Avoiding Coordination-Failure using Correlation Devices: Experimental Evidences*

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(Still) Preliminary and Incomplete

Abstract: We consider a parametric version of Chicken and Battle of the Sexes to test whether or not players are able to coordinate on pure Nash equilibria using correlation devices. We use two different correlation devices, *public* and *private* to send recommendations in different sessions with different payoffs for these games and test whether the players follow the recommended strategies to avoid coordination-failure in the respective games. We find that the players overall do achieve coordination by following the recommended strategies; however, "following the recommendation" varies significantly with the treatment (game), period, recommended strategy and Markov (last period) effects.

Keywords and Phrases: Public message, Correlated equilibrium, Recommendation.

JEL Classification Number: C72.

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1. INTRODUCTION

Many games of economic interest involve multiple (pure) Nash equilibria and it is therefore important to understand how players select or coordinate to select a particular equilibrium. This class of games is a challenging domain for game theory and has inspired the development of economic models in cheap talk. In particular, the problem of multiplicity has been theoretically analysed using the literature of equilibrium selection. Harsanyi and Selten (1988) introduced the concepts of payoff dominance and risk dominance as selection criteria, suggesting that the former rather than the latter criterion should be chosen in case of conflicting recommendations. In another influential study, Farell (1987) shows that many rounds of cheap talk minimises the probability of mis-coordination, which goes to zero as the number of rounds of cheap talk increases.

Parallel to the theoretical literature, the tension of interests in coordination games is a central issue for the behavioural sciences, and the empirical validity of selection criteria has attracted the attention of many experimental economists. In the last thirty years of experimental research, a growing literature suggests that although coordination failures typically occur in the laboratory (e.g., Cooper et al. 1990; Van Huyck, et al, 1990; 1991), individuals may be able to coordinate if they are helped to do so by some mechanisms. For instance, in a well-known study by Cooper et al. (1992) the role of pre-play communication in coordination games is explored and the authors provide evidence that non binding communication can significantly improve the frequency of equilibrium play. Since then, many experiments have been conducted on how coordination failures can be avoided and an excellent survey of their main findings is provided by Devetag and Ortmann (2007). A critical conclusion from this survey is that while coordination failures are common in controlled settings, they are by no means ubiquitous. Factors such as costless messages and announcements (e.g., Brandts and MacLeod, 1995; Clark et al., 2001; Blume and Ortmann, 2007; Manzini et al., 2009), providing information about the other players' choice (e.g., Charness and Grosskopf, 2004), social history of play and observation of others' actions (e.g., Duffy and Feltovich, 2002; 2006, Schmidt et al, 2003), attractiveness of the payoff dominant outcome (Battalio et al., 2001), recommending the payoff dominant outcome (e.g., Chaudhuri and Paichayontvijit, 2010), can help overcome well-documented problems of equilibrium selection and coordination failure.

However, in most of these experiments, the selected game has a point of coordination that can be easily chosen, such as the unique payoff or risk dominant equilibrium. What if the game has multiple symmetric equilibria and none of these can be naturally selected? Experimental evidence (e.g., Cooper et al., 1989; Straub, 1995) indicates that players fail to coordinate in such a game with multiple equilibria without some help. In these cases, as Camerer (2003) rightly pointed out, "*players in a BOS crave any tie-breaking feature that distinguishes one player from another, to break the stalemate*" (see Ch. 7, pp.356, emphasis added). In our paper, we consider coordination games, such as battle of the sexes and chicken games, where mis-coordination is undesirable and there is no natural way to coordinate on one of the three (two pure and one mixed) equilibria.

Many games of economic interest involve multiple (pure) Nash equilibria. It is therefore important to understand how players select or coordinate to play a particular one. This problem of multiplicity perhaps can be theoretically solved using the literature of equilibrium selection (ref : van damme? Selten ? Harsanyi ?).
From the experimental literature, players fail to coordinate without some help (Straub 1995?); that is players may be able to coordinate if and only if they are helped to do so by some mechanisms (Cooper et al?);.
In most experiments, the point of coordination is however easily selected – in most cases this is the unique dominant (payoff or risk dominant) equilibrium – ref Cooper et al?
or in some cases has a desirable characteristics (such as focal point or the cooperative outcome even though it is not Nash) – ref
with the help of some coordinating mechanism (ref) – players coordinate to one outcome – equilibrium or ow These games have been extensively studied experimentally and their main findings are surveyed in Devetag and Ortmann (2007). A critical message from these studies is that while coordination failures are common in controlled settings, they are by no means ubiquitous and mechanisms such as pre-play communication (e.g., Cooper et al., 1992), observing action choices (e.g., Duffy and Feltovich, 2002; 2006), group composition (e.g., Schmidt et al, 2003), and social norms and group identification (e.g., Charness et al., 2007) are possible ways to engineer efficient outcomes.
There is a substantial literature on experiments on "communication" in different types of games (for different purposes including to coordinate on a specific outcome) and on "coordination" (typically on coordination games where outcomes/equilibria are Pareto ranked) using different methods incl communication

What if the game has multiple equilibria that are symmetric however does not have one that can be naturally selectable

Here we are thinking battle of the sexes type games where miscoordination is undesirable however there is no natural way to coordinate on one of the three (two pure and one mixed) equilibria.

Camerer rightly pointed out “players in a BOS crave any tie-breaking feature … to break the stalemate”

Theory – Farell cheap talk – many rounds of cheap talk minimises the probability of miscoordination (the prob of miscoordination goes to 0 as the number of rounds of cheap talk gets large)

Experiments (all references on BOS) somehow pick an equilibrium – Cooper et al (4 papers), Struab (1995)

Refer to experiments using cheap talk (eg, Kawagoe and Takizawa 2009)

None of the above to our knowledge does coordinating on different Nash outcomes using correlation device/public signals.

Randomised Public messages – if followed, no miscoordination; expected payoff

experiments on sunspots

we test this by varying the game in two ways – BoS asymmetric and then Chicken

features of chicken – cooperative outcome which is not Nash –

fairness outcome in chicken (ref?)

The second line of research to which our investigation contributes is the experimental literature on coordination games. Our paper adds to the existing experimental literature by exploring the extent to which a mediator, whose aim is to promote efficiency, can successfully prevent coordination failures in a laboratory environment.

On correlation, papers by Cason and Sharma, and Duffy and Feltovich, which are the closest papers relative to our study. two distinctive features: we examine and compare behaviour in two games (Chicken and BoS); and

Cabon-Dhersin, M-L. and Etchart-Vincent, N., (2010). “Cooperation, the power of a simple word. Some experimental evidence on wording and gender effects in a Game of Chicken”, CES Working Paper Series.

Cabon-Dhersin, M-L. and S. V. Ramani, 2007, Opportunism, Trust and Cooperation: A Game Theoretic Approach with Heterogeneous Agents, Rationality and Society 19, 203-228.

Refer to Miguel and Crawford’s papers

On the first strand of literature, the closest investigations to ours are due to Cason and Sharma (2007) and Duffy and Feltovich (2010).1 It is worth noting that, given the wide range of procedural differences between the two experiments, their main findings produce divergent results. Both papers consider individuals' recommended play in a Chicken game.

In our paper, we apply the concept of "correlated equilibrium" in two types of games with multiple Nash equilibria: Chicken and Battle of the Sexes. This class of games is a challenging domain for game theory and has inspired the development of economic models in cheap talk (any good theoretical survey to cite here?). In addition, the tension between cooperative and competitive interests that these games embody is a central issue for the behavioural and social sciences, and makes them fruitful for empirical investigation (see Camerer, 2003).

We tehn comparepublic devices with fully correlated device

This paper investigates experimentally how individuals behave in normal form games with multiple Nash equilibria in the presence of a mediator. By mediator, we mean an exogenously determined device which allows correlation in player's strategies.

A normal form game can be played using a correlation device. The correlation device first sends private messages to each player according to a probability distribution and then the players play the original normal form game. A correlation device is called direct or canonical if the set of messages is identical to the set of pure strategies of the original game, for each player. A (direct) correlated equilibrium (Aumann, 1974, 1987) can best be described as a mediator whose recommendations the players find optimal to follow obediently. Any (pure or mixed) Nash equilibrium and any convex combination of Nash equilibria can also be viewed as a direct correlated equilibrium.

The aim of our paper is twofold: to study coordination and correlation

we give a full explanation about which criteria have to be satisfied by the parameters used in each of the games. the structure of each of the two games we use and subsequently, the reason for choosing these two games. the criteria we use to observe behaviour. First, we provide a complete characterisation of which criteria the payoff parameters in our chosen games have to satisfy. To the best of our knowledge, this is the first paper which offers such a full theoretical explanation in the correlated equilibrium literature.

Second, we experimentally observe subjects' behaviour by considering a parametric version of Chicken and Battle of the Sexes to test whether and under which conditions players correlate their strategies. In particular, we examine correlated devices which send signals to each player according to two probability distributions (depending on the game).

Our study contributes both to the literature exploring experimentally the concept of correlation and the one assessing the role of correlation in enhancing coordination.

Our paper differs in two main respects. We extend the investigation of the empirical validity of the correlated equilibrium concept in coordination games using as our framework the well-known paradigm of the Battle of the Sexes. We also provide a full explanation about which criteria have to be satisfied by the payoff parameters.

Our experimental design consists of four treatments in total. Two treatments were conducted with the Chicken game where signals were either private or public, and two other treatments were conducted with the Battle of the Sexes game where the payoffs on the diagonal of the matrix were either symmetric or asymmetric. For the Battle of the Sexes only public signals were used. This design allows us to assess the impact of different probability distributions on individuals' play (by comparing the two Chicken treatments). We are also able to investigate the pure behavioural effects of mediation on promoting coordination (by comparing all three treatments with public signals).

We do not have a treatment without messages – this is known from the existing literature. In BoS, players miscoordinate (ref) and for chicken (ref C-S, Feltovich)

We ask

Do they follow recommendations to coordinate? (not to miscoordinate)

Do the games differ (as the miscoordination results in different outcomes)

Device matters? Public vs private (direct messages – not sunspot)

We look at factors

Period factor – do they "learn" to follow to coordinate after a while

Markov factor – they follow conditional on the last period choice to follow (own and opponent)

Signal factor – y factor in different games – cooperative outcome

We compare different games using the treatment variable and analyse the above factor

Results: expected?!

Our main findings suggest that, when signals are public, subjects' correlate their strategies more often compared to the case where signals are private. We also find that the use of a correlation device substantially increases coordination rates among players and this crucially depends on the size of the payoff of the cooperative outcome in each game.

The remainder of the paper is structured as follows. Section 2 provides some theoretical background of the general formulation underlying the theory of correlated equilibrium and explains in detail the parameter specification of our payoff criteria. Section 3 describes the design and procedures for our experiment. Section 4 discusses the results and Section 5 concludes.

papers listed in the reference section of this paper

2. MODEL

2.1. Correlation

The following concepts are well-established in the literature, following the seminal work of Aumann (1974, 1987). We are presenting here the definitions and notations (as in Ray 2002, 2009) we need in this paper, just for the sake of completeness.

Fix any normal form game, $G = [N, \{S_i\}_{i\in N}, \{u_i\}_{i\in N}]$ with set of players: $N = \{1,...., n\}$, finite pure strategy sets: $S_1,...., S_n$; $S = \prod_{i\in N} S_i$, and payoff functions: $u_1,...., u_n$; $u_i: S \rightarrow \Re$, for all i.

Definition 1. (i) A *direct correlation device* μ is a probability distribution over S $(= \prod_{i\in N} S_i)$. The device selects a strategy profile s $(= (s_1,...., s_n))$ according to μ and then sends the private recommendation s_i to each player i.

(ii) The extended game G_μ is the game where the correlation device μ selects and sends recommendations to the players and then the players play the original game G. A pure[4] strategy for player i in the game G_μ is a map $\sigma_i: S_i \rightarrow S_i$ and the corresponding (*ex-ante*, *expected*) payoff to player i is given by $u_i^*(\sigma_1,...., \sigma_n) = \Sigma_{s\in S}\, \mu(s)\, u_i(\sigma_1(s_1),...., \sigma_n(s_n))$.

[4] One may consider behavioral strategies here; however we are considering only pure strategies for simplicity in presentation and analysis.

Definition 2. (i) Given a direct correlation device μ, a strategy profile s (= (s_1,...., s_n)) is called a *public recommendation* or a *sunspot* in the device if $\mu(s) > 0$, and the *conditional probability* of ((s_{-i})) given s_i is 1 for all i.

(ii) A direct correlation device μ is called a *public device* if for all s with $\mu(s) > 0$, s is a public recommendation.

Definition 3. A direct correlation device μ is called a (*direct*) *correlated equilibrium* of the game G if the obedient strategy profile given by the identity map $\sigma_i(s_i) = s_i$, for all i, is a Nash equilibrium of the extended game G_μ. The payoff from μ to player i is $\Sigma_{s\in S}\ \mu\ (s)\ u_i(s)$.

For any normal form game G, let $N(G)$ denote the set of all distributions that correspond to any pure Nash equilibrium point and $CONV(G)$ denote any convex combination of several pure Nash equilibria.

A direct correlated equilibrium can be identified with an element of $\Delta(S)$. Let $C(G)$ denote the set of all (direct) correlated equilibria of a given game G while $P(G)$ denote the set of all (direct) correlated equilibria that are also public devices.

Clearly, any pure Nash equilibrium and any convex combination of several pure Nash equilibria of a game G, *corresponds* to a direct correlated equilibrium. Thus, $N(G) \subseteq CONV(G) \subseteq C(G)$. It is also obvious that $P(G)$ must coincide with $CONV(G)$. Hence, we have, $N(G) \subseteq CONV(G) = P(G) \subseteq C(G)$.

2.2. Game 1: Chicken

Consider a parametric version of the two-person game of *Chicken* (as presented in Kar, Ray and Serrano, 2005, 2010) shown in Figure 1a, where, $0 \leq a < b < c < d$. Each of the two players has two strategies, namely, X and Y. This game has two pure Nash equilibrium, namely, (X, Y) and (Y, X) and a mixed Nash equilibrium in which each player plays the strategy X with probability $(d-c)/\{(b-a) + (d-c)\}$.

	X	Y
X	a, a	d, b
Y	b, d	c, c

Figure 1a

Consider the following direct symmetric correlation device as in Figure 1b, where, $0 < p < 1$. It is easy to check that the above device is a direct correlated equilibrium for any parametric chicken game when $p \leq (b - a)/(b - a + 2d - 2c)$. The payoff from this correlated equilibrium to either of the players is $cp + (b + d)(1 - p)/2$.

	X	Y
X	0	$(1\text{-}p)/2$
Y	$(1\text{-}p)/2$	p

Figure 1b

One may now consider the direct correlated equilibrium that maximizes the sum of the expected payoffs, called the *utilitarian correlated equilibrium*. Clearly, if $b + d > 2c$, then any convex combination of the two pure Nash equilibrium outcomes of the game corresponds to the utilitarian correlated equilibrium with the sum of the expected payoffs $b + d$. However, if $b + d < 2c$, the utilitarian correlated equilibrium (Kar Ray and Serrano, 2005) of the game is characterised by a device as in Figure 1b with $p = (b - a) / (b - a + 2d - 2c)$. Consequently, under $b + d = 2c$, *utilitarian correlated equilibrium* is not unique, as we will see for a specific set of parameters below.

2.3. Game 2: Battle of the Sexes (BoS)

Using the same parametric notations as in the game of *Chicken*, one may construct a two-player game of *Battle of the Sexes* (*BoS*) as shown in Figure 2, where, $0 \leq a \leq a' < b < d$. Each of the two players has two strategies, namely, X and Y. We call this game *symmetric BoS* when $a = a'$ and *asymmetric BoS* when $a < a'$. This game has two pure Nash equilibrium, namely, (X, Y) and (Y, X) and a mixed Nash equilibrium in which each player plays the strategy X with probability $(d - a^{'})/\{(b - a) + (d - a^{'})\}$. For this game, for any values of a, $a^{'}$, b and d, clearly any convex combination of the two pure Nash equilibrium outcomes of the game corresponds to the utilitarian correlated equilibrium with the sum of the expected payoffs $b + d$.

	X	Y
X	a, a	d, b
Y	b, d	$a^{'}, a^{'}$

Figure 2

2.4. Devices

As explained earlier in the Introduction, we focus on two particular direct correlation devices. The first one is a “public” device as shown in Figure 3a. Clearly it is a direct correlated equilibrium for any parametric version of *Chicken* and *BoS* described above as it is a convex combination of two pure Nash equilibria, (X, Y) and (Y, X), of either of these games.

	X	Y
X	0	1/2
Y	1/2	0

Figure 3a

The second device we analyse is the following device as shown in Figure 3b. This direct correlation device clearly is not a public device. However, the posterior probabilities of two events given a recommendation are, respectively, (0, 1) and (½, ½) and hence are “easy” to understand and interpret. In the rest of the paper we call this specific correlation device the “private” device.

	X	Y

X	0	1/3
Y	1/3	1/3

Figure 3b

This private device is a direct correlated equilibrium for any parametric version of *Chicken* as long as $b + c \geq a + d$ which implies $b – a \geq d - c$ (note that the other equilibrium condition is satisfied as we have $d – c > 0$ for any *Chicken*).

2.5. Parameters

We choose the parameters in the parametric version of *Chicken* and *BoS* games to satisfy certain criteria so that the devices chosen above deem appropriate for our analysis of coordination by correlation. As we are going to use both the devices for *Chicken*, we impose the following conditions on the parameters of *Chicken* and thereby choose suitable parameter values for *Chicken* first and then use the same parameter values in *BoS* as indicated above.

Condition A: For a parametric version of *Chicken*, both the public and the private device maximizes the sum of the expected payoffs and hence be the *utilitarian correlated equilibrium*.
From the analysis in Section 2.2, note that for Condition A to hold, we require, $2c = b + d$ and also $(b + d)/2 = (b + c + d)/3 = cp + (b + d)(1 - p)/2$ with $p = (b – a)/(b – a + 2d - 2c)$.

Condition B.1: For a parametric version of *Chicken*, in the private device, the equilibrium conditions (incentive constraints) are satisfied with strict inequalities which implies $b + c > a + d$ (note that the other constraint is satisfied with strict inequality anyway as $d > c$).
Condition B.2: For a parametric version of *Chicken*, in the private device, at equilibrium, the conditional expected gain in payoffs from following the recommendation are the same for both possible recommendations; that is, expected payoff form X given X – expected payoff form Y given X = expected payoff form Y given Y – expected payoff form X given Y.
From the analysis in Section 2.2, it is obvious that for Conditions B.1 and B.2 to hold, we require, $b – a = 3(d - c)$.

Condition C.1: For a parametric version of *Chicken*, the mixed strategy Nash equilibrium strategy is not (½, ½).

Condition C.2: For a parametric version of *Chicken*, the mixed strategy Nash equilibrium payoff is strictly less than the payoffs from the public and the private devices.

Condition D: For a parametric version of *Chicken*, $a > 0$.

The rationale behind imposing the above conditions is easily justifiable. Condition A allows us to compare the results from two different devices while Condition B allows us to compare the results from two different recommendations within the private device. Condition C makes sure correlation is better than independent individual randomisation. Condition D avoids "zero-aversion" in experimental studies.

Following the above condition, let us now choose the parameters. Take $(c - b) = (d - c) = x$ (say) and $(b - a) = 3x$. That is, the parameters are $a > 0$, $b = a + 3x$, $c = b + x = a + 4x$, $d = c + x = a + 5x$. The *Chicken* we analyse therefore is as in Figure 4.

	X	Y
X	a, a	$a + 5x, a + 3x$
Y	$a + 3x, a + 5x$	$a + 4x, a + 4x$

Figure 4

The game of *Chicken* that satisfies all the above conditions thus can be identified by the values a (> 0) and x (> 0) only. For any value of x, clearly Conditions B and D are met. To check Condition A, note that the *utilitarian correlated equilibrium* is characterised by the device in Figure 1b with $p = (b - a) / (b - a + 2d - 2c) = 3/5$ with the payoff of $(b + 3c + d)/5 = a + 4x$. Also note that the payoffs from the public and the private devices are $(b + d)/2 = (b + c + d)/3 = a + 4x$. Finally, for Condition C, observe that with these parameter choices, the mixed strategy Nash equilibrium strategy is (1/4, 3/4), with the payoff of $(a + 3.75x)$ which is clearly less than the payoff from either of the devices, $(a + 4x)$.

A remark is in order here. When x is small (that is, when $a + 4x$ is "similar" to $a + 5x$), Y appears to be weakly "better" than X, that is, Y becomes a weakly dominant strategy. Hence, we should choose $x >> 0$ accordingly. Obviously (Y, Y) is not a Nash equilibrium, for any $x > 0$. However, Y may seem to be the "cooperative" strategy and thus (Y, Y) may be a "cooperative" outcome which requires coordination on a point that is not Nash.

One can now use the above parameters chosen for the game of *Chicken* to describe the game of *Battle of the Sexes* (*BoS*) as in Figure 5, where, $0 \leq a' - a < 3x$. The game is called *symmetric BoS* when $a = a'$.

	X	Y
X	a, a	$a + 5x$, $a + 3x$
Y	$a + 3x$, $a + 5x$	a', a'

Figure 5

Note that the public device as shown in Figure 3a is a *utilitarian correlated equilibrium* for the *BoS* with payoff $a + 4x$, same payoff from the public and private devices in the game of *Chicken*. This allows us to compare the results from these two games with public devices.

3. EXPERIMENT

3.1. Payoffs

Following the model and the conditions from the previous section, we

Cason and Sharma: 3,9,39,48	3	9	6	30
Duffy and Feltovich: 0,3,7,9	0	2	3	4

Cabon-Dhersin, M-L. and Etchart-Vincent, N., 5, 7, 10, 12

Cason-Sharma, Duffy-Feltovich do not satisfy some of the criteria.

3.2. Treatments

we varied the game that subjects were playing as well as the type of recommendations that they were given. As explained above, we used two different games and two different correlation devices. We refer to the former case as “Public signals” and to the latter case as “Private signals”. In total, we have four experimental treatments. These are: symmetric Battle of the Sexes (BoS) game with public signals, asymmetric Battle of the Sexes (BoS) game with public signals.

	X	Y
X	2,2	17,11
Y	11,17	14,14

Battle of the sexes

Here the miscoordination payoffs are worse. Hence we test coordination by the public device. The game can be written as

	X	Y
X	a,a	a+5x,a+3x
Y	a+3x,a+5x	a,a

The one I would like

	X	Y
X	2,2	17,11
Y	11,17	2,2

we can modify

	X	Y
X	a,a	a+5x,a+3x

Y	a+3x,a+5x	b,b

with b>a.

The parameters

	X	Y
X	2,2	17,11
Y	11,17	7,7

3.3. Design

In our design, We had 6 matching groups, for each of our treatments,. Each matching group consists of 8 subjects.

A total of 24 matching groups were used, with each one lasting for 20 rounds. Each session comprises one treatment condition.

Because of the likely dependencies between decisions within matching groups, we take the matching group as our unit of observation and treat these observations as independent for performing statistical tests. We randomly re-matched subjects in every period within each matching group in order to create an environment as close as possible to a single-period interaction between subjects. Subjects were informed that they are randomly paired with another participant, different from one round to the next, but they did not know with whom of the other people in the room were matched. The same matching protocol was used in all matching groups. The overview of the experimental design is summarized in Table 1.

Table 1 Overview of experimental design

Game	Device	No. of matching groups	No. of subjects
Symmetric BoS	Public	6	6 × 8 = 48
Asymmetric BoS	Public	6	6 × 8 = 48
Chicken	Public	6	6 × 8 = 48
Chicken	Private	6	6 × 8 = 48

All sessions used an identical protocol. At the beginning of a session, subjects were seated and given a set of written instructions.[5] In an attempt to make the rules of the game common knowledge, subjects were informed that all participants in the session have identical instructions. After subjects having read the instructions, they were allowed to ask questions by raising their hands and speaking to the experimenter in private. Subjects were not allowed to communicate with one another throughout the session, except via the decisions they entered on their terminals. At the end of their instructions, subjects were given a short questionnaire in order to ensure that they understood the instructions. The experiment did not proceed until every subject had answered these questions correctly. Our instructions used a neutral terminology. We avoided using terms that may suggest competitive framing such as "your opponent" or "your partner". We instead used terms such as "your counterpart". Subjects were not given identifying information about their counterparts in any round and thus, no subject-specific reputations can develop across rounds.

At the beginning of a round, subjects were shown the payoff matrix corresponding to a game (depending on the treatment), along with their recommended action, which was randomly drawn from the appropriate outcome distribution. We used a neutral framing to suggest recommendations by saying "It is recommended that you choose__". In all sessions, we used the same random sequence of recommendations for all subjects (depending on the type of recommendations) to reduce across-subject variation. After subjects decided which action to choose, they were provided with the following feedback: own recommendation, own action, opponent recommendation, opponent action, own payoff and opponent payoff.

At the end of round 20 of any treatment, the experimental session ended. Subjects were then privately paid according to their point earnings from all 20 rounds, using an exchange rate of £0.03 per point. Average earnings per treatment were as follows: £7.50 for Chicken private signals; £7.82 for Chicken public signals; £7.29 for asymmetric BoS; and £7.53 for symmetric BoS. Sessions lasted, on average, 45 minutes. The experiment was conducted at the University of York in the Centre for Experimental Economics (EXEC) lab using subjects recruited from a university-wide pool of students. Subjects were students from various fields of studies including, but not confined to, economics. We recruited subjects using the ORSEE software (Greiner, 2004). The experiment was programmed and conducted with the software

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[5]Instructions for the Chicken game with public and private signals are included in an Appendix. Instructions for the Battle of the Sexes games paralleled these.

z-Tree (Fischbacher, 2007).

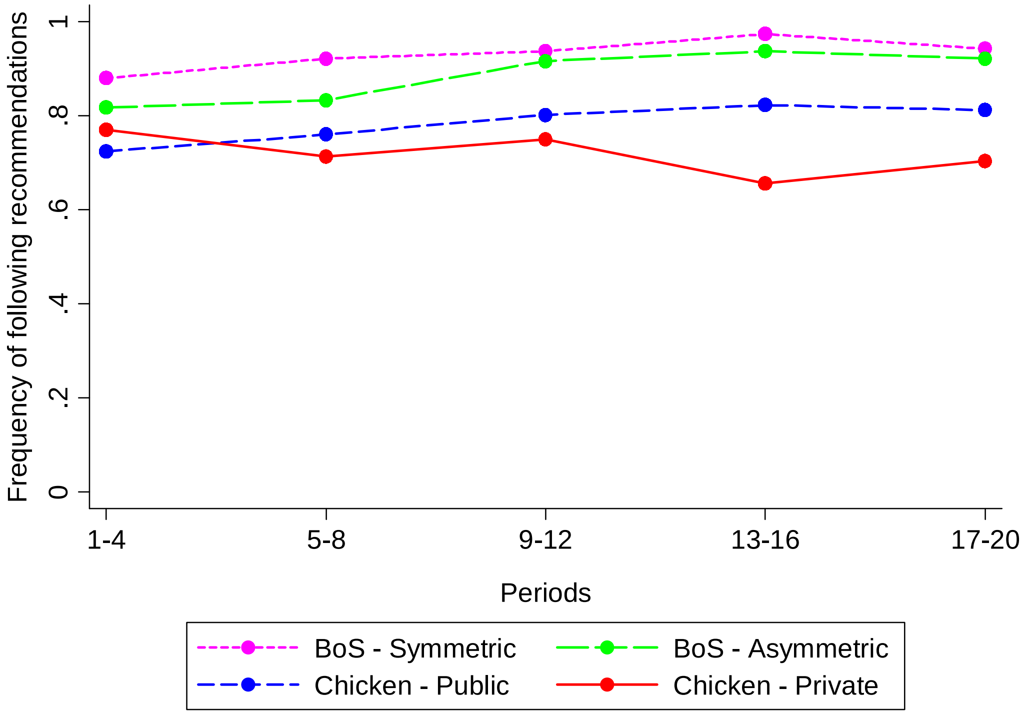
4. RESULTS: FOLLOWING RECOMMENDATIONS

In this section, we present the main results of our experiment. As mentioned in the introduction, we are concerned with the following issues: (a) do individuals follow recommendations to coordinate (or to avoid miscoordination) and how does the frequency of following recommendations differs as the games differ in terms of the miscoordination outcomes); and (b) which factors affect individuals' decision to follow recommendations for each game and correlation device we used. In particular we examined the significance of the following factors: i) period factor (i.e., do subjects "learn" to follow to coordinate as the game progresses?); ii) Markov factor (i.e., do subjects follow recommendations conditional on their own and their counterparts' choice to follow in the previous period?); iii) signal factor (i.e., as the cooperative outcome differs across games, does receiving a given signal impact on subjects' decision to follow?). In the following sub-sections, we provide answers to each of these questions in turn.

5.1. Descriptive Analysis

By looking at the descriptive statistics from the raw data set, we first inspect how the frequency of following a recommendation evolves over time for each treatment separately. Figure 1 presents the overall frequency of the subjects who followed their recommendations. We have divided our 20 periods in five 4-period blocks. For instance, in the asymmetric BoS treatment, we see that in the first four-period block, the frequency of following a signal is equal to 81.77% and it further increases by the last block to 92.19%. A clear observation suggests that the average frequency of following a recommendation is quite high, especially for the treatments where signals were public. In sum, a visual inspection of Figure 1 suggests that subjects are most likely to follow a recommendation in the symmetric BoS and least likely in the Chicken with private signals.

Fig. 1 Average frequency of those who follow their recommendation



We next examine whether there are any significant differences in the observed frequencies of following a recommendation" between our treatments? Table 2 reports the corresponding p-values from a Wilcoxon ranksum test performed for each pairwise comparison. We record significant differences between both versions of the BoS game and the corresponding Chicken games either with public or private signals. We find no significant differences between the two Chicken games.

Table 2 p-values of pair wise Wilcoxon rank sum tests comparing frequencies of following recommendations

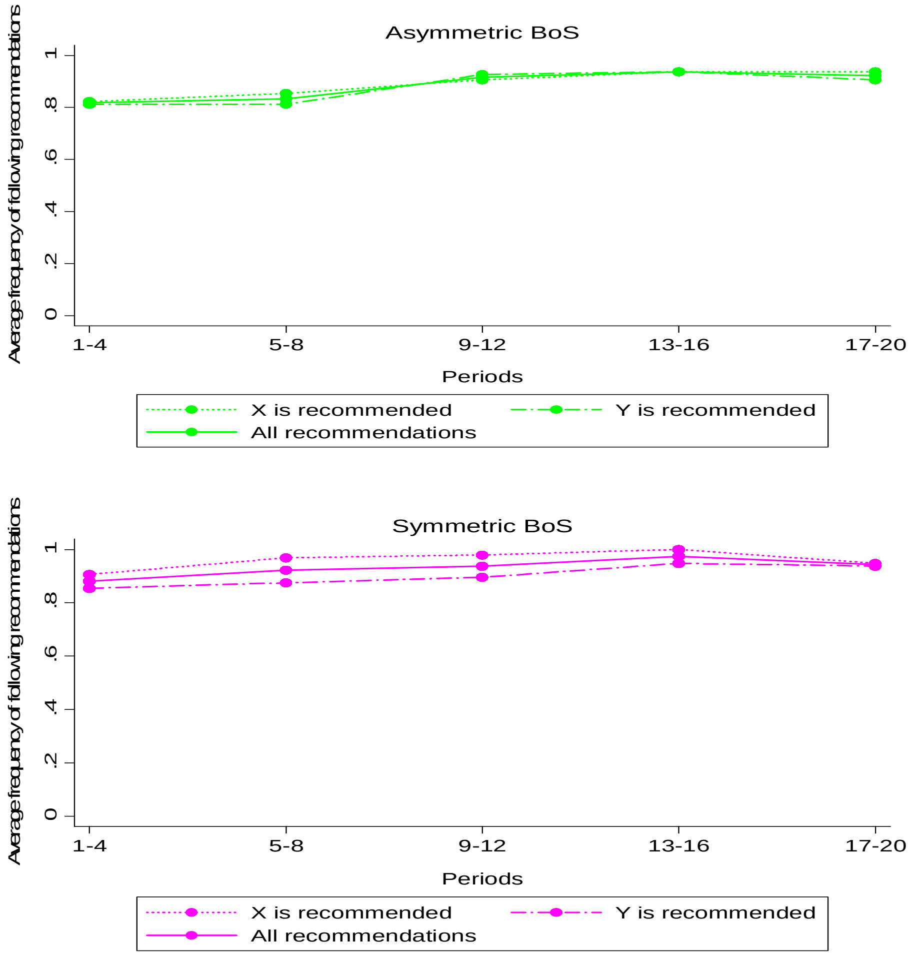
Treatment	Symmetric BoS (93.13%)	Asymmetric BoS (88.54%)	Chicken with public signals (78.44%)	Chicken with private signals (71.88%)
Symmetric BoS (93.13%)	--			
Asymmetric BoS (88.54%)	0.1986	--		
Chicken with public signals (78.44%)	0.0161	0.0542	--	
Chicken with private signals	0.0039	0.0065	0.1994	--

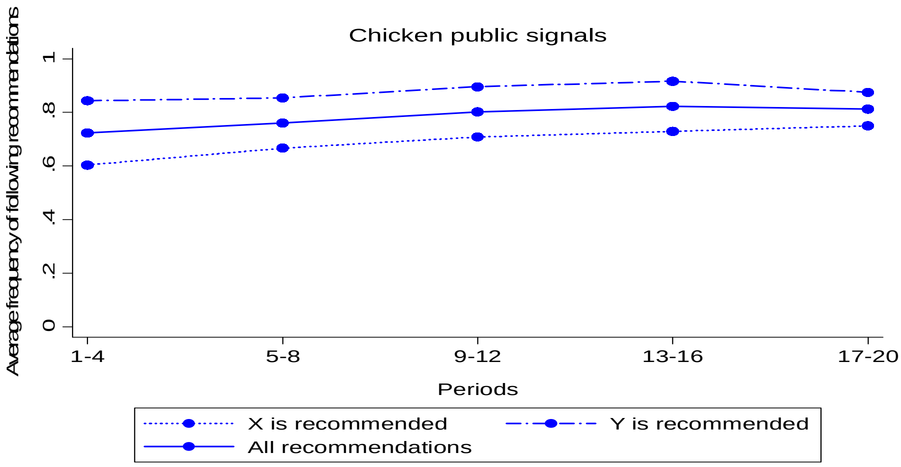
	(71.88%)

Note: Frequencies of following recommendations are presented in parentheses.

We conclude this sub-section by examining how frequent a given signal was followed in each treatment condition. Figure 2 below illustrates the pattern in each of our four treatments in four panels. For each game separately, each panel illustrates the average frequency of following recommendation X (when a subject is recommended X), the average frequency of following recommendation Y (when a subject is recommended Y), and the average frequency of following all recommendations as a function of five 4-period blocks.

Fig. 2 Average frequency of following recommendations in each treatment





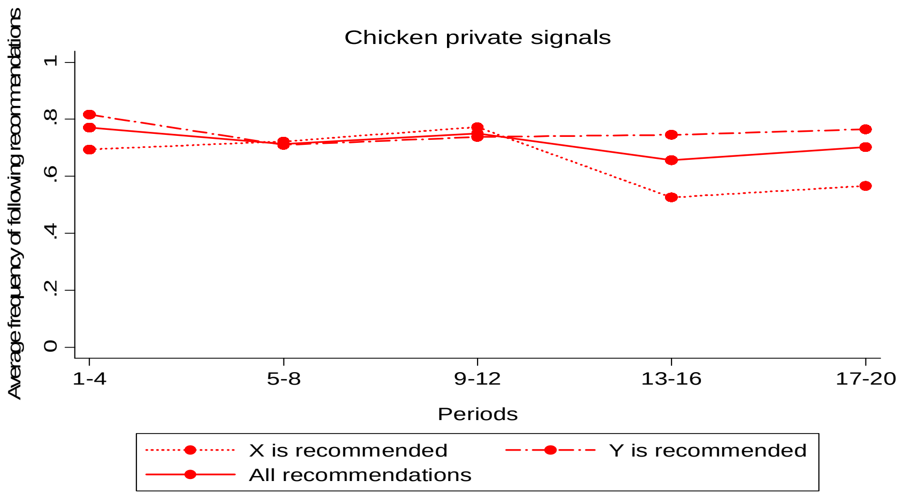


Table 3 below summarises over all 20 periods the average frequencies in each treatment separately when subjects followed X, Y and both signals.

Table 3 Frequencies of following recommendations

Treatment	Following X	Following Y	Following Recommendations
Symmetric BoS	96.04%	90.21%	93.13%
Asymmetric BoS	89.17%	87.92%	88.54%
Chicken with public signals	69.17%	87.71%	78.44%
Chicken with private signals	65.15%	75.40%	71.88%

We notice very high frequencies of following recommendations in both versions of the BoS, irrespective of the signals received. For example, in the symmetric BoS, when signal X (Y) was given, subjects selected X (Y) 96.04% (90.21%) of the time. As we move to the

Chicken game with private signals, we observe that, on average, subjects follow their signals 71.88% of the time.[6]

As the statistical tests reported above do not control for other characteristics that may affect an individual's decision to follow a recommendation in the presence of a correlation device, we next use multivariate regressions to address our main hypotheses.

5.2. Econometric Analysis

We run probit regressions, since the dependent variable is a binary variable which equals '1' if a subject followed her recommendation and '0' otherwise. As explained in the previous section, we are interested in three dimensions: a) period factor; b) signal factor; and c) Markov factor. Therefore, to assess the impact of these variables, the regressions reported below include the following independent variables: a) 'Period', which is equal to the number of periods (and captures period effects); b) 'Signal', which is equal to '1' when the recommendation is Y and '0' when the recommendation is Y; and c) variables indicating subjects' actions in the previous period. In particular, we include the variables 'Own choice in t-1' which is equal to '1' if a subject chose 'Y' in the previous period and '0' otherwise, 'Counterpart's choice in t-1' which is equal to '1' if her counterpart chose 'Y' in the previous period and '0' otherwise, 'Own profit in t-1' which is equal to a subject's profit earned in the previous period, 'Follow in t-1' which is equal to '1' if a subject followed her recommendation in the previous period and '0' otherwise, and 'Counterpart follows in t-1' which is equal to '1' if her counterpart followed her own recommendation in the previous period and '0' otherwise.

5.2.1 Determinants of following recommendations in the presence of a correlation device

Table 4 presents the regression results for each treatment separately. Two things stand out from the table below. First, a subject's choice in the previous period affects the likelihood of a subject following a recommendation. How their counterpart chose also affects their decision to follow or not their recommendation. Both variables are significant in all four treatments. The impact of past actions on current behaviour has also been stressed and

[6] See Tables A.3 – A4 in the appendix for average frequencies per matching group in each of our four treatment conditions.

recorded in previous experiments of similar context (e.g., see Duffy and Feltovich (2010)). Second, the dummy variable ‘Signal’ is statistically significant in all treatments apart from the asymmetric BoS. In particular, receiving a "Y" signal increases the probability of following a recommendation in the Chicken with public with and private signals (compared to when an ‘X’ signal is received), and decreases the likelihood of following in the symmetric BoS.

We also observe that period has a significant and positive effect only in the asymmetric BoS game. For the role of period, we comment on section 5.2.2.

Table 4 Determinants of following or not recommendations

	Dependent variable: Follow recommendation = 1; Don’t follow recommendation = 0			
Independent Variables	Asymmetric BoS	Symmetric BoS	Chicken private signals	Chicken public signals
Period	0.005*** (0.006)	0.002 (0.177)	-0.002 (0.413)	0.003 (0.193)
Signal	-0.009 (0.637)	-0.051*** (0.000)	0.083** (0.011)	0.185*** (0.000)
Own choice in t – 1	-0.021 (0.320)	0.019 (0.250)	-0.017 (0.601)	-0.014 (0.659)
Counterpart’s choice in t – 1	-0.035 (0.203)	0.006 (0.760)	0.063 (0.231)	-0.009 (0.867)
Own profit in t – 1	0.004 (0.228)	-0.000 (0.899)	-0.008 (0.147)	0.005 (0.432)
Follow in t – 1	0.201*** (0.001)	0.227*** (0.004)	0.203*** (0.000)	0.248*** (0.000)
Counterpart follows in t – 1	0.075* (0.084)	0.085* (0.097)	0.070* (0.053)	0.125*** (0.004)
Obs.	912	912	912	912
Pseudo R^2	0.1194	0.1602	0.0414	0.1234

*Note: Table lists marginal effects after probit estimation. Robust standard errors are reported. P-values are presented in parentheses. * denotes significance at the 10-percent level, ** at the 5-percent level, and *** at the 1-percent level. Note that if we replace the dummy variables "Follow in t-1" and "Counterpart follows in t-1" by* *their product indicated by a single dummy variable "Both players follow in t-1" (which equals to `1' when both players followed their recommendations in the previous period and `0' otherwise), we get similar results.*

Finding 1. *Subjects' following of recommendations is affected by history. The more successful following recommendations has been in the past, the more likely a subject is to follow recommendations in the current round. Receiving a given signal affects their following of recommendation in all but one treatment (asymmetric BoS).*

5.2.2 Differences between treatments

We next compare whether there are differences in subjects' following their recommendations between treatments. To assess the impact of treatment differences, we run Probit regressions as in the previous section, with the only exception that we now include an additional dummy variable, which captures differences between and to which we refer as 'Treatment'. Our analysis provides answers to whether there are differences in games as the miscoordination results in different outcomes and to which correlation device matters (public vs. private) to induce higher coordination. Apart from the variable 'Treatment', our variables of interest are: a) Period factor; b) Signal factor; and c) Markov factor.

Our regression results are presented in Table 5. We observe significant differences among treatments. In particular, regression coefficients suggest that in the asymmetric BoS subjects are 3.1% less likely to follow their recommendations compared to those in the Symmetric BoS. In the comparable Chicken game with public signals, subjects are always less likely to follow compared either to the asymmetric or the symmetric BoS. With respect to the asymmetric BoS, they are 7.5% less likely to follow, whereas, being in the symmetric BoS increases the probability of following a recommendation by 10.9% (relative to being in the Chicken game with public messages). Finally, in the Chicken games, we also observe significant differences: a subject is less likely by 7.9% to follow his recommendation when signals are private than when they are public.

Interestingly, looking at the variable 'Period', we observe positive and significant coefficients (that is, as the session progresses, following a recommendation in more likely) in all pairwise comparisons where the correlation device is public. Regarding the variable 'Signal', it is also positive and significant in all cases where a Chicken game is included. When the treatment comparison consists only of the BoS games, then the coefficient on 'Signal' becomes negative and remains statistically significant. Confirming the impact of past history on current behaviour, we find significant and positive coefficients of the variables 'Follow in t – 1' and 'Counterpart follows in t – 1' for all comparisons.

Table 5 Differences between treatments

	Dependent variable: Follow recommendation = 1; Don't follow recommendation = 0			
Independent Variables	Comparison 1: Asymmetric BoS vs. Symmetric BoS	Comparison 2: Chicken 1/2 vs. Asymmetric BoS	Comparison 3: Chicken 1/2 vs. Symmetric Bos	Comparison 4: Chicken 1/3 vs. Chicken 1/2
Period	0.003*** (0.003)	0.004*** (0.006)	0.003* (0.066)	0.001 (0.656)
Treatment	-0.031*** (0.008)	-0.075*** (0.000)	-0.109*** (0.000)	-0.079*** (0.000)
Signal	-0.032*** (0.007)	0.082*** (0.000)	0.053*** (0.000)	0.138*** (0.000)
Own choice in t – 1	-0.001 (0.952)	-0.019** (0.282)	0.013 (0.445)	-0.029 (0.172)
Counterpart's choice in t – 1	-0.013 (0.429)	-0.034 (0.216)	0.003 (0.924)	0.008 (0.819)
Own profit in t – 1	0.002 (0.354)	0.006* (0.057)	0.003 (0.357)	-0.001 (0.847)
Follow t – 1	0.081** (0.013)	0.211*** (0.000)	0.214*** (0.000)	0.224*** (0.000)
Counterpart follows in t – 1	-0.046 (0.389)	0.093*** (0.001)	0.106*** (0.000)	0.098*** (0.000)
Obs.	1,824	1,824	1,824	1,824
Pseudo R^2	0.1364	0.1244	0.1518	0.0741

*Note: Table lists marginal effects after probit estimation. Robust standard errors are reported. P-values are presented in parentheses. * denotes significance at the 10-percent level, ** at the 5-percent level, and *** at the 1-percent level. The dummy variable "Treatment" equals 1 for the first treatment in each pairwise comparison reported below. By replacing the dummy variables "Follow in t-1" and "Counterpart follows in t-1" by their product as a dummy variable "Both players follow in t-1", we get similar results.*

Finding 2. *There are significant differences across treatments in whether subjects follow their recommendation. Subjects are most likely to follow their recommendations in the symmetric BoS and least likely in Chicken game with private signals.*

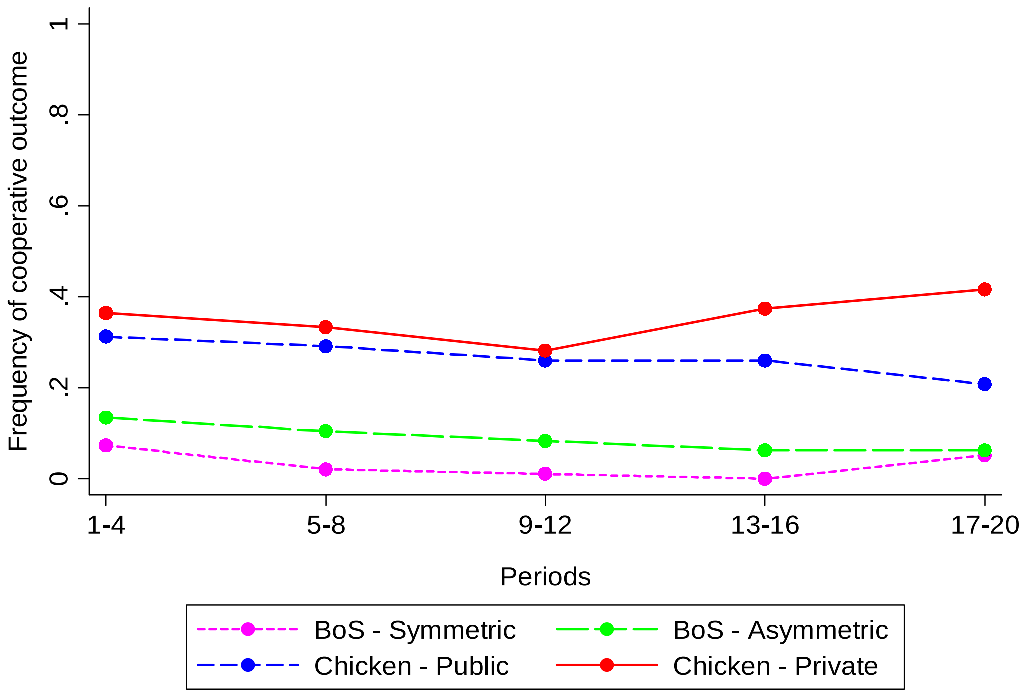
5. RESULTS: COOPERATION

Does the value of the cooperative outcome matter?

Our analysis in the previous section indicates differences in how individuals use the correlated device. In particular, we find that subjects follow more their recommendations in the BoS games and less in the Chicken. This is an interesting point as from a theoretical perspective we should not observe differences in how these devices are used across games. Our design allows us to explain these differences by investigating how behaviour between treatments changes as the payoff of the cooperative outcome (Y, Y) changes. In sum, our analysis shows that as (Y, Y) payoff becomes more attractive, individuals have a higher tendency to mismatch.

Figure 3 plots the overall frequency of the cooperative choices in each four-period block of periods for each of our games.

Fig. 7 Average frequency of cooperative outcome



What we observe in Figure 7 is a mirror image of the frequency of following recommendations as presented in Figure 3. That is the cooperative outcome is chosen less frequently in the BoS symmetric and more frequently in the Chicken game with private signals. As for the BoS asymmetric, the frequency for this outcome is in between the other two games. More specifically, across all five blocks, on average 26.67% of subjects choose the cooperative outcome in the Chicken game with public signals; whilst, the percentage for the asymmetric BoS and for the symmetric BoS becomes 8.96% and 3.13%, respectively. The decline of the cooperative choice is also in line with Cason and Sharma's result, who also observe that in their comparable treatment with recommendations the mean rate of their cooperation choice decreases as the game progresses.

Table 6 shows the corresponding p-values for all pairwise comparisons between treatments after performing a ranksum Wilcoxon test. This Table also reports in parentheses the average frequencies of (Y, Y) play across all periods.

Table 6 p-values of pair wise Wilcoxon rank sum tests comparing frequencies of cooperative play

Treatment	Symmetric BoS (3.13%)	Asymmetric BoS (8.96%)	Chicken with public signals (26.67%)	Chicken with private signals (35.42%)

Symmetric BoS (3.13%)	--			
Asymmetric BoS (8.96%)	0.0222	--		
Chicken with public signals (26.67%)	0.0038	0.0080	--	
Chicken with private signals (35.42%)	0.0038	0.0038	0.2615	--

Note: Frequencies of cooperative play are presented in parentheses.

It is clear that the raw average frequencies indicate a pattern of playing the cooperative outcome less and less when its monetary value decreases. Our econometric evidence provides further support for this observation. Below we estimate a probit model, with the dependent variable ('Cooperative choice') being equal to '1' if both players have chosen (Y, Y) and '0' otherwise. The inclusion of independent variables follows similar reasoning as in previous econometric models reported earlier.

Table 7 suggests that the marginal effects of the dummy variable 'Treatment' are positive in all four comparisons. In particular, interpreting these coefficients, we find that the likelihood of choosing (Y, Y) is higher by 5.7% in the asymmetric BoS than in the symmetric one. Also, compared with the BoS games, in the Chicken game with public messages, subjects are more likely to choose the cooperative outcome. In particular, it is 15.1% more likely for subjects to make the (Y, Y) choice relative to the asymmetric BoS and 20.5% relative the symmetric BoS.

When the payoff of the outcome (Y, Y) is the same but the probability distribution of the signals changes, we also observe significant differences between the two Chicken games. It turns out that subjects are 6% more likely to choose (Y, Y) in the case where signals were private compared to the case where signals were public. This difference between the Chicken games can be explained by the fact that (Y, Y) was a recommended outcome in the game with private signals. Our main finding is recorded in Finding 3.

Table 7 Differences between treatments in playing the cooperative outcome

	Dependent variable: Cooperative Choice (Y,Y) = 1; Otherwise = 0			
Independent	Comparison 1:	Comparison 2:	Comparison 3:	Comparison 4:

Variables	Asymmetric BoS vs. Symmetric BoS	Chicken 1/2 vs. Asymmetric BoS	Chicken 1/2 vs. Symmetric Bos	Chicken 1/3 vs. Chicken 1/2
Period	-0.002* (0.056)	-0.002 (0.188)	-0.000 (0.726)	0.003 (0.153)
Treatment	0.057*** (0.000)	0.151*** (0.000)	0.205*** (0.000)	0.060*** (0.006)
Signal	0.002 (0.874)	0.003 (0.847)	0.000 (0.991)	0.057*** (0.008)
Own choice in t – 1	0.013 (0.298)	0.026 (0.161)	0.034** (0.022)	0.107*** (0.000)
Counterpart's choice in t – 1	0.002 (0.883)	0.023 (0.447)	0.036 (0.127)	0.090** (0.015)
Own profit in t – 1	0.001 (0.426)	-0.005* (0.097)	-0.005** (0.040)	-0.014*** (0.001)
Follow in t – 1	-0.061* (0.052)	-0.080*** (0.008)	-0.039* (0.092)	-0.023 (0.391)
Counterpart follows in t – 1	-0.032 (0.198)	-0.085*** (0.005)	-0.058** (0.021)	-0.025 (0.342)
Obs.	1,824	1,824	1,824	1,824
Pseudo R^2	0.0638	0.0845	0.1773	0.0274

*Note: Table lists marginal effects after probit estimation. Robust standard errors are reported. P-values are presented in parentheses. * denotes significance at the 10-percent level, ** at the 5-percent level, and *** at the 1-percent level. Replacing the dummy variables "Follow in t-1" and "Counterpart follows in t-1" by their product as a dummy variable "Both players follow in t-1", we find very similar results.*

Finding 3. *Subjects' willingness to play the cooperative outcome depends on its monetary value. The lower the monetary value of the cooperative outcome the higher individuals' aversiveness to choose it.*

6. REMARKS

It is well known that an extended game, extended by a (direct) correlation device, may have equilibrium other than the obedient one. A direct correlation device or a mediator therefore may face this *multiple equilibrium problem*.[7] First of all, *babbling* equilibrium always exists; i.e., ignoring the messages from the device altogether and playing a Nash equilibrium of the original game constitutes trivially a Nash equilibrium in any such extended game. For example, (*AA*, *PP*) is a Nash equilibrium in the extended game in the above example. There may also be non-babbling Nash equilibrium in which players do not follow the mediator's suggestions. Ray studies the multiple equilibrium problem in normal form games played using correlation devices and asks the question whether there exists a communication scheme, more specifically, a non-canonical correlation device that can implement a correlated equilibrium and does not suffer from the multiple equilibrium problem. In a recent work Kar Ray, Serrano formally address and study the issue of (full and virtual) implementation of correlated equilibrium distributions.

One possible way is to include a sunspot in the non-canonical device, as one of the examples indicates. However, one perhaps can do the same job without a sunspot, as another example confirms. This paper analyses three different non-canonical structures, one with and two without a sunspot, to understand this problem.

This paper simply takes the first step towards understanding For future research, one might consider a couple of different directions. First, as mentioned earlier, it is now well known that mediated and unmediated (cheap) talk can generate any correlated equilibrium of a given game. Second, one reckons that the non-canonical structures discussed here might be useful to model and analyse communication between

the multiple equilibrium problem by restricting the attention to a particular type of multiple equilibrium problem and a particular communication scheme.

this paper considers only *non-direct* mediators or *non-canonical* devices. A non-direct mediator or a non-canonical device is a device in which the messages are not the strategies of the original game. The paper offers three different non-canonical structures (one with and two without a *public message* or a *sunspot*) each of which, together with a particular strategy profile of the non-canonical extended game,

[7] The multiple equilibrium problem is well understood in other contexts, such as, implementation theory (Palfrey, 1992), principal-agent theory (Mookherjee, 1984), differential-information economies (Postlewaite and Schmeidler, 1986), mechanism design (Demski and Sappington, 1984). There also exists an extensive literature on mechanism design exploring mechanisms that can uniquely implement an outcome (Ma, 1988; Ma, Moore and Turnbull, 1988).

7. APPENDICES

7.1. Appendix 1: Frequency Tables

Table A.1. Average frequency of following X and Y in asymmetric BoS

Matching group	Following X recommendation	Following Y recommendation	Following all recommendations
1	0.9375	0.9875	0.9625
2	0.9375	0.9	0.91875
3	0.95	0.8625	0.90625
4	0.8875	0.7875	0.8375
5	0.875	0.9	0.8875
6	0.7625	0.8375	0.8
Total	0.89166667	0.87916667	0.88541667

Table A.2. Average frequency of following X and Y in symmetric BoS

Matching group	Following X recommendation	Following Y recommendation	Following all recommendations
1	1	0.975	0.9875
2	0.9375	0.8375	0.8875
3	0.9375	0.8125	0.875
4	0.9375	0.9625	0.95
5	0.9625	0.875	0.91875
6	0.9875	0.95	0.96875
Total	.96041667	.90208333	.93125

Table A.3. Average frequency of following X and Y in Chicken public signals

Matching group	Following X recommendation	Following Y recommendation	Following all recommendations
1	0.7125	0.8375	0.775
2	0.875	0.95	0.9125
3	0.7375	0.8125	0.775
4	0.5125	0.8125	0.6625
5	0.8	0.9625	0.88125
6	0.5125	0.8875	0.7
Total	0.69166667	0.87708333	0.784375

Table A.4. Average frequency of following X and Y in Chicken private signals

Matching group	Following X recommendation	Following Y recommendation	Following all recommendations
1	0.65454545	0.74285714	0.7125
2	0.6	0.71428571	0.675
3	0.65454545	0.64761905	0.65
4	0.54545455	0.77142857	0.69375
5	0.8	0.83809524	0.825
6	0.65454545	0.80952381	0.75625
Total	0.65151515	0.75396825	0.71875

Table A.5. Average frequency of outcomes in asymmetric BoS

Matching group	XX	XY (or YX)	YY
1	.0125	.925	.0625
2	.1	.8375	.0625
3	.125	.8375	.0375
4	.1875	.725	.0875
5	.075	.825	.1
6	.1125	.7	.1875
Total	.10208333	.80833333	.08958333

Table A.6. Average frequency of outcomes in symmetric BoS

Matching group	XX	XY (or YX)	YY
1	.025	.975	0
2	.125	.85	.025
3	.1875	.75	.0625
4	.0375	.9	.0625
5	.1125	.8625	.025
6	.05	.9375	.0125
Total	.08958333	.87916667	.03125

Table A.7. Average frequency of outcomes in Chicken (public signals)

Matching group	XX	XY (or YX)	YY
1	.1125	.65	.2375
2	.05	.825	.125
3	.1125	.7	.1875
4	.1125	.475	.4125
5	.0375	.7625	.2
6	.0625	.5	.4375
Total	.08125	.65208333	.26666667

Table A.8. Average frequency of outcomes in Chicken (private signals)

Matching group	XX	XY (or YX)	YY
1	.1125	.5625	.325
2	.1125	.5625	.325
3	.2	.5125	.2875
4	.1	.475	.425
5	.1375	.4875	.375
6	.0875	.525	.3875
Total	.125	.52083333	.35416667

7.2. Appendix 2: Instructions

7.2.1. Instructions for the Chicken-Public Treatment

All participants in this session have the following identical instructions:

Welcome to this experiment, and thank you for participating. From now onwards please do not talk to any other participants until the experiment is finished.
You will be given five minutes to read these instructions. Then we will ask you to complete a brief test to ensure that you have understood them, before starting the experiment itself.

Your decision problem
In this experiment you are asked to make a simple choice, in each of 20 successive rounds. In each round you earn a number of points, as described below. The total number of points you accumulate over the 20 rounds determines your final money payment, at a conversion rate of 10 points = 30 pence.
In each round you are randomly paired with another participant, different from one round to the next, whom we call your *counterpart* for that round. You and your various counterparts remain anonymous to each other at all times, and you have no direct contact with each other during the experiment.
In each round you and your counterpart each have to choose one of two alternatives, X and Y. You do so independently of each other and without any communication. So at the moment you make your own choice, you do not know what is your counterpart's choice.
You and your counterpart's choices together determine the points you each earn from that round, as in the following table:

		your counterpart's choice	
		X	Y
your choice	X	2 , 2	17 , 11
	Y	11 , 17	14 , 14

The first number in each cell indicates your points, and the second your counterpart's points. For example, if in some round you choose X while your counterpart chooses Y then from that round you will earn 17 points and your counterpart will earn 11 points.
Notice that, whatever your counterpart's choice, you earn more points by choosing *differently* from your counterpart. Thus, if your counterpart's choice is X then you earn more points by choosing Y rather than X (giving you 11 points rather than 2), while if your counterpart's choice is Y then you earn more points by choosing X rather than Y (17 points rather than 14).
Notice also that if your counterpart's choice is equally likely to be X or Y, then you earn more points on average by choosing Y (12.5 being the average of 11 and 14) rather than X (9.5 being the average of 2 and 17).
As you can see from the table, everything is symmetric between you and your counterpart. So exactly the same considerations as above apply for your counterpart, to whom of course *you* are the counterpart, and who will have read these exact same instructions.

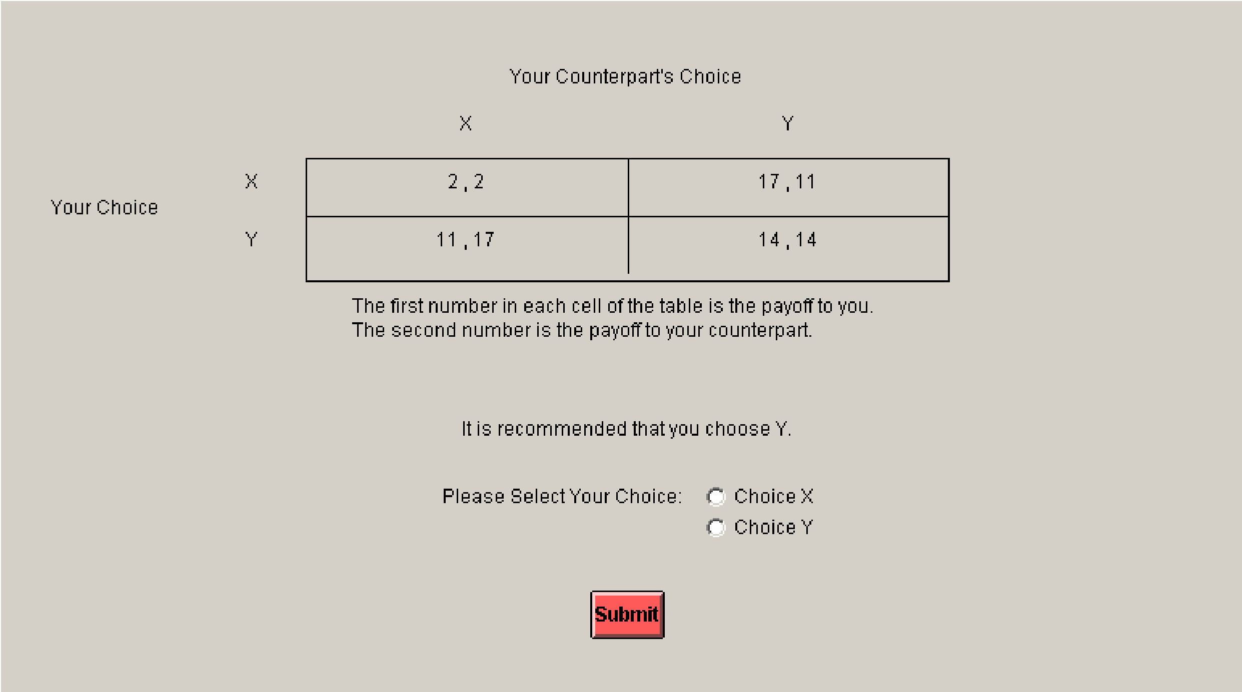
Recommendations
At the start of each round you and your counterpart are each given *recommendations* for your choices, generated randomly by the computer.
It is entirely up to you, in any round, whether or not to follow the recommendation you are

given. The points that you earn depend only on the actual choices made by you and your counterpart, as described on the previous page, irrespective of the recommendations.
In each round you are informed of only of the recommendation for you. But, as explained below, you may be able to infer something about your counterpart's recommendation.
The recommendations are generated randomly by the computer in each round, programmed such that there are only two equally-likely possibilities:
there is a 1/2 chance that you are recommended to choose X, and your counterpart recommended to choose Y;
there is a 1/2 chance that you are recommended to choose Y, and your counterpart recommended to choose X;
It will never happen that you are both recommended to choose X. And it will never happen that you are both recommended to choose Y.
These possibilities are summarised as follows:

recommendation for you	recommendation for your counterpart	probability
X	X	0
X	Y	½
Y	X	½
Y	Y	0

Notice that if the recommendation for you is X then you can infer that the recommendation for your counterpart is Y, and if the recommendation for you is Y then you can infer that the recommendation for your counterpart is X.
It is entirely up to you whether or not to follow your recommendation in any round. But notice that if your counterpart follows his or her recommendation then you earn more points by following yours, than by not doing so. This is because:
if your recommendation is X then your counterpart's must be Y, and if your counterpart chooses Y then you earn more points by choosing X rather than Y;
if your recommendation is Y then your counterpart's must be X, and if your counterpart chooses X then you earn more points by choosing Y rather than X.
However, if your counterpart does *not* follow his or her recommendation then you will earn more points by also not following yours. This is because in any round it is always better for you to choose differently from your counterpart, as explained on the previous page, whatever the recommendations you have each received.

The computer screen
The main screen for each round looks like this. It includes the payoff table, which is the same in each round, and below it the recommendation for you in that round, which is random and may vary from one round to the next. Shown here, to illustrate, is a recommendation for you to choose Y.
To make your choice you simply select the appropriate button and then click on Submit.



You may then have to wait a few moments until all participants have made their choices, after which will appear onscreen the results for you and your counterpart in that round. On your desk is a Record Sheet on which you can keep a note of these results, if you wish to.
After all the participants have read their results and clicked Continue, the main screen for the next round will appear, again as shown above.

At the end of the experiment
When all 20 rounds have been completed, you be asked to complete a brief onscreen questionnaire, which provides useful supplementary (anonymous) information for us.
Having completed the questionnaire, you will see a final screen reporting your total points accumulated over the 20 rounds and the corresponding £ payment.
Please then wait for further instructions from the experimenter, who will pay you in cash before you leave. While waiting, please complete the receipt form which you will also find on your desk. We need these receipts for our own accounts.
The results from this experiment will be used solely for academic research. Participants will remain completely anonymous in any publications connected with this experiment. Thank you for participating. We hope that you enjoy the experiment, and that you will be willing to participate again in our future experiments.

7.2.2. Instructions for the Chicken-Private Treatment

Instructions for Chicken-Private differ from that for Chicken-Public only in the following:

Recommendations
At the start of each round you and your counterpart are each given *recommendations* for your choices, generated randomly by the computer.
It is entirely up to you, in any round, whether or not to follow the recommendation you are given. The points that you earn depend only on the actual choices made by you and your counterpart, as described on the previous page, irrespective of the recommendations.
In each round you are informed of only of the recommendation for you. But, as explained below, you may be able to infer something about your counterpart's recommendation.
The recommendations are generated randomly by the computer in each round, programmed such that there are only three equally-likely possibilities:
there is a 1/3 chance that you are recommended to choose X, and your counterpart recommended to choose Y;
there is a 1/3 chance that you are recommended to choose Y, and your counterpart recommended to choose X;
there is a 1/3 chance that you are both recommended to choose Y.
It will never happen that you are both recommended to choose X.
These possibilities are summarised as follows:

recommendation for you	recommendation for your counterpart	probability
X	X	0
X	Y	⅓
Y	X	⅓
Y	Y	⅓

Notice that if the recommendation for you is X then you can infer that the recommendation for your counterpart is Y, and if the recommendation for you is Y then you can infer that the recommendation for your counterpart is equally likely to be X or Y.
It is entirely up to you whether or not to follow your recommendation in any round. But notice that if your counterpart follows his or her recommendation then (on average) you earn more points by following yours, than by not doing so. This is because:
if your recommendation is X then your counterpart's must be Y, and if your counterpart chooses Y then you earn more points by choosing X rather than Y;
if your recommendation is Y then your counterpart's is equally likely to be X or Y, and if your counterpart is equally likely to choose X or Y then you earn more points on average by choosing Y rather than X.
However, if your counterpart does *not* follow his or her recommendation then it is possible that you will earn more points by also not following yours. This is because in any round it is always better for you to choose differently from your counterpart, as explained on the previous page, whatever the recommendations you have each received.

Your decision problem

In this experiment you are asked to make a simple choice, in each of 20 successive rounds. In each round you earn a number of points, as described below. The total number of points you accumulate over the 20 rounds determines your final money payment, at a conversion rate of 10 points = 30 pence.

In each round you are randomly paired with another participant, different from one round to the next, whom we call your *counterpart* for that round. You and your various counterparts remain anonymous to each other at all times, and you have no direct contact with each other during the experiment.

In each round you and your counterpart each have to choose one of two alternatives, X and Y. You do so independently of each other and without any communication. So at the moment you make your own choice, you do not know what is your counterpart's choice.

You and your counterpart's choices together determine the points you each earn from that round, as in the following table:

		your counterpart's choice	
		X	Y
your choice	X	2 , 2	17 , 11
	Y	11 , 17	2 , 2

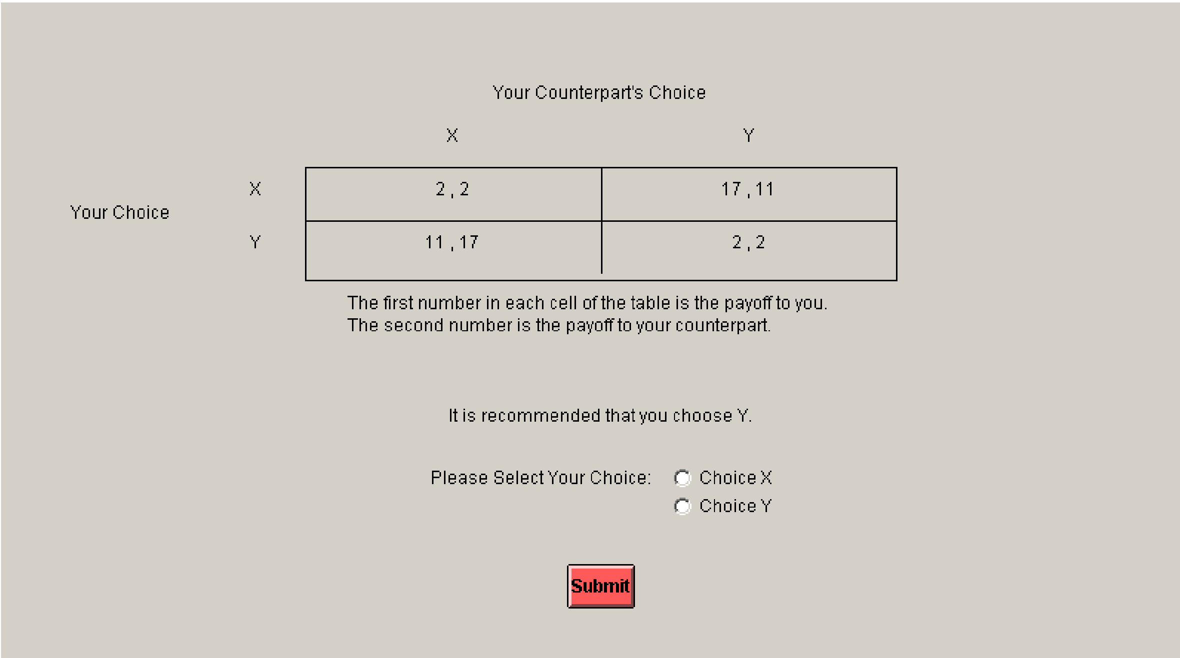
The first number in each cell indicates your points, and the second your counterpart's points. For example, if in some round you choose X while your counterpart chooses Y then from that round you will earn 17 points and your counterpart will earn 11 points.

Notice that, whatever your counterpart's choice, you earn more points by choosing *differently* from your counterpart. Thus, if your counterpart's choice is X then you earn more points by choosing Y rather than X (giving you 11 points rather than 2), while if your counterpart's choice is Y then you earn more points by choosing X rather than Y (17 points rather than 2).

Notice also that if your counterpart's choice is equally likely to be X or Y, then you earn more points on average by choosing X (9.5 being the average of 2 and 17) rather than Y (6.5 being the average of 11 and 2).

As you can see from the table, everything is symmetric between you and your counterpart. So exactly the same considerations as above apply for your counterpart, to whom of course *you* are the counterpart, and who will have read these exact same instructions.

The computer screen



The main screen for each round looks like this. It includes the payoff table, which is the same in each round, and below it the recommendation for you in that round, which is random and may vary from one round to the next. Shown here, to illustrate, is a recommendation for you to choose Y.

To make your choice you simply select the appropriate button and then click on Submit.

You may then have to wait a few moments until all participants have made their choices, after which will appear onscreen the results for you and your counterpart in that round. On your desk is a Record Sheet on which you can keep a note of these results, if you wish to.

After all the participants have read their results and clicked Continue, the main screen for the next round will appear, again as shown above.

7.3. Appendix 3: Record Sheet

Use of this sheet is optional. It is provided so that you can keep a record of the results in each round, as reported on your computer screen at the end of the round. This may be useful to you in considering your decisions in subsequent rounds. In each cell in the table below, simply circle X or Y as appropriate, while the information is still on your screen at the end of that round, before clicking Continue.

Round	recommendation for me	my choice	recommendation for my counterpart	my counterpart's choice	my points
1	X Y	X Y	X Y	X Y	
2	X Y	X Y	X Y	X Y	
3	X Y	X Y	X Y	X Y	
4	X Y	X Y	X Y	X Y	
5	X Y	X Y	X Y	X Y	
6	X Y	X Y	X Y	X Y	
7	X Y	X Y	X Y	X Y	
8	X Y	X Y	X Y	X Y	
9	X Y	X Y	X Y	X Y	
10	X Y	X Y	X Y	X Y	
11	X Y	X Y	X Y	X Y	
12	X Y	X Y	X Y	X Y	
13	X Y	X Y	X Y	X Y	
14	X Y	X Y	X Y	X Y	
15	X Y	X Y	X Y	X Y	
16	X Y	X Y	X Y	X Y	
17	X Y	X Y	X Y	X Y	
18	X Y	X Y	X Y	X Y	
19	X Y	X Y	X Y	X Y	
20	X Y	X Y	X Y	X Y	

7.4. Appendix 4: Test

After reading the instructions you will be asked to complete this brief test, to ensure you have understood them, before starting the experiment itself.
You may look again at the instructions while answering these questions.
For questions 1-4, write the answers in the corresponding boxes.

1 If you choose Y and your counterpart chooses X, how many points do you earn in that round?	[ ]
2 If you choose Y and your counterpart chooses X, how many points does your counterpart earn in that round?	[ ]
3 If you choose X and your counterpart chooses X, how many points do you earn in that round?	[ ]
4 If over the 20 rounds you accumulate a total of 100 points, what is your final cash payment (in £) for the experiment?	£

For questions 5-8, circle either True or False.

5 Your counterpart is the same person in each round.	True False
6 If the recommendation for you is Y, then your counterpart's recommendation must be X.	True False
7 Whatever your counterpart chooses, you always get more points by following your recommendation.	True False
8 In any publications arising from this experiment the participants will be completely anonymous.	True False

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Thank you for completing this test. Please leave this completed sheet face up on your desk. The experimenter will come round to check that you have the correct answers. If any of your answers are incorrect then the experimenter will give you some explanatory feedback.

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