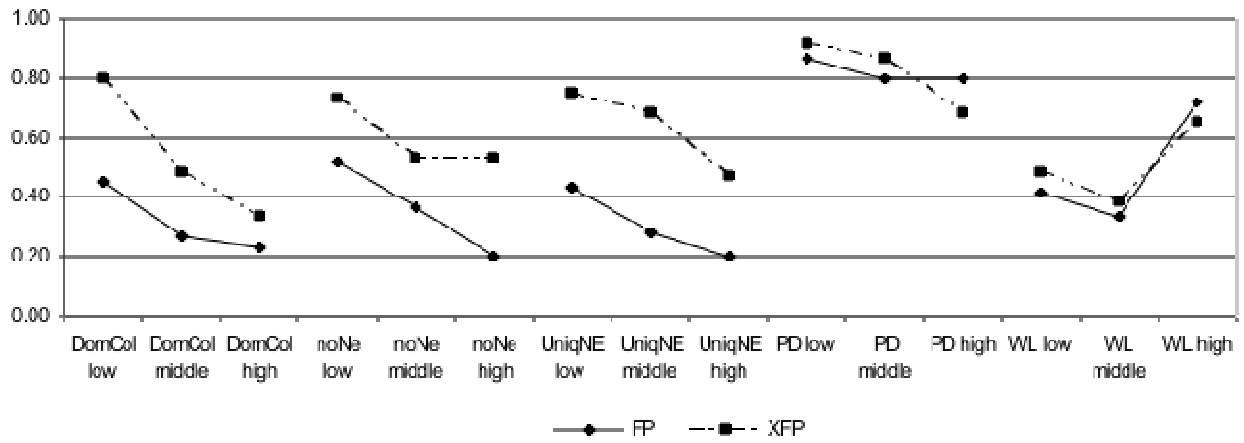


Fig. 2: Observed frequencies of row 1 choices

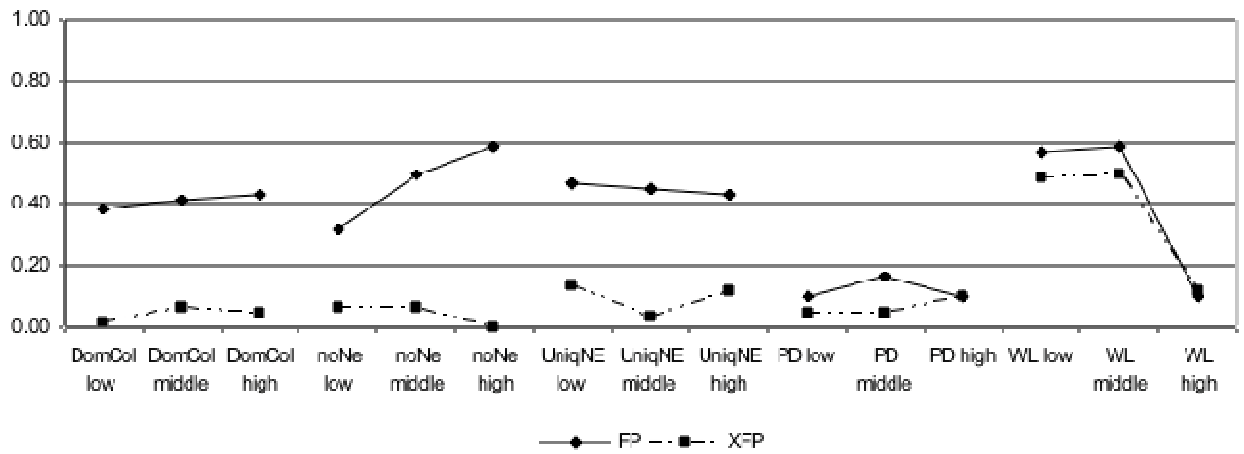


Fig. 3: Observed frequencies of row 2 choices

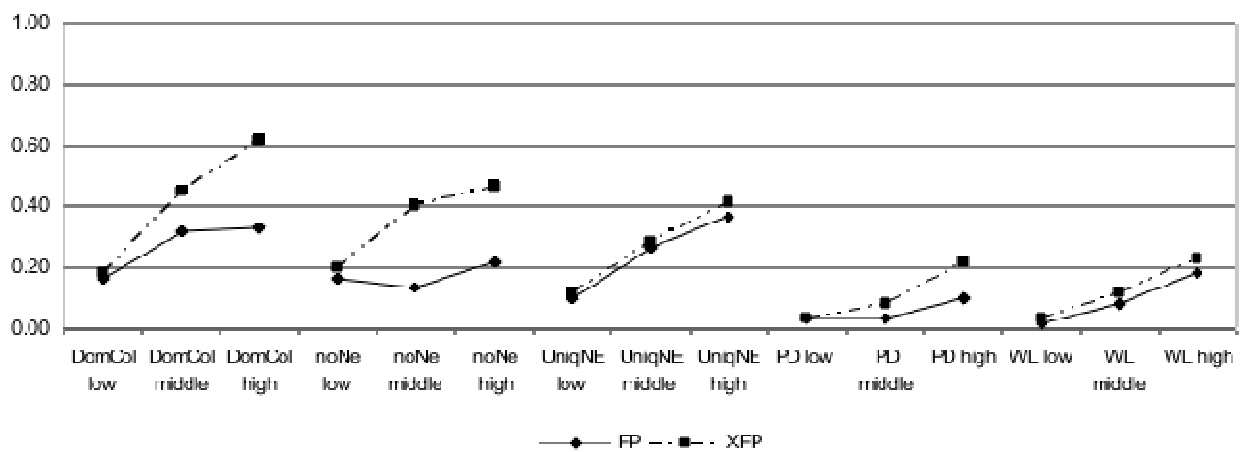


Fig. 4: Observed frequencies of row 3 choices

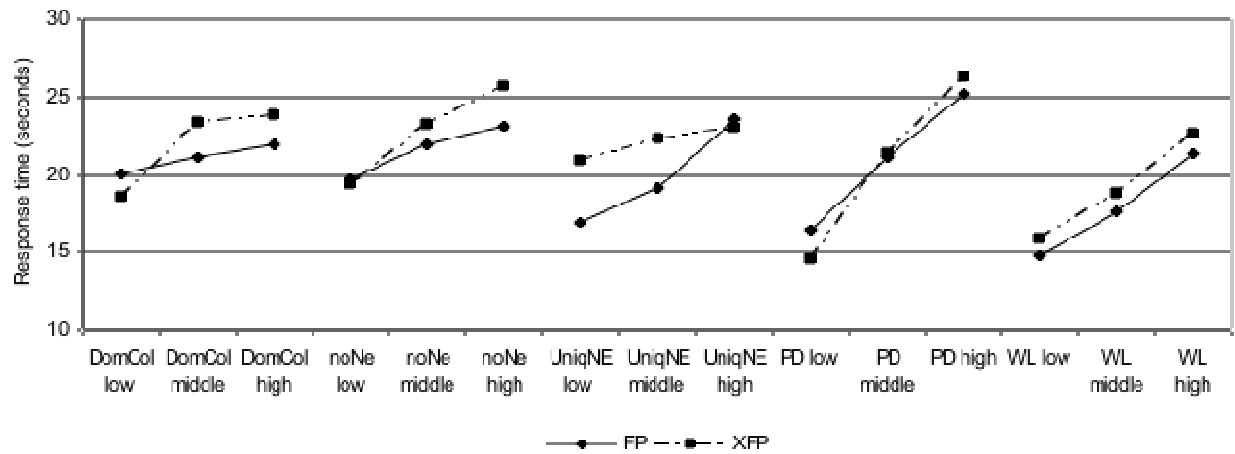


Fig. 5: Average response time in seconds, for each matrix

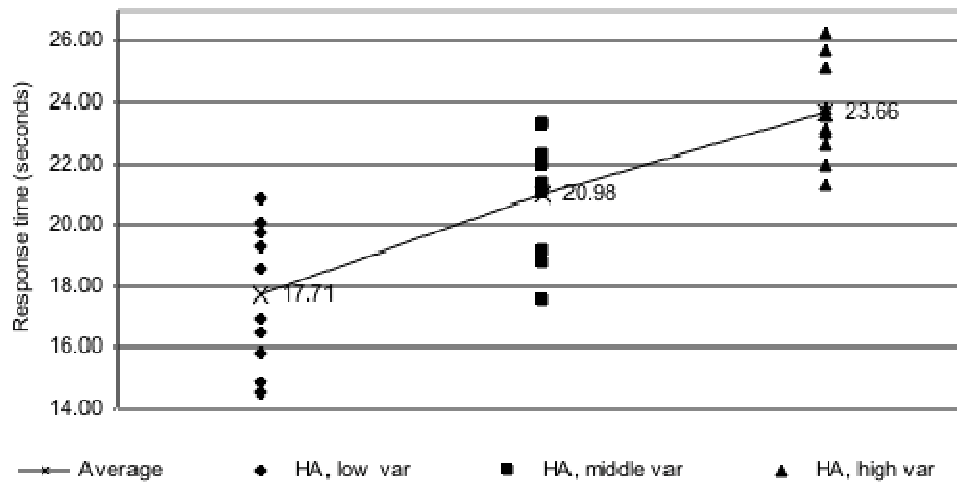


Fig. 6: Average response time as a function of HA variance level

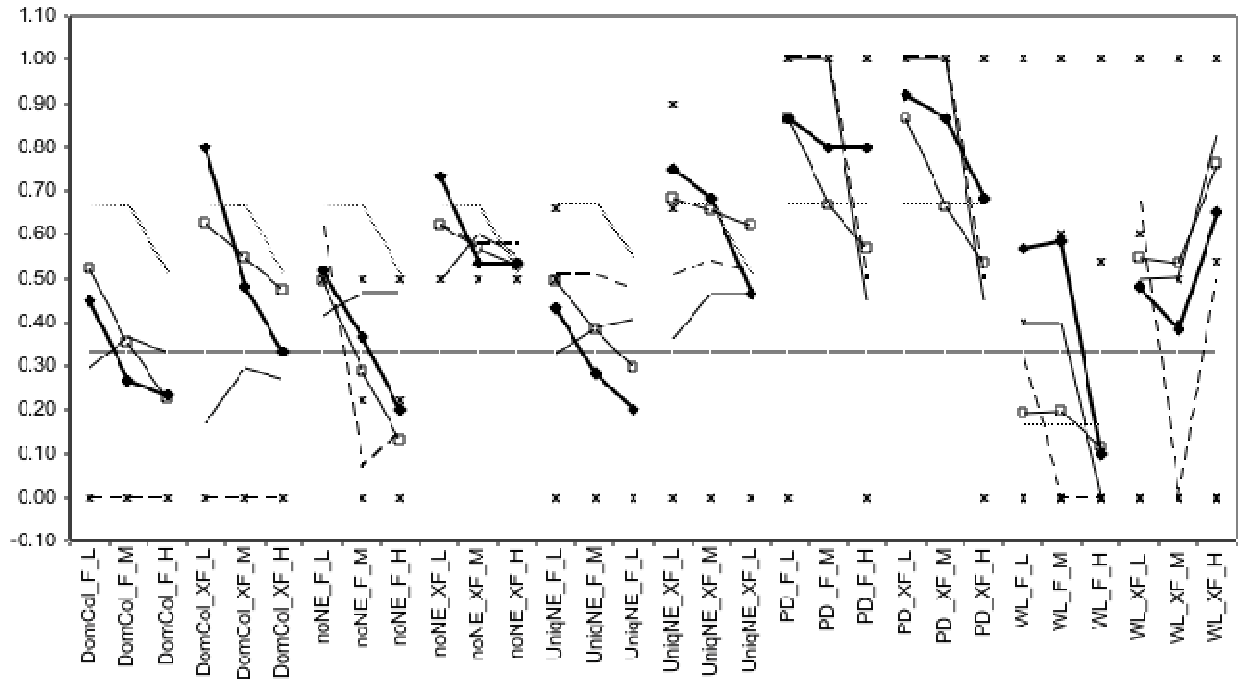


Fig. 7: Observed and estimated frequencies for row 1 choices Nash Equilibria (stars), Action Sampling (dashed line), Payoff Sampling (thin continuous line), QRE (thin continuous line, with empty squares), Cognitive Hierarchy (dotted line), Random Choice (continuous horizontal line), Observed Frequencies (thick continuous line, with small squares)

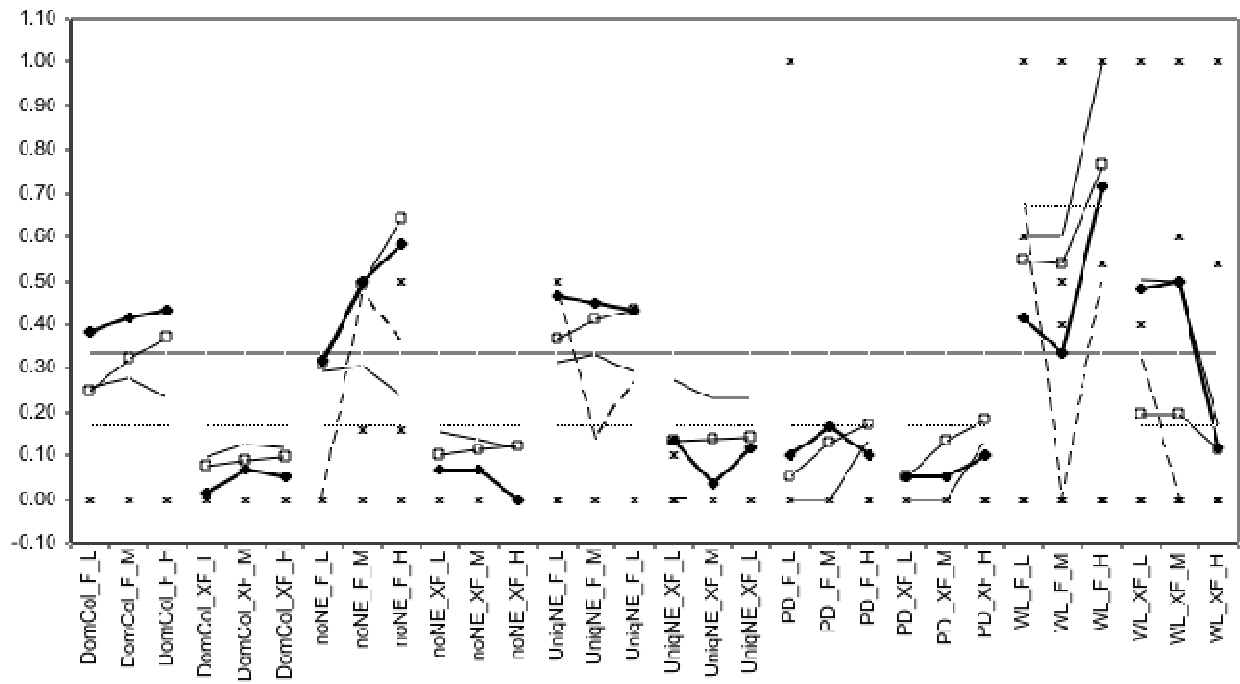


Fig. 8: Observed and estimated frequencies for row 2 choices.

Nash Equilibria (stars), Action Sampling (dashed line), Payoff Sampling (thin continuous line), QRE (thin continuous line, with empty squares), Cognitive Hierarchy (dotted line), Random Choice (continuous horizontal line), Observed Frequencies (thick continuous line, with small squares)

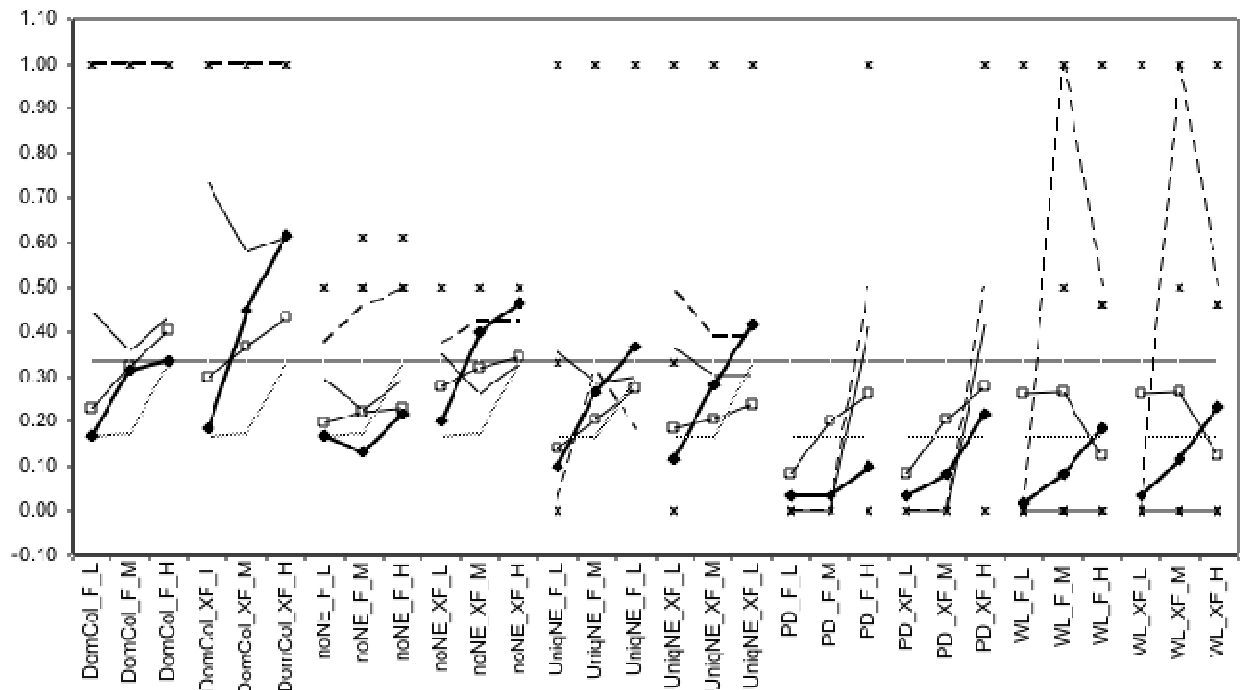


Fig. 9: Observed and estimated frequencies for row 3 choices.

Nash Equilibria (stars), Action Sampling (dashed line), Payoff Sampling (thin continuous line), QRE (thin continuous line, with empty squares), Cognitive Hierarchy (dotted line), Random Choice (continuous horizontal line), Observed Frequencies (thick continuous line, with small squares)

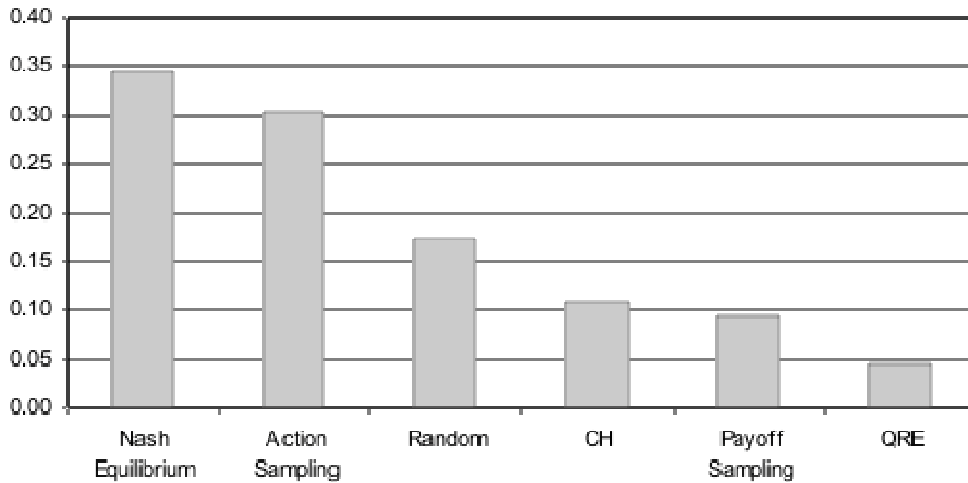


Fig. 10: Overall mean squared distances of five stationary concepts

Tables

		HA low var				HA middle var				HA high var							
		C1	C2	C3		C1	C2	C3		C1	C2	C3					
DomCol	FP	R1	35,20	35,25	35,30	HA	R1	60,20	20,25	25,30	HA	R1	80,20	10,25	15,30	HA	
		R2	5,55	80,80	5,85	FP	R2	5,55	80,80	5,85	FP	R2	5,55	80,80	5,85	FP	
		R3	10,20	10,15	40,25*	EQ	R3	10,20	10,15	40,25*	EQ	R3	10,20	10,15	40,25*	EQ	
				FP	EQ/HA			FP	EQ/HA			FP	EQ/HA				
	XFP	R1	35,20	35,25	35,30	HA	R1	60,20	20,25	25,30	HA	R1	80,20	10,25	15,30	HA	
		R2	5,55	50,25	5,85	FP	R2	5,55	50,25	5,85	FP	R2	5,55	50,25	5,85	FP	
R3		10,20	10,15	40,25*	EQ	R3	10,20	10,15	40,25*	EQ	R3	10,20	10,15	40,25*	EQ		
			XFP	EQ/HA			XFP	EQ/HA			XFP	EQ/HA					
noNe	FP	R1	35,15	35,20	35,30	HA	R1	55,15	25,20	25,30	HA	R1	75,15	15,20	15,30	HA	
		R2	5,45	75,75	10,80	FP	R2	5,45	75,75	10,80	FP	R2	5,45	75,75	10,80	FP	
		R3	15,35	5,25	40,20	QES	R3	15,35	5,25	40,20	QES	R3	15,35	5,25	40,20	QES	
				FP	QES/HA			FP	QES/HA			FP	QES/HA				
	XFP	R1	35,15	35,20	35,30	HA	R1	55,15	25,20	25,30	HA	R1	75,15	15,20	15,30	HA	
		R2	5,45	50,25	10,80	XFP	R2	5,45	50,25	10,80	XFP	R2	5,45	50,25	10,80	XFP	
R3		15,35	5,25	40,20	QES	R3	15,35	5,25	40,20	QES	R3	15,35	5,25	40,20	QES		
			XFP	QES/HA			XFP	QES/HA			XFP	QES/HA					
UniqNe	FP	R1	35,10	35,15	35,10	HA	R1	55,10	25,15	25,10	HA	R1	70,10	20,15	15,10	HA	
		R2	10,50	70,70	5,75	FP	R2	10,50	70,70	5,75	FP	R2	10,50	70,70	5,75	FP	
		R3	5,10	10,5	40,15*	EQ	R3	5,10	10,5	40,15*	EQ	R3	5,10	10,5	40,15*	EQ	
				FP	EQ/HA			FP	EQ/HA			FP	EQ/HA				
	XFP	R1	35,10	35,15	35,10	HA	R1	55,10	25,15	25,10	HA	R1	70,10	20,15	15,10	HA	
		R2	10,50	50,25	5,75	XFP	R2	10,50	50,25	5,75	XFP	R2	10,50	50,25	5,75	XFP	
R3		5,10	10,5	40,15*	EQ	R3	5,10	10,5	40,15*	EQ	R3	5,10	10,5	40,15*	EQ		
			XFP	EQ/HA			XFP	EQ/HA			XFP	EQ/HA					
PD	FP	R1	35,10	35,5	35,35*	EQ/HA	R1	25,10	60,5	20,20*	EQ/HA	R1	15,10	80,5	10,10*	EQ/HA	
		R2	10,35	35,35*	5,35	FP	R2	10,35	35,35	5,60	FP	R2	10,35	35,35	5,80	FP	
		R3	15,15	35,10	10,35	DOM	R3	15,15	35,10	10,25	DOM	R3	15,15*	35,10	10,15*	DOM	
				FP	EQ/HA			FP	EQ/HA			FP	EQ/HA				
	XFP	R1	35,10	35,5	35,35*	EQ/HA	R1	25,10	60,5	20,20*	EQ/HA	R1	15,10	80,5	10,10*	EQ/HA	
		R2	10,35	35,25	5,35	XFP	R2	10,35	35,25	5,60	XFP	R2	10,35	35,25	5,80	XFP	
R3		15,15	35,10	10,35	DOM	R3	15,15	35,10	10,25	DOM	R3	15,15*	35,10	10,15*	DOM		
			XFP	EQ/HA			XFP	EQ/HA			XFP	EQ/HA					
WL	FP	R1	60,60*	35,45	5,35	FP	R1	60,60*	35,45	5,35	FP	R1	60,60*	35,45	5,35	FP	
		R2	45,35	45,45*	35,35	HA	R2	50,35	50,50*	20,35	HA	R2	60,35	60,60*	5,35	HA	
		R3	35,5	35,35	35,35*	COS	R3	35,5	35,35	35,35*	COS	R3	35,5	35,35	35,35*	COS	
				FP	HA	COS		FP	HA	COS		FP	HA	COS			
	XFP	R1	35,35	45,45*	45,35	HA	R1	20,35	50,50*	50,35	HA	R1	5,35	60,60*	60,35	HA	
		R2	5,35	35,45	60,60*	XFP	R2	5,35	35,45	60,60*	XFP	R2	5,35	35,45	60,60*	XFP	
R3		35,35*	35,35	35,5	COS	R3	35,35*	35,35	35,5	COS	R3	35,35*	35,35	35,5	COS		
			COS	HA	XFP		COS	HA	XFP		COS	HA	XFP				

Table 1: Summary of all experimentally investigated games, grouped by type of game, level of HA variance, and presence of FP. * : pure strategy Nash Equilibria

Row player	Freq. FP	Freq. XFP	P-value chi-square	P-value one-tail binomial
DomCol HA low	38%	2%	0.00	0.00
DomCol HA middle	42%	7%	0.00	0.00
DomCol HA high	43%	5%	0.00	0.00
noNE HA low	32%	7%	0.00	0.00
noNE HA middle	50%	7%	0.00	0.00
noNE HA high	58%	0%	0.00	0.00
UniqNE HA low	47%	13%	0.00	0.00
UniqNE HA middle	45%	3%	0.00	0.00
UniqNE HA high	43%	12%	0.00	0.00
PD HA low	10%	5%	0.58	0.24
PD HA middle	17%	5%	0.07	0.04
PD HA high	10%	10%	0.20	0.50
WL HA low	57%	48%	0.60	0.46
WL HA middle	58%	50%	0.62	0.46
WL HA high	82%	77%	0.73	0.65

Table 2: Frequencies of FP and XFP choices for row players, and corresponding p-values

Column player	Freq. FP (EQ)	Freq. XFP (EQ)	P-value one-tail binomial
DomCol HA low	30% (70%)	5% (95%)	0.05
DomCol HA middle	50% (50%)	0% (100%)	0.00
DomCol HA high	35% (65%)	5% (95%)	0.02
noNE HA low	25% (75%)	0% (100%)	0.03
noNE HA middle	45% (55%)	0% (100%)	0.00
noNE HA high	30% (70%)	5% (90%)	0.05
UniqNE HA low	60% (40%)	15% (70%)	0.00
UniqNE HA middle	45% (55%)	30% (70%)	0.26
UniqNE HA high	60% (40%)	25% (70%)	0.03

Table 3: Frequencies of FP and XFP choices for column players, and corresponding p-values

In brackets, frequencies of EQ and QES strategies in corresponding matrices.

Game	Frequencies of FP + HA low var	Frequencies of HA with low var in matrices XFP
DomCol	83%	80%
noNE	83%	73%
UniqNE	90%	75%
PD	97%	92%
WL	99%	48% (+48%)

Table 4: Observed frequencies of FP + HA choices in matrices with HA low var, and HA choices in matrices with HA high var

	HA low variance	HA middle variance	HA high variance	Chi-square test	Binomial test one- tailed
DomCol FP	45%	27%	23%	0.02	0.01
DomCol XFP	80%	48%	43%	0.00	0.00
NoNE FP	52%	37%	20%	0.01	0.00
NoNE XFP	73%	53%	53%	0.00	0.02
UniqNE FP	43%	28%	20%	0.00	0.00
UniqNE XFP	75%	68%	47%	0.00	0.00
PD FP	87%	80%	80%	0.34	0.23
PD XFP	92%	87%	68%	0.00	0.00

Table 5: Frequencies of HA choices for row players, and corresponding p-values obtained by comparing low and high variance frequencies

	PD		DomCol, noNE, UniqNE		WL		PD	DomCol
Strategy (matrix)	FP low var	XFP low var	FP middle var	XFP middle var	FP low var	XFP low var	DOM low var	XFP middle var
Payoff magnitude			X		X	X		X
Symmetry of payoff	X		X		X	X	X	
Centrality of cell	X	X	X	X	X			X
Pareto efficiency	X	X	X	X	X	X		X
Frequency	10%	5%	42%	7%	57%	48%	3%	2%

Table 6: Attributes and choice frequencies for a sample of cells

		Chi-square test			Binomial test, two-tailed HA/no HA			Binomial test, two-tailed FP/no FP		
		noNE	UniqNE	PD	noNE	UniqNE	PD	noNE	UniqNE	PD
HA low var FP	DomCol	0.72	0.47	0.00	0.58	1.00	0.00	0.57	0.46	0.00
	noNE		0.21	0.00		0.46	0.00		0.13	0.01
	UniqNE			0.00			0.00			0.00
HA middle var FP	DomCol	0.05	0.83	0.00	0.01	1.00	0.00	0.46	0.85	0.00
	noNE		0.18	0.00		0.44	0.00		0.71	0.00
	UniqNE			0.00			0.00			0.00
HA high var FP	DomCol	0.23	0.88	0.00	0.82	0.82	0.00	0.14	1.00	0.00
	noNE		0.16	0.00		1.00	0.00		0.14	0.00
	UniqNE			0.00			0.00			0.00
HA low var XFP	DomCol	0.36	0.04	0.02	0.52	0.66	0.12	0.36	0.04	0.61
	noNE		0.26	0.01		1.00	0.02		0.36	1.00
	UniqNE			0.05			0.03			0.21
HA middle var XFP	DomCol	0.85	0.08	0.00	0.71	0.04	0.00	1.00	0.68	1.00
	noNE		0.23	0.00		0.13	0.00		0.68	1.00
	UniqNE			0.02			0.03			1.00
HA high var XFP	DomCol	0.03	0.07	0.00	0.04	0.19	0.00	0.24	0.32	0.49
	noNE		0.02	0.00		0.58	0.13		0.02	0.04
	UniqNE			0.04			0.03			1.00

Table 7: Comparison of games with same key features and different strategic structures. Shaded p-values ≤ 0.1

Appendix A

Instructions for experiment

INSTRUCTIONS

Welcome!

You are about to participate in an experiment on interactive decision-making, funded by the R.O.C.K. (Research on Organizations, Coordination and Knowledge) research group of the University of Trento. 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.

The experiment is divided in two, unrelated parts. The instructions for the second part will be distributed at the end of the first part. Your behavior and the earnings you obtain in the first part do not affect your earning in the second part in any way. The maximum you can earn in the experiment is 20 Euros.

PART 1

The experiment consists of 30 rounds; in each round you will face an interactive decision-making situation. 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. More specifically, your earnings in each decision-making situation will be determined by the combination of your choice and the choice of the participant with whom you will be paired in that round.

EXPERIMENTAL STRUCTURE

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

		OTHER PLAYER'S ACTIONS (Column Player)	
		C1	C2
YOUR ACTIONS (Row Player)	R1	(6,4)	(4,7)
	R2	(3,4)	(5,6)

The table is to be read as follows: you and the participant with whom you are paired will play the roles, respectively, of ROW PLAYER and COLUMN PLAYER, or vice versa. The available choices of the ROW PLAYER are represented by the rows of the table (in the example, R1 and R2), and the available choices of the COLUMN PLAYER are represented by the columns of the table (in the example, C1 and C2).

If your role in a round is that of ROW PLAYER, the participant with whom you are paired will have the complementary role of COLUMN Player, and vice versa. You will learn your role by reading the labels on the table. The label “YOUR ACTIONS” will be placed close to your role, and the label “OTHER PLAYER'S ACTIONS” will be close to the role of the player you are paired with. For example, in a table like the one presented above, you have the role of ROW player, and

the player with whom you are paired has the role of COLUMN player, so that the labels are inverted.

IMPORTANT: you will keep the same role (ROW or COLUMN) in all the decisional tables of the experiment, although the participant with whom you are paired will be picked randomly (and therefore may be different) in each round.

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 in brackets. These values indicate the earnings (in Experimental Currency Units) of each participant associated with that combination of choices. Conventionally, the first number represents the earnings of the ROW PLAYER (regardless of whether it is you or the other player), and the second number represents the earnings of the COLUMN PLAYER.

For example: in the table below, if YOU, the ROW PLAYER, choose row R1 and the OTHER PLAYER chooses column C2, then your earnings will be those in the cell at the intersection between row R1 and column C2; YOU (ROW Player) earn 4 ECUs and the OTHER PLAYER (COLUMN PLAYER) 7 ECUs.

		OTHER PLAYER (Column Player)	
		C1	C2
YOU (Row Player)	R1	(6,4)	(4,7)
	R2	(3,4)	(5,6)

Bear in mind that you cannot directly choose the cell of the table, but only one of the rows or columns, depending on your role. Only the combination of both choices will select one and only one cell, corresponding to your earnings and to those of the other participant.

MATCHING RULES

For each decisional table, the participant with whom you are paired is randomly selected by the software. Obviously, as the matching rule is random and as the number of decisional tables larger than the number of participants in the session, during the experiment you will be paired more than once with the same subject. However, you will never know the identity of the participant you are matched with, nor will you know that person's choice in a table after you have made yours.

INFORMATION

In each of the 30 rounds, the screen will show the decisional table (see Appendix B) for that round, and you will be asked to make a decision. Each table is marked by a numerical code, which will be used for the final payment. The code appears in the top left-hand corner of each decisional table. The top right-hand corner of the screen specifies the time remaining for your decision. You must communicate your decision by typing 1, 2 or 3 in the space "I choose row/column number", and by clicking the "confirm" button with the mouse.

In order for the next round to start, ALL participants must have entered their decision for the current round, and we therefore ask you not to take more than 30 seconds to choose. After 30 seconds, a text message in the top right-hand corner of the screen will ask you to write down your decision. If you delay your decision considerably, you will oblige the other players to wait. You will face 30 decisional matrices, corresponding to 30 different interactive situations. There is no relation among your choices in the different games, each game is independent of the others. 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 one of you, selected randomly, to verify that the box contains 30 tags, and also that the codes on the tags are really different from each other. Subsequently, the experimenter will ask a different participant, selected randomly, to pick 5 of these tags from the box. Each of you will be paid according to the earnings obtained in the tables corresponding to the extracted codes. The earnings in each of the 5 selected tables will be determined by matching your choice with the choice of the participant with whom you were matched at that table. 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 (see Appendix C), in order to make sure that you have understood the instructions perfectly 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 will start.

It is very important that you remain silent during the experiment, and that you never communicate with the other participants, either verbally, or in any other way. For any doubts or problems you may have, please just raise your hand and the experimenter will approach you. If you do not remain silent or if you behave in any way that could potentially disturb the experiment, you will be asked to leave the laboratory, and you will not be paid.

Thank you for your kind participation!

Appendix B

QUESTIONNAIRE

Dear Participant,

The following questionnaire is anonymous and has the sole purpose of verifying your understanding of the rules of this experiment.

We ask you to answer to the following questions. If you are uncertain about how to respond, please consult the instructions sheet.

When you have finished, please raise your hand and a member of the staff will check that all your answers are filled in.

Thank you for your cooperation!

	COLUMN Player		
	C1	C2	C3
ROW Player	R1	10,20	30,40
	R2	1,2	3,4
	R3	15,30	5,9

· **Suppose you are assigned the role of ROW PLAYER:** If the COLUMN PLAYER chooses strategy C2 and you choose strategy R2, how many ECUs will you earn? And the other player?.....If you choose strategy R2, and COLUMN PLAYER chooses strategy C3, how many ECUs will that person earn? And what about you?

· If the other player chooses C1, your earnings will be:

- If you choose R1:
- If you choose R2:
- If you choose R3:

Suppose you are assigned the role of COLUMN PLAYER

· If the ROW PLAYER chooses strategy R2 and you choose strategy C1, how many experimental points will you earn? And the other player?.....

· If the other player chooses R1, your earnings will be:

- If you choose C1:
- If you choose C2:
- If you choose C3:

· 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

Instructions for Experiment (Phase 2)

The sheet given to you shows 10 numbered ROWS, and each ROW presents 2 OPTIONS: **L** and **R**. We ask you to choose one and only one of the two options in each row. Your earnings will be determined in the following way.

This is a box containing 10 numbers, from 1 to 10, which will be used to determine your earnings. After you have made your choices, we will extract 2 numbers: the first number will determine the ROW that will be used to calculate your earnings, and the second number will determine your earnings given the OPTION, L or R, that you chose for that ROW. Obviously, each ROW has the same probability of being chosen, i.e., 1 of out 10.

Now, pay attention to ROW 1. OPTION L pays 2 Euros if the number drawn is 1, and 1.60 Euros if the number drawn is a number between 2 and 10 (extremes included). OPTION R pays 3.85 Euros if the number drawn is 1, and 0.1 Euros if the number drawn is a number between 2 and 10 (extremes included). All the ROWS are similar, meaning that the earnings for both OPTIONS remain the same. The only difference is that, moving towards the bottom of the table, the possibility of winning the larger amount increases for both OPTIONS. Consequently, the possibility of winning the lower amount decreases. If ROW 10 is selected, there will be no need to extract the second number, because each OPTION will certainly pay the larger amount, that is, 2 Euro (et seq.) for OPTION L and 3.85 Euros for OPTION R.

L is the default option for all ROWS, but you can choose to switch to OPTION R by simply marking the desired ROW. If you prefer OPTION R from a certain point onwards, just mark the corresponding ROW. Please note that you can switch from L to R only once and that the switch is irreversible; therefore, you must mark only ONE ROW, which indicates that, in all the ROWS above, you prefer OPTION L, whereas in the marked ROW and in all ROWS below, you prefer OPTION R. If you do not want to change, i.e., if you prefer OPTION L in all ROWS, don't mark anything. If you always prefer OPTION R, you must mark the first ROW. You can choose any of the 10 ROWS, but you can only pass from L to R once, and therefore at most you can put 1 mark.

When you have finished, we will collect your sheet. When all participants have completed their choices, one of you will draw the two numbers from the box. Remember, the first extraction determines the ROW that will be used to calculate everybody's earnings, and the second number will determine your earnings; the first number will be put back in the box before the second number is extracted. Your earnings in this choice task will be added to those obtained in the first part of the experiment, and the total amount will be paid to you privately at the end of the experiment.

EXAMPLE

Suppose that the ROW drawn randomly is ROW 3, and that you have marked one of the rows below ROW 3. Since ROW 3 is above your mark, this indicates that you prefer OPTION L for ROW 3. Then, if the second drawn number is (for example) 5, your earnings are 1.6 Euros.

Please answer the questions at the end of the sheet. We need this information for statistical purposes only.

	Option L	Switch from L to R	Option R
ROW 1	2 € with 1 or 1.6 € with 2-10	<input type="checkbox"/>	3.85 € with 1 or 0.1 € with 2-10
ROW 2	2 € with 1-2 or 1.6 € with 3-10	<input type="checkbox"/>	3.85 € with 1-2 or 0.1 € with 3-10
ROW 3	2 € with 1-3 or 1.6 € with 4-10	<input type="checkbox"/>	3.85 € with 1-3 or 0.1 € with 4-10
ROW 4	2 € with 1-4 or 1.6 € with 5-10	<input type="checkbox"/>	3.85 € with 1-4 or 0.1 € with 5-10
ROW 5	2 € with 1-5 or 1.6 € with 6-10	<input type="checkbox"/>	3.85 € with 1-5 or 0.1 € with 6-10
ROW 6	2 € with 1-6 or 1.6 € with 7-10	<input type="checkbox"/>	3.85 with 1-6 or 0.1 € with 7-10
ROW 7	2 € with 1-7 or 1.6 € with 8-10	<input type="checkbox"/>	3.85 € with 1-7 or 0.1 € with 8-10
ROW 8	2 € with 1-8 or 1.6 € with 9-10	<input type="checkbox"/>	3.85 € with 1-8 or 0.1 € with 9-10
ROW 9	2 € with 1-9 or 1.6 € with 10	<input type="checkbox"/>	3.85 € with 1-9 or 0.1 € with 10
ROW 10	2 € with 1-10	<input type="checkbox"/>	3.85 € with 1-10

Please answer the following questions:

What faculty are you enrolled in? _____

When did you enrol? (year)

When were you born? _____/_____/_____

Please specify where you were born and your nationality _____

Specify M or F

Have you attended any courses on Game Theory?

If so, which courses? _____

Do you know what a Nash Equilibrium is? _____

If so, in what courses did you study it?
