



Lancaster University
Management School

Economics Working Paper Series

2026/004

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John Bone, Michalis Drouvelis, Konstantinos Georgalos
and Indrajit Ray

The Department of Economics
Lancaster University Management School
Lancaster LA1 4YX
UK

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Coordination by Sunspots: Letter is Mightier than Colour*

John Bone[†], Michalis Drouvelis[‡], Konstantinos Georgalos[§] and Indrajit Ray[¶]

28th September, 2026

Abstract

We set up an experiment to test whether players use a payoff-irrelevant public message (BLUE or RED) as a possible sunspot to coordinate in a Battle of the Sexes game in which the pure strategies are labelled as X and Y . We find that most players do not play a “sunspot equilibrium”; instead, they learn to coordinate on a particular focal point (pure strategy X) in the game, largely ignoring the presence of the public signal (colour), and stick to this focal point, even after the public signal is withdrawn. Colour-contingent play emerges in only two of the six matching groups, which adopt opposite mappings.

Keywords: Battle of the Sexes, Coordination, Sunspots, Public Signal, Focal Point.

JEL Classification Numbers: C72, C73, D83.

*We are grateful to Dale Stahl for his suggestions on the experimental set up used in this paper. We would also like to thank all seminar and conference participants at Birmingham, Exeter and Middlesex and in particular, Tim Cason, Simon Gächter, David Gill, Anders Poulsen and Chris Starmer for constructive comments.

[†]Department of Economics, University of York, Heslington, York YO10 5DD, UK. E-mail: john.bone@york.ac.uk.

[‡]Department of Economics, University of Birmingham, Edgbaston, Birmingham B15 2TT, UK; CESifo, Munich, Germany. E-mail: m.drouvelis@bham.ac.uk.

[§]Department of Economics, Lancaster University Management School, Lancaster University, Bailrigg, Lancaster LA1 4YX, United Kingdom. E-mail: k.georgalos@lancaster.ac.uk.

[¶]*Author for Correspondence.* Economics Section, Cardiff Business School, Cardiff University, Colum Drive, Cardiff CF10 3EU, United Kingdom. E-mail: rayi1@cardiff.ac.uk.

1 INTRODUCTION

In many simple 2×2 games with multiple equilibria, such as, the Battle of the Sexes (henceforth, BoS), it is difficult to naturally select one equilibrium, as players “crave any tie-breaking feature ... to break the stalemate” (Camerer 2003, Chapter 7, Page 356). Experimental evidence indicates that players fail to coordinate on a particular equilibrium outcome in such games unless there is a way to select one of the equilibria (Van Huyck *et al.* 1992; Cooper *et al.* 1989, 1990, 1992; Straub 1995).

On the other hand, coordination is observed when the chosen setup (game) has a desirable characteristic, such as, the unique payoff or risk dominant equilibrium (Cabrales *et al.* 2000), or a “focal” point (Crawford *et al.* 2008). Experimental literature also suggests that individuals indeed are able to coordinate, if they are helped to do so, using some suitably chosen scheme. Costless messages and announcements (Brandts and MacLeod 1995; Blume 1998; Clark *et al.* 2001; Blume and Ortmann 2007; Manzini *et al.* 2009), information about the other players’ choice (Charness and Grosskopf 2004), social history of play and observation of others’ actions (Duffy and Feltovich 2002, 2006; Schmidt *et al.* 2003), attractiveness of the payoff-dominant outcome (Battalio *et al.* 2001) and advice on the desirable outcomes (Croson and Marks 2001; Chaudhuri *et al.* 2009; Chaudhuri and Paichayontvijit 2010) can help to overcome the well-documented problems of equilibrium-selection and coordination-failure (see Devetag and Ortmann 2007, for a survey).

Along this line of research, there is also substantial experimental work on involving public information (McKelvey and Page 1990; Marimon *et al.* 1993; McCabe *et al.* 2000; Anctil *et al.* 2004, Heinemann *et al.* 2004), public recommendations (Brandts and MacLeod 1995; Seely *et al.* 2005), randomised messages for cooperation (Stahl 2013; Camera *et al.* 2013), sunspots as coordination devices (Duffy and Fisher 2005).¹ Thus, it is perhaps easy to construct a scheme to help the players to avoid coordination-failure and to select an outcome in a BoS type game.

The main motivation behind our present paper is to study two different attributes that may help coordination or equilibrium selection in a game, namely, (i) a focal point within a game and (ii) an external factor in the form of a public signal that can be observed before playing the game and can be implicitly used to choose a strategy in the game. We set up an experiment that has both these features in its design.

Our experiment is designed to test whether players use a public signal (as a sunspot) to coordinate on a particular equilibrium in a specific BoS game which actually does have an intrinsic focal point. The question we ask is whether either of these two factors (focal points and external coordination

¹ Cheap-talk (as in Farrell 1987) and any pre-play non-binding communication can significantly improve coordination in games like BoS (Cooper *et al.* 1989); for a recent work in this literature, see Cabrales *et al.* (2026) and all relevant references therein.

devices) affect coordination rates and if so, how do these two compare.

In our BoS game, the strategies are labelled X and Y which lead to equilibrium outcomes (X, X) and (Y, Y) . Clearly, (X, X) becomes a natural choice for selection as X (before Y) provides a focal point.² We also show a colour (RED or BLUE) as a public message to the participants in the experiment (shown both on a big screen and on individual terminals), that individual players may use to choose a strategy in the game, as a mapping, based on the colour.

Our main treatment, that we call the “Colour” treatment, has four parts, each with 20 periods played by randomly matched players. In Part 1, the BoS game is played without any public message (colour signal), while both Parts 2 and 3 have a randomly selected public message of colour RED or BLUE, shown before each period. Parts 2 and 3 are identical, so that the beginning of Part 3 is simply a restart of Part 2. Finally, Part 4 of this treatment is identical to Part 1, where no message (colour) is shown.³ We also contrast this treatment with a “Control” treatment in which we have 4 identical parts; all these parts are like Part 1 of the Colour treatment, without any public signal.

The question we ask is whether the players coordinate by using the public message; that is, whether the players play a “sunspot equilibrium” by using symmetric strategies of mapping 1–1 from a colour to a choice (such as, X when RED and Y when BLUE). We then subsequently ask whether players keep on playing any coordinated outcome, even when the public message (colour) is no longer available in Part 4 (of the Colour treatment). This research question is somewhat related to the real life phenomenon of indicating V-shaped chevrons that are often painted at 40–metre intervals in the UK motorways. These markings help drivers to keep a safe gap, recommending two chevrons between vehicles at high speeds; however, it is also expected that the drivers will follow the recommendation of maintaining safe gaps, even when the chevrons are not marked on the motorway.

Our Control treatment contrasts the Colour treatment and tries to capture possible natural coordination in BoS, without any public message. Following the literature, we expect that our Colour treatment will show more coordination than that in the Control treatment. It is however not a priori clear what the level of coordination in Part 4 of the Colour treatment will be. On one hand, there is no public signal (colour) and hence one may expect the coordination should be lower than that in Parts 2 and 3; on the other hand, one may see an increase in coordination over time anyway. Therefore, one may not be able to predict the difference between treatments for the level of overall coordination.

In our experiment, we find (see Table 8 and Claim 4 below) that there is no difference in (total) coordination in BoS between our two treatments in any part. We then carefully look at the level of

²This is similar in nature to the experiments reported in Cabon-Dhersin and Etchart-Vincent (2012, 2013) where strategies in a Chicken game are named “Red” and “Blue”.

³This setup has been influenced by Stahl (2013). We would like to sincerely thank Dale Stahl for suggesting this design.

coordination on the two Nash equilibrium outcomes, (X, X) and (Y, Y) and observe the focal point effect of (X, X) .

Our main result (Proposition 1) indicates that, in the Colour treatment, coordination on the outcome (X, X) is significantly more than that on outcome (Y, Y) in every part. We also find (Proposition 2) that most players do not play a sunspot equilibrium; instead, they coordinate on the outcome (X, X) in the presence of a public signal and stick to this point even after the public signal is withdrawn. Colour-contingent play emerges in only two of the six matching groups, which adopt opposite mappings. We thus reject our hypothesis on coordination using public signals (colour) for most groups, but find strong evidence of coordinating on the equilibrium outcome (X, X) , using focal point X .

1.1 Related Literature

Our question of whether players “follow” the “guide” provided by the colour is similar to the question of whether players follow a public randomisation or recommendations from a direct correlation device. A relevant experimental literature on the concept of correlated equilibrium (Aumann 1974, 1987) shows that players do follow recommendations from a correlation device when it is a correlated equilibrium (Moreno and Wooders 1998; Cason and Sharma 2007; Duffy and Feltovich 2010). In strategic form games, any convex combination (public lottery) over pure Nash equilibrium outcomes can be viewed as a (public) correlated equilibrium. Cason and Sharma (2007), Duffy and Feltovich (2010) and Bone *et al.* (2026) use a (public) correlated equilibrium that randomly selects one of the two pure Nash equilibria in symmetric 2×2 games like Chicken and BoS and show that the subjects do play the recommended strategies. However, Georgalos *et al.* (2020) analyse the notion of coarse correlated equilibrium (Moulin and Vial, 1978) and show that players do not commit to a (coarse) correlation device that picks, with equal probability, the pure Nash outcome and other symmetric outcomes around the Nash point of the game.⁴

Perhaps, the closest in nature to us is the work of Duffy *et al.* (2017) who use a version of BoS and considered different treatments to study coordination using perfectly correlated signals. Duffy *et al.* (2017) test whether people can learn to use a correlation device to reach correlated equilibria in BoS, comparing a direct device (messages labelled X and Y) with an indirect device (meaningless symbols @ and #), under random vs. fixed matching. Duffy *et al.* (2017) vary the type of device (a direct device with action-labelled messages vs. an indirect device with meaningless symbols) and the matching protocol (strangers and fixed partners, where alternation can emerge). Our design, in contrast, uses (i) only a public signal (colour, RED/BLUE) equivalent to an indirect device and (ii) strangers only, ruling out partner-specific alternation. Their treatments are primarily between-

⁴See the literature review in Cason *et al.* (2020, 2026) and Chen and Cason (2026).

subjects, while ours are both within-subjects across different parts (with or without colour) of the Colour treatment, letting us observe the same participants before/with/after the public signal and between-subjects, using data from the Control treatment. They find that with random rematching, the direct device yields significantly higher coordination than the indirect (and than no device), while with fixed partners, subjects often adopt history-contingent alternation and may ignore the device; subjects do eventually learn mappings for the indirect device, but more slowly and less uniformly.

Our study tackles the same question (can a payoff-irrelevant public signal restore coordination in asymmetric BoS?) but uses a colour signal (RED and BLUE) as the indirect-public device within a random-rematching, multi-part design, rather than between-subjects treatments, and without fixed-partner alternation as a substitute mechanism. Thus, their results benchmark expectations (public correlation helps; indirect is harder; fixed partners can crowd it out), while our design isolates how a public colour sunspot affects coordination under stranger matching over time. Our main extension relative to Duffy *et al.* (2017) is to isolate the causal role of a purely payoff-irrelevant, indirect public signal under strangers matching, using a within-subjects, multi-part design. Instead of comparing different groups across treatments (direct vs. indirect vs. none, and strangers vs. partners), we track the same participants before/with/after exposure to the public signals (colour) in four parts. This lets us (i) identify how a public signal (colour, RED/BLUE) changes coordination when alternation cannot arise (no fixed partners), (ii) measure learning and persistence by testing whether colour-contingent play emerges and whether it survives removal of the signal in Part 4, and (iii) reduce noise by using the same signal-realisation sequence across sessions, cleanly separating behaviour from draws. Together, these features provide sharper evidence on whether, and if so, how quickly, subjects adopt a sunspot-based correlation rule in a BoS type situation when labels alone are weak, complementing Duffy *et al.*'s between-subjects comparisons of device types and matching protocols. Finally, our feedback and analysis focus on whether the public signal (sunspot) raises coordination relative to the control and how its use evolves over time, while Duffy *et al.* (2017) benchmark direct vs. indirect devices and show that fixed-partner environments can crowd out reliance on the device via alternation.

Crawford *et al.* (2008) show that label-based focal points aid coordination in pure coordination games, but break down under even small payoff asymmetries, with behaviour drifting toward mixed-equilibrium levels. They explain this result via a level- k account anchored in mild payoff-bias rather than pure label-salience. Our study shares the same conflict in coordination but differs on two key dimensions. First, we use a public, payoff-irrelevant colour signal (RED/BLUE), to enable players to play sunspot (or correlated) equilibrium that their one-shot, no-signal design cannot test. Second, we observe repeated play with random rematching across parts, allowing learning in the use of the public signal. Thus, their results benchmark our control (where labels are fragile), while our treatment asks

whether a common external signal can restore coordination where labels may fail.

Label salience and alphabetical primacy have been shown to guide coordination in the absence of other selection criteria (Schelling 1960; Mehta, Starmer and Sugden 1994; Crawford *et al.* 2008). In particular, Crawford *et al.* (2008) mention that they “anticipated that X would be more salient than Y , because ‘ X marks the spot’ and X precedes Y in the alphabet.”

Our findings complement recent evidence that seemingly incidental features of how strategic environments are presented can influence behaviour. Lugin *et al.* (2025) show that the visual presentation of payoff information affects attention and cooperation. While we do not measure attention directly, our results similarly demonstrate that a payoff-irrelevant public signal need not become an effective coordination device: participants disregard the signal, instead, converge on a persistent focal action.

2 EXPERIMENT

In this paper, we use a well-studied 2×2 normal form game of coordination, commonly known as the Battle of the Sexes (BoS).

2.1 Game (BoS)

In our game of BoS, each of the two players has two pure strategies, called X and Y . The payoffs in the BoS that we analyse in this paper are shown in Table 1 below.

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

Table 1: The 2×2 Game (BoS)

Thus, in this game, coordinated outcomes, (X, X) and (Y, Y) , are both efficient but favour different players, while miscoordination $((X, Y)$ or $(Y, X))$ is a bad outcome for both players. This game has two pure Nash equilibria, namely, (X, X) and (Y, Y) , and a mixed Nash equilibrium in which player 1 plays X with probability $\frac{5}{8}(= 0.625)$ and player 2 plays X with probability $\frac{3}{8}(= 0.375)$. The distribution over the outcomes from the mixed Nash equilibrium is as shown in Table 2.

	X	Y
X	$\frac{15}{64}$	$\frac{25}{64}$
Y	$\frac{9}{64}$	$\frac{15}{64}$

Table 2: The Mixed Nash Distribution

Hence, the coordination frequency $((X, X)$ and $(Y, Y))$ in the mixed Nash equilibrium distribution is $\frac{30}{64} = \frac{15}{32}$ (that is, 46.875%). The mixed Nash equilibrium expected payoff (for either player) is $\frac{61}{8} (= 7.625)$.

The payoffs in the game are chosen so that (i) miscoordination payoffs (from either (X, Y) or (Y, X)) are positive (here, 2), (ii) miscoordination payoff (here, 2) is considerably lower than that of coordination for either of the players (here, 11 and 17), (iii) the mixed Nash equilibrium is not $\frac{1}{2}$, for either player (here, $\frac{3}{8}$), (iv) the mixed Nash equilibrium expected payoff (here, 7.625) is considerably less than either of the pure Nash equilibrium payoff for either player (here, 11 and 17) and (v) coordination frequency in the mixed Nash equilibrium distribution is not high (here, 46.875%).

For this game, players may first receive a *public* signal or a message (sunspot) from a finite set of possible messages. One can thereby extend the given game of BoS in which the public message is provided first according to the probability distribution and then the players choose a pure strategy of the game. For simplicity, one may consider just two public messages, m_1 and m_2 , with respective probabilities p_1 and $p_2 (= 1 - p_1)$. In such an extended game, a pure strategy for each player i , is simply a map from $\{m_1, m_2\}$ to $\{X, Y\}$. There are thus four possible pure strategies in this extended game. Abusing notation, these pure strategies (maps) can be labelled as XX , XY , YX and YY , where, for example, XY is the pure strategy in which a player chooses X when the public message is m_1 and chooses Y when the message is m_2 . In short, XY is called a *sunspot equilibrium* if (XY, XY) is a (pure) Nash equilibrium in the extended game. Clearly, in this simple set up, there are two possible such sunspot equilibria, namely, XY and YX .

2.2 Design

Our experiment featured two treatments: the Colour treatment and the Control treatment. Each treatment consisted of 4 parts of 20 periods each (hence, 80 decisions per subject). At the start of the session, participants were randomly assigned the role of “Player 1” or “Player 2”. This role remained fixed for the entire experiment. In every period, subjects were randomly and anonymously rematched: each Player 1 was paired again with a Player 2, (typically) different from the previous period. Thus, each period was effectively a one-shot interaction, but repeated 20 times in each part. In every period, subjects played the same 2×2 BoS game, as described above. Each player chose simultaneously between actions X and Y , without any communication.

In the Colour Treatment, Part 1 consisted of 20 periods of the BoS game as described. However, in Parts 2 and 3, the game played was identical, except for the presence of a public, payoff-irrelevant colour signal. At the start of each period, the computer publicly drew either RED or BLUE, each with probability $\frac{1}{2}$. Using the notation above, here we are using two public messages $m_1 = \text{RED}$ and $m_2 =$

BLUE, with respective probabilities $p_1 = p_2 = \frac{1}{2}$.

The same colour was shown to all participants, both on their individual screens and on a big screen in the room at the same time. The colour had no effect on payoffs; it was simply an extra public information that players could, in principle, condition on, when choosing X or Y . The same pre-generated sequence of colours was used across sessions to reduce across-subject variation.

Then, in Part 4, just the BoS was played (without any colour), as in Part 1.

The Control treatment consisted of four parts that were identical to Parts 1 and 4 from the Colour treatment (i.e., the same 20-period BoS game with random rematching and no public colour signal in any part).

The overview of the experimental design is summarised in Table 3 below.

Treatment	Part 1	Part 2	Part 3	Part 4	#Subjects	#Ind. Obs.	#Data per Part
Colour	No	Yes	Yes	No	48	6	960 ($= 48 \times 20$)
Control	No	No	No	No	48	6	960 ($= 48 \times 20$)

Table 3: Experimental Design

In Table 3 above, “No” corresponds to the lack of a public device, while “Yes” corresponds to the existence of a public signal that displays RED or BLUE, with equal chances.

2.3 Procedure

In any of our experimental sessions, only one treatment condition was run. For each of the treatments, we used 6 matching groups. Thus, a total of 12 matching groups were used in two treatments. In total, 96 subjects participated. 8 subjects (that is, 4 pairs) constituted one matching group and each matching group lasted for 80 periods. Because of the likely dependencies between decisions made within matching groups, we take one matching group as our unit of observation and treat these observations as independent data points for performing all the statistical tests reported in this paper. We randomly re-matched the subjects in every period within each matching group in order to create an environment as close as possible to a one-period interaction between subjects. Subjects were informed that they had been randomly paired with participants, typically different from one period to the next; however, they were not aware of the identity of the subjects they were matched with. The same matching protocol was used in all matching groups.

At the beginning of a session, subjects were seated and given a set of written instructions. In an attempt to make the rules of the game common knowledge, subjects were informed that all participants in the session have identical instructions. Having read the instructions, the subjects might ask questions to the experimenter in private. Subjects were not allowed to communicate with one another throughout

the session, except of course via the decisions they made during the experiment. After each period, subjects were shown feedback on screen: the colour of the period (if applicable), their own action, the matched player's action, and the payoffs to both players. Subjects also received a record sheet to keep track of outcomes across periods.

Full instructions (including the record sheet) for the Colour treatment are in the Appendix. The instructions and the record sheet for the Control treatment are identical to the first (and the fourth) part of the Colour treatment and hence have been omitted. Note that we used a neutral terminology here and avoided using any term that may have some other connotations, such as your opponent or your partner. Subjects were not given identifying information about their paired subjects in any period so that no subject-specific reputation could develop across periods.

Subjects were reminded to read the instructions for Part 1 only first and not to open the rest until the experimenter would ask them to do so. The instructions for Parts 2 – 4 were circulated at the start of each part. At the end of Part 4, the experimental session ended. Sessions lasted about 40 minutes. Subjects were privately paid according to their point earnings from all 80 ($= 20 \times 4$) periods, using an exchange rate of 1 point = 1 penny (that is, 100 points = £1). Average earning in the Colour treatment was £8.49, whereas that in the Control treatment was £8.62; the overall average was £8.56 (with the minimum of £4.51 and the maximum of £13.30).

The experiment was programmed and conducted with the software *z-Tree* (Fischbacher, 2007). All the sessions were conducted at the laboratory of the Centre for Experimental Economics (EXEC) at the University of York, using subjects recruited from a university-wide pool of students, using the ORSEE software (Greiner, 2004). Subjects were students from various fields of studies of the University of York including, but certainly not confined to, Economics or other social sciences.

2.4 Hypotheses

Following the issues mentioned in the Introduction, we focus on how players coordinate on one of the two pure Nash equilibria in the game (in both treatments). We will check whether the frequencies of actual (total) coordination differ across different parts within each treatment and also between two treatments. We measure “coordination” by the union of the outcomes (X, X) and (Y, Y) (that is, $\#(X, X) + \#(Y, Y)$), in all parts of both treatments.

First of all, we expect in this game, individuals will learn to coordinate more over time anyway, even without any (public) signal. Hence, total coordination will gradually increase over Parts 1 – 4 of the Control treatment.

Hypothesis 1 Within the Control treatment, the level of coordination will gradually increase over

four parts.

Second, we predict that the individuals will use the public signal (colour) as a “sunspot” and will coordinate more on either of the two pure Nash equilibria in Parts 2 and 3 of the Colour treatment, and as a result, (total) coordination will be higher in Parts 2 and 3 in the Colour treatment than that in Part 1 (of both treatments, for that matter).

Hypothesis 2 Within the Colour treatment, the level of coordination achieved in Part 2 and Part 3 will be higher than that in Part 1.

Third, we believe that the individuals will not be able to coordinate (as much) in the absence of the public signal (colour) in Part 4 of the Colour treatment, and as a result, (total) coordination will be lower in Part 4 than that in Parts 2 and 3 in the Colour treatment. In this treatment Part 1 and Part 4 will be similar, as the absence of the public signal in both parts provides no external device to facilitate coordination.

Hypothesis 3 Within the Colour treatment, the level of coordination in Part 4 will not differ from that in Part 1.

If the public signal facilitates coordination beyond what players learn through repetition alone, we also expect the following.

Hypothesis 4 Total coordination will be higher in the Colour treatment than that in the Control treatment (overall, over all parts).

We also expect that, in the absence of the public signal (colour), individuals will coordinate more on (X, X) than on (Y, Y) , as X may provide a natural focal point (as alphabetically, X precedes Y). Hence, all through the Control treatment and when the public signal is absent, as in Part 1 and Part 4 of the Colour treatment, outcome (X, X) will be played more than the outcome (Y, Y) . This is summarised in the following hypothesis.

Hypothesis 5 Coordination on outcome (X, X) , by playing X , will be more than that on outcome (Y, Y) , by playing Y , in all four parts of the Control treatment and also in Parts 1 and 4 of the Colour treatment.

Finally, we analyse how the public signal (colour) may affect individuals’ choice in the game in Parts 2 and 3 of the Colour treatment. Following the logic of a possible “sunspot equilibrium”, as explained above, we expect in Parts 2 and 3, that the individuals will follow one of the pure strategies (1 – 1 mappings) in the extended game, either BLUE with X and RED with Y or vice versa, that is, BLUE with Y and RED with X .

Hypothesis 6 Players will match the observed colour with their choice in the game as a 1 – 1 mapping in Part 2 and Part 3 of the Colour treatment.

In the following section (and its sub-sections), we report all the experimental data. To test our hypotheses, we provide the descriptive statistics from the raw data set from the experiment. Also, we formally examine whether there are significant differences in the observed frequencies by using exact non-parametric Wilcoxon tests (signed-rank tests within treatments and rank-sum tests between treatments), taking the matching group as the unit of observation, and report the corresponding p -values. With six matching groups per treatment, the smallest attainable one-sided p -value is 0.016 for a signed-rank test and 0.001 for a rank-sum test.

3 RESULTS

In this section, we present the main findings from our experiment.

3.1 Coordination in Treatments

We first consider the question whether coordination (on pure Nash equilibrium outcomes) has been achieved within four parts (of both treatments) and thus test Hypotheses 1 – 3. We present the frequencies (in %) of the coordinated outcomes ($\#(X, X) + \#(Y, Y)$) over 20 periods, divided into five equal four-period blocks for each of the four parts separately within each treatment. We start with the Control treatment as shown in Figure 1 and Table 4 below.

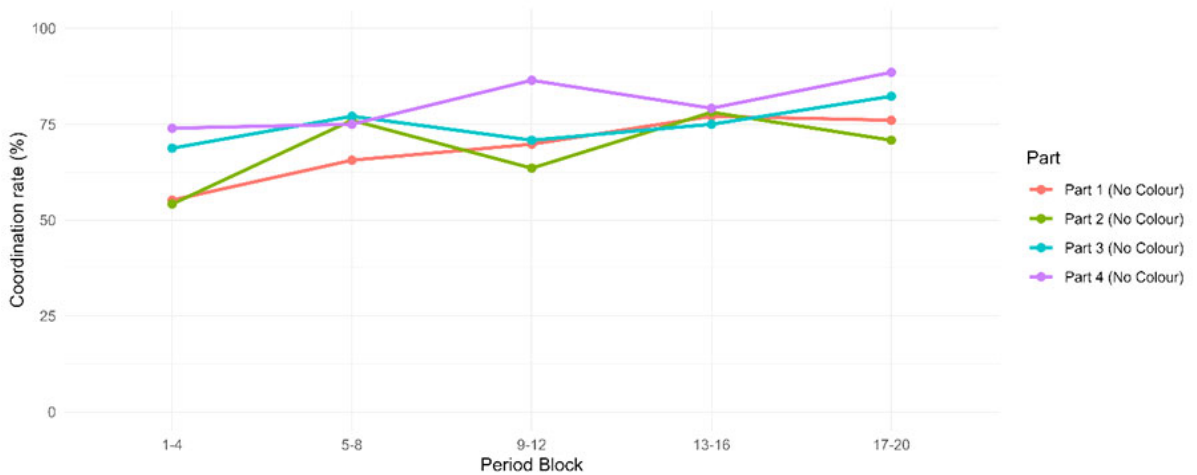


Figure 1: Coordination in the Control Treatment (Plotted by Parts)

Parts / % of Coordination in Periods	1 – 4	5 – 8	9 – 12	13 – 16	17 – 20	Total
Part 1 (No Colour)	55.21	65.62	69.79	77.08	76.04	68.75
Part 2 (No Colour)	54.17	76.04	63.54	78.12	70.83	68.54
Part 3 (No Colour)	68.75	77.08	70.83	75.00	82.29	74.79
Part 4 (No Colour)	73.96	75.00	86.46	79.17	88.54	80.62

Table 4: Coordination in the Control Treatment

We use an exact Wilcoxon paired signed-ranks test on the six matching-group coordination rates to test whether coordination in each later part is significantly higher than in earlier parts, using a one-sided alternative of an increase (except for the comparison between Part 2 and Part 3, which uses a two-sided alternative). In Table 5 below, we report the corresponding p -values for these pairwise comparisons. (Frequencies of coordination in each part are presented in parentheses).

Parts (% of Coordination)	Part 1	Part 2	Part 3
Part 1 (68.75%)	—	—	—
Part 2 (68.54%)	0.500	—	—
Part 3 (74.79%)	0.141	0.438	—
Part 4 (80.62%)	0.062	0.016	0.125

Table 5: p -values for Differences in Coordination among Parts in the Control Treatment

Frequencies of coordination in Part 1 and Part 2 are not significantly different ($p = 0.500$), and coordination in Part 3 is not significantly higher than that in either Part 1 ($p = 0.141$) or Part 2 ($p = 0.438$). Coordination in Part 4 is significantly higher than that in Part 2 ($p = 0.016$), higher than that in Part 1 at the 10% level ($p = 0.062$), and not significantly higher than that in Part 3 ($p = 0.125$). Tables 4 and 5 above therefore provide only weak evidence of an increase in coordination over time.

Claim 1 *Hypothesis 1 is only weakly supported: coordination in the Control treatment rises from 68.75% in Part 1 to 80.62% in Part 4, but the increase is significant only for Part 4 relative to Part 2 ($p = 0.016$) and, at the 10% level, relative to Part 1 ($p = 0.062$).*

A possible interpretation of Claim 1 for the Control Treatment could be that given the lack of any public message (sunspot) to help coordination, there is no difference between Parts 1 and 2; however, subjects learn how to coordinate without the help of any signal. They perhaps take time to figure out what to play; as a result, the highest level of coordination is in Part 4 in this treatment.

We now present corresponding frequencies of coordination (in %) in the Colour treatment in Figure 2 and Table 6 below.

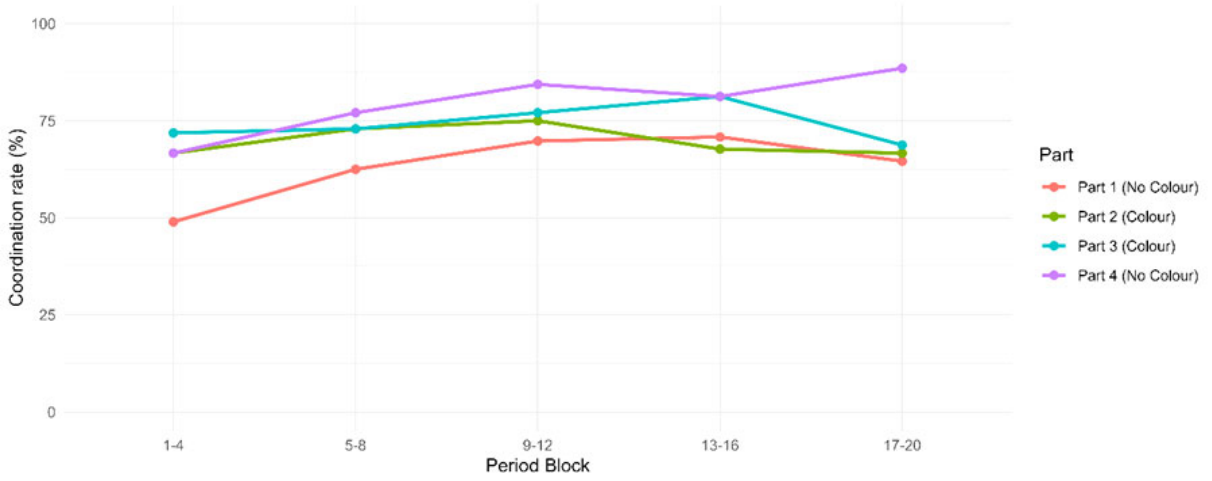


Figure 2: Coordination in the Colour Treatment (Plotted by Parts)

Parts / % of Coordination in Periods	1 – 4	5 – 8	9 – 12	13 – 16	17 – 20	Total
Part 1 (No Colour)	48.96	62.50	69.79	70.83	64.58	63.33
Part 2 (Colour)	66.67	72.92	75.00	67.71	66.67	69.79
Part 3 (Colour)	71.88	72.92	77.08	81.25	68.75	74.38
Part 4 (No Colour)	66.67	77.08	84.38	81.25	88.54	79.58

Table 6: Coordination in the Colour Treatment

From Figure 2 and Table 6, we observe that the average frequencies of coordination are quite high in all parts in the Colour treatment. However, Figure 2 and Table 6 also suggest that there are clear differences among these parts. We now formally examine whether these differences in the observed frequencies in these parts are significant or not by using an exact Wilcoxon paired signed-ranks test on the six matching-group coordination rates, with a one-sided alternative of an increase (except for Part 2 vs Part 3, which uses a two-sided alternative). The following table (Table 7) reports the corresponding p -values for each pairwise comparison. (Frequencies of coordination in each part are presented in parentheses).

Parts (% of Coordination)	Part 1	Part 2	Part 3
Part 1 (63.33%)	—	—	—
Part 2 (69.79%)	0.016	—	—
Part 3 (74.38%)	0.062	0.250	—
Part 4 (79.58%)	0.016	0.016	0.141

Table 7: p -values for Differences in Coordination among Parts in the Colour Treatment

It is clear from Table 7 that coordination in Parts 2 and 4 is significantly higher than that in Part 1 ($p = 0.016$ in both cases), while coordination in Part 3 is higher than that in Part 1 only at the 10% level ($p = 0.062$). This partly supports our second hypothesis (Hypothesis 2).

Claim 2 *Hypothesis 2 is partly supported: within the Colour treatment, coordination in Part 2 is significantly higher than that in Part 1 ($p = 0.016$), while the increase in Part 3 is significant only at the 10% level ($p = 0.062$).*

Since coordination also increases over time in the Control treatment (Claim 1), Claim 2 does not by itself show that the public message affected individuals' choices; we examine this directly in Section 3.4. Table 7 also shows that there is no significant difference between Parts 2 and 3 ($p = 0.250$), which is clearly justifiable as the public message was the same in these parts and thus presumably individuals used the same strategy.

It is however interesting to note that the level of coordination in Part 4 is significantly higher than that in Part 1 and Part 2 ($p = 0.016$ and $p = 0.016$, respectively), but not significantly higher than that in Part 3 ($p = 0.141$).

Claim 3 *Hypothesis 3 is rejected: coordination in Part 4 is significantly higher than that in Part 1 ($p = 0.016$) of the Colour treatment.*

Claim 3 implies that individuals have learned how to coordinate even without the help of a public message, suggesting that subjects have learned to coordinate during Parts 2 and 3 and retain this ability even after the public signal is withdrawn.

One may also want to compare our coordination rates to the mixed strategy Nash equilibrium of the game. As mentioned earlier, in the mixed Nash equilibrium, player 1 plays X with probability $\frac{5}{8}(= 0.625)$ and player 2 plays X with probability $\frac{3}{8}(= 0.375)$ and the coordination frequency ((X, X) and (Y, Y)) in this equilibrium is 46.875%. Taking the matching group as the unit of observation, we compare the six group-level coordination rates in each part against this benchmark, using an exact one-sided Wilcoxon signed-rank test. Observed coordination significantly exceeds the mixed Nash equilibrium prediction in every part of both treatments ($p = 0.016$ in seven out of eight part-treatment cells, and $p = 0.031$ in Part 1 of the Control treatment). The only exceptions are the first four periods of Part 1 in both treatments (Colour: 48.96%, $p = 0.312$; Control: 55.21%, $p = 0.156$) and of Part 2 in the Control treatment (54.17%, $p = 0.172$), where coordination is not significantly different from the mixed Nash equilibrium prediction. We thereby reject mixed Nash equilibrium play.

3.2 Differences between Treatments

We now compare the level of (total) coordination between two treatments and consider the differences, if any, between them. In Table 8 below, we use an exact two-sided Wilcoxon rank-sum test (six matching groups per treatment) to test whether the differences in the observed frequencies of coordination between two treatments (for each part) are significant or not.

Treatment / Parts	Part 1	Part 2	Part 3	Part 4	Total
Colour (Percentages (%) of coordination)	63.33	69.79	74.38	79.58	71.77
Control (Percentages (%) of coordination)	68.75	68.54	74.79	80.62	73.18
p -value (Difference)	0.457	0.965	0.974	0.729	0.729

Table 8: p -values for Differences in Coordination among Parts of Treatments.

The p -values in Table 8 imply the following claim regarding our Hypothesis 4.

Claim 4 *Hypothesis 4 is not supported, as the level of (total) coordination does not differ between two treatments (in all parts of the treatments).*

Claim 4 is indeed surprising. However, a careful look at the coordination on outcomes (X, X) and (Y, Y) makes it clear. Table 9 below presents the level of (percentages (%) of) coordination by outcomes in all parts of both treatments.

Control Treatment				Colour Treatment			
Parts/Coordination	$\%(X, X)$	$\%(Y, Y)$	%Total	Parts/Coordination	$\%(X, X)$	$\%(Y, Y)$	%Total
1 (No Colour)	44.58	24.17	68.75	1 (No Colour)	53.96	9.38	63.33
2 (No Colour)	36.67	31.87	68.54	2 (Colour)	60.83	8.96	69.79
3 (No Colour)	42.92	31.87	74.79	3 (Colour)	62.50	11.88	74.38
4 (No Colour)	49.17	31.46	80.62	4 (No Colour)	68.96	10.62	79.58

Table 9: Coordination on Outcomes (X, X) and (Y, Y) in all Parts of both Treatments

We now present a couple of charts (Figures 3 and 4 below) plotting the level of total coordination and for both outcomes over all parts (altogether 80 periods) for both treatments. First, we report the data for the Control treatment, as in Figure 3. Figure 4 is for the Colour Treatment.

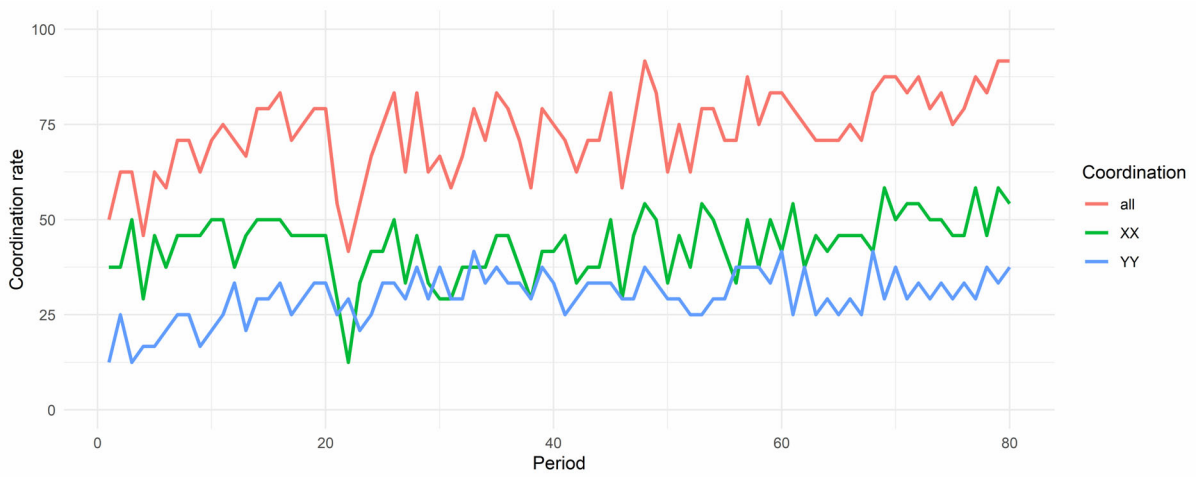


Figure 3: Coordination on Outcomes (X, X) and (Y, Y) in all Parts of Control Treatment

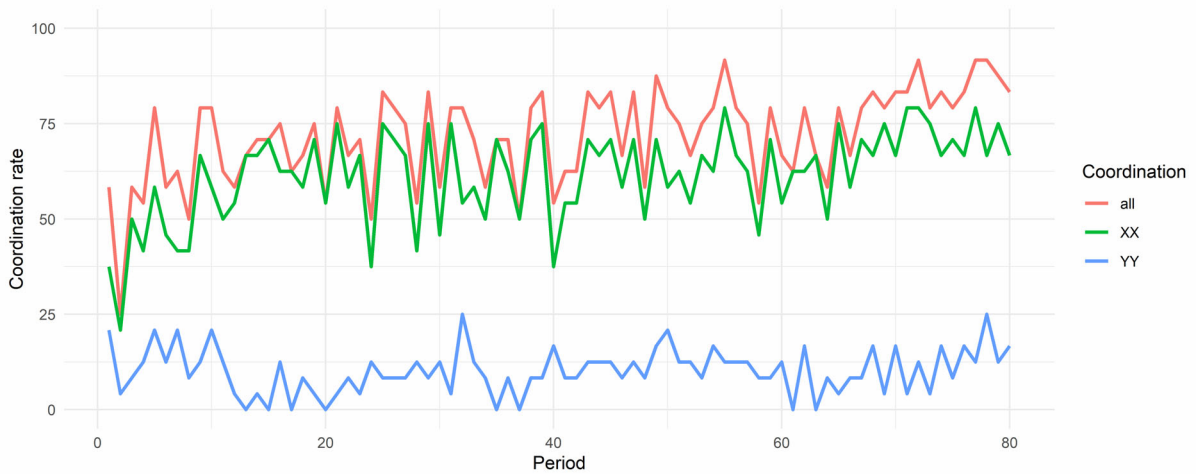


Figure 4: Coordination on Outcomes (X, X) and (Y, Y) in all Parts of Colour Treatment

Table 9, Figure 3 and Figure 4 together clearly show the full picture indicating the difference between these two treatments. Within the Colour treatment, the coordination is effectively on the outcome (X, X) , which is not the case in the Control treatment.

We have formally compared the differences in the distribution of coordination in (X, X) and (Y, Y) for every part, both within and between treatments, at the level of matching groups (exact tests). As an illustration, we just report in the table below coordination for Part 2 only. In Table 10, horizontally, we compare between treatments, that is the difference in the distribution of (X, X) and (Y, Y) coordination in the Colour and Control treatments, while vertically we compare within a treatment, the difference in the distribution of (X, X) and (Y, Y) coordination.

Coordination in Part 2	Colour	Control	p -value (Difference)
% of (X, X)	60.83	36.67	0.167
% of (Y, Y)	8.96	31.87	0.288
p -value (Difference)	0.031	0.578	—

Table 10: p -values for Differences in Outcomes Within and Between Treatments

Similar to the analysis presented in Table 10, we have also checked these differences for all other parts as well. Within the Colour treatment, (X, X) coordination is significantly more frequent than (Y, Y) coordination in every part ($p = 0.031, 0.031, 0.016$ and 0.031 for Parts 1 – 4), whereas within the Control treatment it is not ($p = 0.078, 0.578, 0.578$ and 0.500). None of the differences between treatments is significant, either for (X, X) ($p = 0.260, 0.167, 0.589$ and 0.225) or for (Y, Y) ($p = 0.089, 0.288, 0.846$ and 0.318). This provides support for our Hypothesis 5 in the Colour treatment only. Based on this analysis, we present the main finding of this paper.

Proposition 1 *In the Colour treatment, coordination on outcome (X, X) is significantly more than that on outcome (Y, Y) in all parts.*

3.3 Equilibrium Selection in the Colour Treatment

Proposition 1 in the previous subsection suggests that coordination on (X, X) in the Colour treatment is significantly higher than that on (Y, Y) , which perhaps is coming from the focal point effect to select a specific Nash equilibrium. We thus focus on this particular equilibrium in the Colour treatment. We present the overall (percentages (%)) frequencies of the pure Nash equilibrium outcomes in each of the four parts of the Colour treatment, over 20 periods in five equal four-period blocks in Table 11 below.

Parts	Periods 1 – 4		5 – 8		9 – 12		13 – 16		17 – 20	
% of NE	(X, X)	(Y, Y)	(X, X)	(Y, Y)	(X, X)	(Y, Y)	(X, X)	(Y, Y)	(X, X)	(Y, Y)
1	37.50	11.46	46.88	15.62	57.29	12.50	66.67	4.17	61.46	3.12
2	59.38	7.29	63.54	9.38	62.50	12.50	60.42	7.29	58.33	8.33
3	61.46	10.42	62.50	10.42	61.46	15.62	68.75	12.50	58.33	10.42
4	60.42	6.25	67.71	9.38	75.00	9.38	69.79	11.46	71.88	16.67

Table 11: Equilibrium Outcomes in the Colour Treatment

Following the analysis presented in Duffy *et al.* (2017), we now focus on the independent observations in the Colour treatment. Figure 5 presents a scatterplot of the frequencies (in %) of coordination

on (X, X) and (Y, Y) at the level of independent observations (matching groups) in the Colour treatment. Each point represents one matching group, with the 45-degree line as a reference: points below the line indicate that (X, X) coordination is more frequent than (Y, Y) for that group. Figure 6 is similar to Figure 5; however, it presents the same scatterplot for the second half only (periods 11 – 20) of Parts 1 – 4.

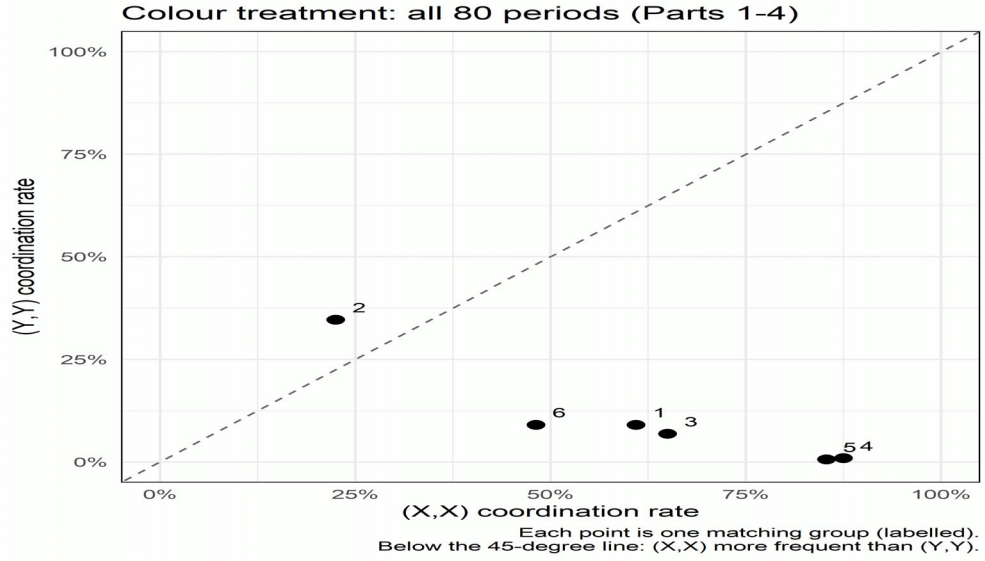


Figure 5: Coordination on (X, X) and (Y, Y) for each Matching Group in the Colour Treatment (All 80 Periods)

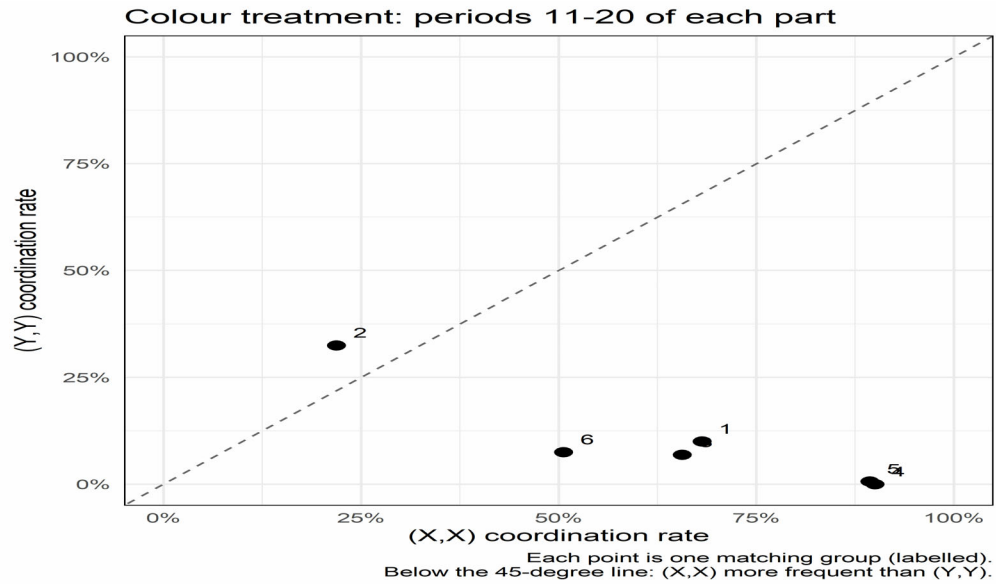


Figure 6: Coordination on (X, X) and (Y, Y) for each Matching Group in the Colour Treatment (Periods 11 – 20 of Each Part)

It is clear from Figures 5 and 6 that the vast majority of matching groups lie below the 45-degree line, confirming that coordination on (X, X) substantially dominates coordination on (Y, Y) at the level of individual observations. This pattern becomes more pronounced in the second half of each part, suggesting that subjects increasingly converged on the (X, X) equilibrium over time. One notable exception is matching group 2 that consistently lies above the 45-degree line, indicating a tendency to coordinate on (Y, Y) rather than on (X, X) . The frequencies reported in Figures 5 and 6 clearly imply the following claim.

Claim 5 *Individuals, for most independent observations, coordinated on the outcome (X, X) considerably more than on (Y, Y) , and in most cases, more so in the last 10 periods of each part, in the Colour treatment.*

Following Figures 5 and 6, we end this subsection with the (percentages (%) of) frequencies of all outcomes at the level of independent observations, but only in Parts 2 and 3, which will lead to the analysis in the next subsection. Figures 7 and 8 below report coordination outcomes at the matching-group level, conditional on the public message (colour); they present scatterplots for Parts 2 and 3 of the Colour treatment, conditional on the public colour signal being RED and BLUE, respectively.

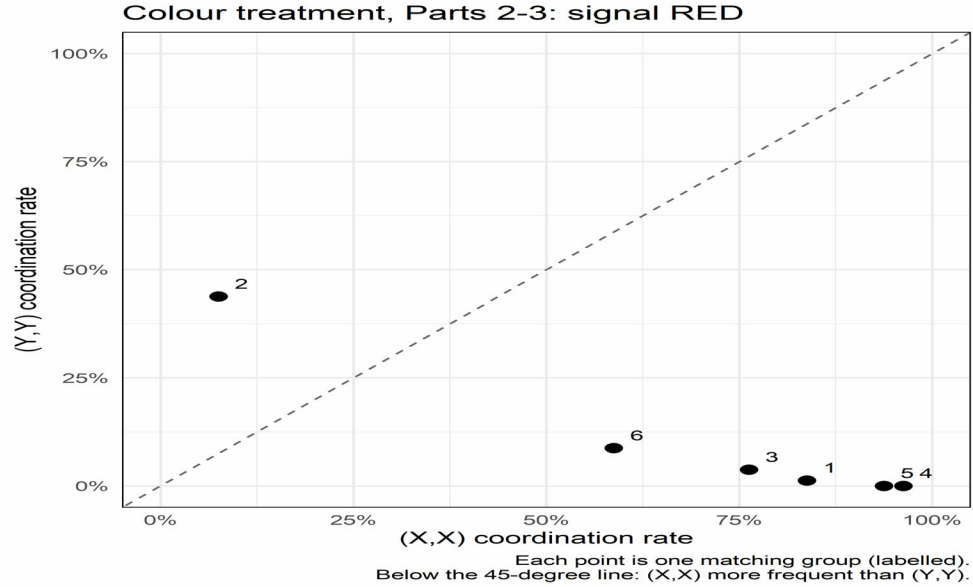


Figure 7: Outcomes by Matching Group in Parts 2 and 3 of the Colour Treatment (RED)

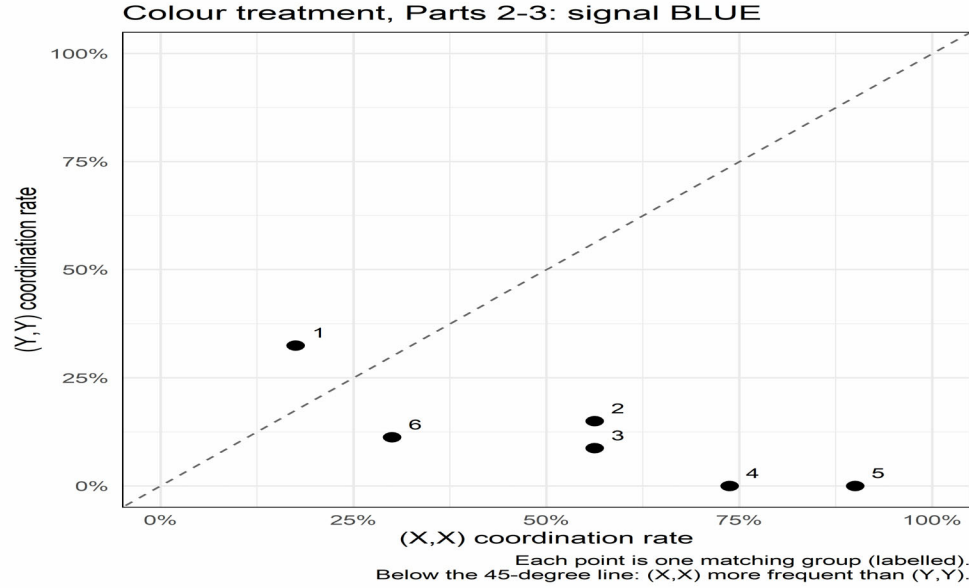


Figure 8: Outcomes by Matching Group in Parts 2 and 3 of the Colour Treatment (BLUE)

In both cases, five of the six points lie below the 45-degree line, confirming that the dominance of (X, X) over (Y, Y) coordination persists for most matching groups regardless of the colour signal observed. The exceptions are informative, however. Matching group 2 lies above the line when the signal is RED ((X, X) : 7.5%, (Y, Y) : 43.8%) but below it when the signal is BLUE (56.2% and 15.0%), whereas matching group 1 shows the opposite pattern (RED: 83.8% and 1.2%; BLUE: 17.5% and 32.5%). These two groups therefore condition their play on the colour, using opposite mappings.

3.4 Sunspot Equilibrium: Colour and Choice

The analysis presented in the previous subsection suggests that individuals play X more than Y in the Colour treatment. We now consider the question whether individuals actually played X and coordinated on (X, X) using a specific public message (colour) in Parts 2 and 3 of this treatment. We thus test our final hypothesis (Hypothesis 6) regarding the possible mapping from colour to choice.

Table 12 below reports the actions chosen by the subjects conditional on colour shown in Parts 2 and 3 of the Colour treatment. For example, in Part 2, out of overall 384 data points when the message was BLUE, X was played in 258 cases (in 67.19% cases).

Part 2 (Out of 960)				
	X	Y	% of X	% of Y
Public Message: BLUE (384)	258	126	67.19	32.81
Public Message: RED (576)	471	105	81.77	18.23
Part 3 (Out of 960)				
	X	Y	% of X	% of Y
Public Message: BLUE (576)	427	149	74.13	25.87
Public Message: RED (384)	296	88	77.08	22.92

Table 12: Choices by Colour in Parts 2 and 3 of the Colour Treatment

Table 12 clearly shows that individuals choose X considerably more than Y , whatever the public message (colour), although X is chosen less often after BLUE than after RED, particularly in Part 2 (67.19% against 81.77%). This indicates that individuals mostly did not use a colour-coded 1 – 1 mapping to choose their actions. To see this more clearly, we look at the choices of each subject conditional on the signal. The subjects could have adopted one of two possible mapping strategies that might lead to a sunspot equilibrium, namely, either X with BLUE and Y with RED, or, vice versa.

The following bar charts demonstrate existence of these strategies, if played, for all individuals in Parts 2 and 3 in the Colour treatment. In Figures 9 and 10 below, we plot all 48 individuals on the horizontal axis and their choices on the vertical axis. First, Figure 9 shows the number of times (out of 20, for each colour, BLUE and RED) each individual played X when the public message was RED and Y when it was BLUE.

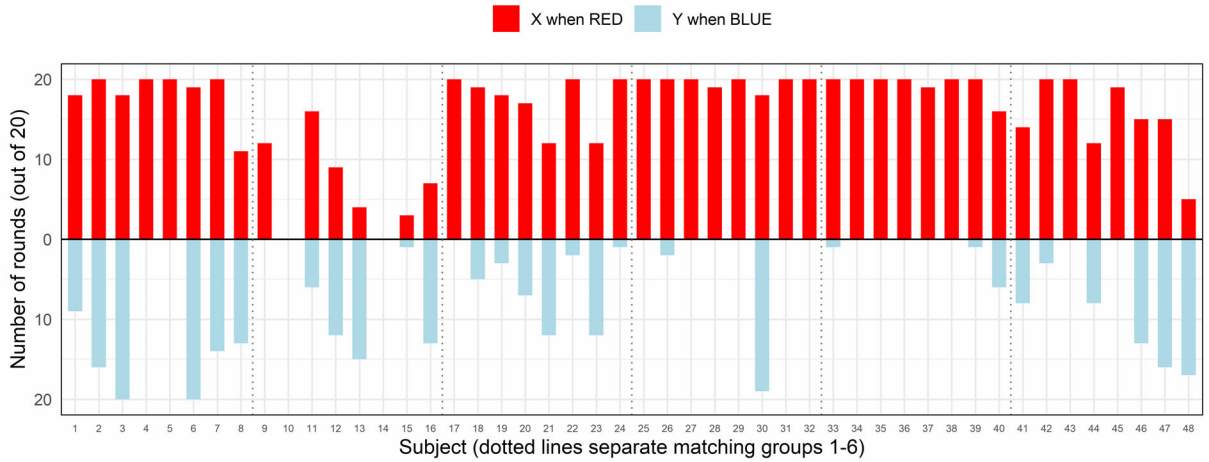


Figure 9: Choice Mapping with Colour (RED to X and BLUE to Y) in the Colour Treatment

In the top half of Figure 9, the height of a red bar denotes the number of times an individual played X when the public message was RED while in the bottom half, the height of a blue bar denotes the number of times Y was played when BLUE. For example, from Figure 9, we note that Individual 1 played X exactly 18 out of 20 times when RED (hence, played Y when RED for the rest, 2 times) and played Y only 9 (out of 20) times when BLUE (that is, played X for the rest 11 times); hence, this individual played X in total 29 (out of 40), times.

One may present the data used in Figure 9 to demonstrate the number of times individuals played Y when the public message is RED and X when it is BLUE, as a complement, as shown in Figure 10 below. In the top half of Figure 10, the height of a red bar denotes the number of times an individual played Y when the public message was RED while in the bottom half, the height of a blue bar denotes the number of times X was played when BLUE. Each of the red (and blue) bars in Figures 9 and 10 adds up to 20 and together they represent an individual's choices given a specific public message (colour).

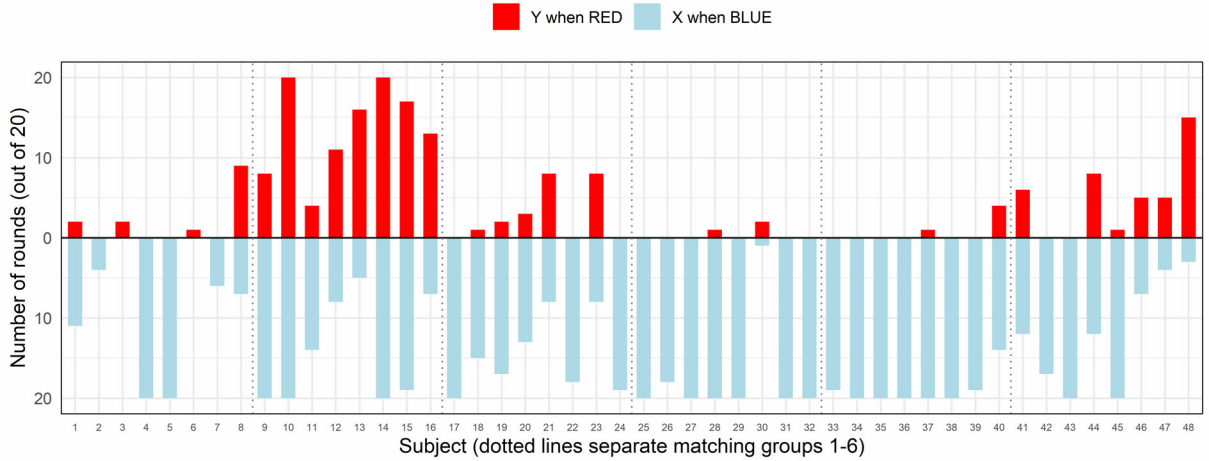


Figure 10: Choice Mapping with Colour (RED to Y and BLUE to X) in the Colour Treatment

It is obvious from Figures 9 and 10 that two individuals (individuals number 10 and 14 in the horizontal axis) adopted the strategy given by the 1 – 1 mapping of RED to Y and BLUE to X , fully, 100% of the times, and a third (individual number 15) did so 90% of the times (17/20 for RED to Y and 19/20 for BLUE to X). We also observe that four individuals adopted the other 1 – 1 mapping (RED to X and BLUE to Y) at least 90% of the times: individual number 2 (90%; 20/20 for RED to X and 16/20 for BLUE to Y), individual number 3 (95%; 18/20 and 20/20), individual number 6 (97.5%; 19/20 and 20/20) and individual number 30 (92.5%; 18/20 and 19/20). Individuals 2, 3 and 6 belong to matching group 1, and individuals 10, 14 and 15 to matching group 2. By contrast, 22 of the 48 individuals played X in at least 36 of the 40 periods with a colour. Figures 9 and 10

thereby suggest that most individuals mostly played X , regardless of colour. Thus, Hypothesis 6 that individuals match the observed colour with their choice in the game in the Colour treatment is not supported for most individuals. We summarise these observations as our second main finding of the paper.

Proposition 2 *Most individuals choose X (more than Y) regardless of the public message (colour) in Parts 2 and 3 of the Colour treatment; colour-contingent play emerges in only two matching groups, which adopt opposite mappings.*

4 CONCLUSION

In this paper, we set up an experiment to analyse whether players follow public signals in order to avoid coordination-failure in a simple BoS game. The game also has an intrinsic focal point. Hence, the aim of the experiment was to see if players use the focal point more than the extraneous signal, if at all.

We find that the focal point, strategy X in the game, has worked, whereas the public signal (colour) has largely been ignored. In particular, a sunspot equilibrium does not emerge in most matching groups; colour-contingent play appears in only two of the six groups, which adopt opposite mappings. We thus may conclude that an intrinsic label of the game can be more effective for social coordination than an extraneous signal; in our game, Letter is mightier than the Colour.

Other than the effect of a focal point, our work also connects with the literature on how coordination can be achieved using a public randomisation or a direct public correlation device.

Our design may also be used, after suitable modification, to answer other research questions, involving public announcements; we plan to address them in follow-up papers.

5 APPENDIX

We report the full instructions only for the Colour treatment here. The instructions for the Control treatment are effectively the same as that for the Part 1 (and Part 4) of the Colour treatment, in an obvious way. These instructions have been omitted here and are available upon request.

5.1 Instructions for the Colour Treatment

All participants in this session have the following identical instructions.

Welcome to this experiment. Thank you for participating. From now onwards please do not talk to any other participants until the session is finished. Please switch off your mobile phone. You may read the initial instructions below. But please do not open this document until the experimenter asks you to do so.

INITIAL INSTRUCTIONS

All participants in this experiment have identical instructions throughout the session. The experiment is in four parts. The instructions for Part 1 are in this document. But please do not open it until the experimenter asks you to do so. The instructions for Parts 2 – 4 will be circulated at the start of each part. Your payment for this experiment will depend on decisions taken by you and by other participants in all four parts.

When we pay you, at the end of Part 4, we will ask you to complete the receipt form which is on your desk. If you wish, you can enter your name, signature and date now. You will need to complete the payment box, on the form, at the end of the session.

When you go at the end of the session, please leave behind on your desk all the documents you have been provided with, including this one. In running further sessions of this experiment it will help us not to have any of these documents circulating outside of the laboratory. Please also leave behind the pen which has been provided for your use.

The results from this experiment will be used solely for academic research. Participants will remain completely anonymous in any publications connected with this experiment.

INSTRUCTIONS FOR PART 1

All participants in this session have the following identical instructions. In Part 1, you have 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 from Part 1, at a conversion rate of 1 point = 1 penny (and thus 100 points = £1).

At the start of the first round, the computer randomly assigns you the role of either Player 1 or Player 2. You keep this same role throughout all 20 rounds. But in each round you are randomly

paired with another participant. So, if you are assigned the role of Player 1, then the Player 2 who is paired with you in each round will probably be a different participant from the Player 2 paired with you in the previous round. And likewise if you are assigned the role of Player 2 then the Player 1 paired with you in each round will probably be a different participant from the Player 1 paired with you in the previous round.

In each round, Player 1 and Player 2 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 the choice of the other player.

The two players' choices together determine the points you each earn from that round, as in the following table.

		Player 2's choice	
		X	Y
Player 1's choice	X	17, 11	2, 2
	Y	2, 2	11, 17

The first number in each cell indicates the points earned by Player 1, and the second number indicates the points earned by Player 2. For example, if in some round both players choose X , then from that round Player 1 will earn 17 points and Player 2 will earn 11 points. And if in some other round both players choose Y , then from that round Player 1 will earn 11 points and Player 2 will earn 17 points.

The main screen for each round looks like this.

Round

1 out of 20

Player 2

X

Y

Player 1

X

Y

17, 11	2, 2
2, 2	11, 17

You have been assigned the role of Player 1. The first number in each cell of the table is your payoff. The second number is the payoff to Player 2.

Please Select Your Choice:

☐ Choice X
 ☐ Choice Y

Submit

At the top of the screen is a message which keeps count of the round, out of 20 (in this example, Round 1). In the centre of the screen is the table which appears on the first page of these instructions. Immediately below the table is a message informing you which role (Player 1 or 2) you have been assigned (in this example, Player 1). This is the same in each round.

To make your choice of X or Y , 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 in that round. This will include information of the choices of each of the two players, and on the points earned for each player. 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.

INSTRUCTIONS FOR PART 2

Part 2 is the same as Part 1, except in one respect. Each of the 20 rounds is given a colour, selected randomly and independently by the computer. Each round is equally likely (i.e. with probability 0.5) to be RED or BLUE. In each round, the colour is the same for all participants.

Round
1 out of 20

BLUE

Player 2

		Player 2	
		X	Y
Player 1	X	17, 11	2, 2
	Y	2, 2	11, 17

You have been assigned the role of Player 1. The first number in each cell of the table is your payoff. The second number is the payoff to Player 2.

Please Select Your Choice: ☐ Choice X ☐ Choice Y

Submit

The main screen for each round is the same as before, except that in the top part of the screen is indicated the colour of the current round (in this example, BLUE). The colour will also appear at the top of the projector screen on the wall in front of you. Immediately below the table is a message informing you which role (Player 1 or 2) you have been assigned (in this example, Player 1). This is the same assignment as in Part 1, and will remain the same throughout Part 2.

The onscreen results which appear at the end of each round will also include a reminder of the

colour of that round, which you can also note on your Record Sheet if you wish to. The points you earn in each of the 20 rounds in Part 2 will be added to the points you accumulated in Part 1.

INSTRUCTIONS FOR PART 3

Part 3 is exactly the same as Part 2. Each of the 20 rounds is given a colour, selected randomly and independently by the computer. Each round is equally likely (i.e. with probability 0.5) to be RED or BLUE. In each round, the colour is the same for all participants.

The points you earn in each of the 20 rounds in Part 3 will be added to the points you accumulated in Parts 1 and 2.

INSTRUCTIONS FOR PART 4

Part 4 is exactly the same as Part 1. There are no colours.

The points you earn in each of the 20 rounds in Part 4 will be added to the points you accumulated in Parts 1, 2 and 3.

When Part 4 has been completed, you will see a final screen reporting your total points accumulated over Parts 1–4, and showing your corresponding $\mathcal{L}$ payment. At that stage, please complete the receipt form which is on your desk, writing your name, signature and date below if you have not already done so, and then writing your payment in the box provided. Please then wait for further instructions from the experimenter, who will pay you in cash before you go.

When you go, please leave behind on your desk all the instructions and the Record Sheets. In running further sessions of this experiment it will help us not to have any of these documents circulating outside of the laboratory. Please also leave behind the pen which has been provided for your use.

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 very much for participating. We hope to see you again at future experiments.

5.2 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.

At the end of each round, circle X or Y as appropriate and record each player's points payoff, before clicking Continue.

Round	My Choice		Other Player's Choice		My Points	Other Player's Points
1	X	Y	X	Y		
2	X	Y	X	Y		
3	X	Y	X	Y		
4	X	Y	X	Y		
5	X	Y	X	Y		
6	X	Y	X	Y		
7	X	Y	X	Y		
8	X	Y	X	Y		
9	X	Y	X	Y		
10	X	Y	X	Y		
11	X	Y	X	Y		
12	X	Y	X	Y		
13	X	Y	X	Y		
14	X	Y	X	Y		
15	X	Y	X	Y		
16	X	Y	X	Y		
17	X	Y	X	Y		
18	X	Y	X	Y		
19	X	Y	X	Y		
20	X	Y	X	Y		

6 REFERENCES

1. Anctil, R. M., J. Dickhaut, C. Kanodia and B. Shapiro (2004), “Information transparency and coordination failure: theory and experiment,” *Journal of Accounting Research*, 42, 159-195.
2. Aumann, R. J. (1974), “Subjectivity and correlation in randomized strategies,” *Journal of Mathematical Economics*, 1, 67-96.
3. Aumann, R. J. (1987), “Correlated equilibrium as an expression of Bayesian rationality,” *Econometrica*, 55, 1-18.
4. Battalio, R., L. Samuelson and J. Van Huyck (2001), “Optimization incentives and coordination failure in laboratory stag hunt games,” *Econometrica*, 69, 749-764.
5. Blume, A. (1998), “Communication, risk, and efficiency in games,” *Games and Economic Behavior*, 22, 171-202.
6. Blume, A. and A. Ortmann (2007), “The effects of costless pre-play communication: experimental evidence from games with Pareto-ranked equilibria,” *Journal of Economic Theory*, 132, 274-290.
7. Bone, J., M. Drouvelis, Z. Gürgüç and I. Ray (2026), “Coordination by following public recommendations in 2 x 2 games with a cooperative outcome,” Working Paper, Section of Economics, Cardiff Business School, Cardiff University.
8. Brandts, J. and W. B. MacLeod (1995), “Equilibrium selection in experimental games with recommended play,” *Games and Economic Behavior*, 11, 36-63.
9. Cabon-Dhersin M-L. and N. Etchart-Vincent (2012), “The puzzle of cooperation in a game of Chicken: An experimental study,” *Theory and Decision*, 72, 65-87.
10. Cabon-Dhersin M-L. and N. Etchart-Vincent (2013), “Cooperation, the power of a single word: Some experimental evidence on rhetorical framing and gender effects,” *Bulletin of Economic Research*, 65, 43-64.
11. Cabrales, A., M. Drouvelis, Z. Gürgüç and I. Ray (2026), “Communicating in a coordination game with private information,” *Economic Theory*, 81, 1407-1434.
12. Cabrales, A., W. García-Fontes and M. Motta (2000), “Risk dominance selects the leader: an experimental analysis,” *International Journal of Industrial Organization*, 18, 137-162.
13. Camera, G., M. Casari and M. Bigoni (2013), “Binding promises and cooperation among strangers,” *Economics Letters*, 118, 459-461.

14. Camerer, C. F. (2003), *Behavioral game theory*, Princeton University Press.
15. Cason, T. N. and T. Sharma (2007), "Recommended play and correlated equilibria," *Economic Theory*, 33, 11-27.
16. Cason, T. N., T. Sharma and R. Vadovič (2020), "Correlated beliefs: Predicting outcomes in 2 x 2 games," *Games and Economic Behavior*, 122, 256-276.
17. Cason, T. N., T. Sharma and R. Vadovič (2026), "Correlated equilibria and forecasts based on naïve play in Hawk-Dove games," *Economic Theory*, 81, 225-251.
18. Charness, G. and B. Grosskopf (2004), "What makes cheap talk effective? Experimental evidence," *Economics Letters*, 83, 383-389.
19. Chaudhuri, A. and T. Paichayontvijit (2010), "Recommended play and performance bonuses in the minimum effort coordination game," *Experimental Economics*, 13, 346-363.
20. Chaudhuri, A., A. Schotter and B. Sopher (2009), "Coordination in inter-generational minimum effort games with private, almost common and common knowledge of advice," *Economic Journal*, 119, 91-122.
21. Chen, Y. and T. Cason (2026), "An experimental study of coarse correlated equilibrium for delegation to connected autonomous systems," Working Paper, Department of Economics, Purdue University.
22. Clark, K., S. Kay and M. Sefton (2001), "When are Nash equilibria self enforcing? An experimental analysis," *International Journal of Game Theory*, 29, 495-515.
23. Cooper, R., D. V. DeJong, R. Forsythe and T. W. Ross (1989), "Communication in the battle of the sexes game: some experimental results," *Rand Journal of Economics*, 20, 568-587.
24. Cooper, R., D. V. DeJong, R. Forsythe and T. W. Ross (1990), "Selection criteria in coordination games: some experimental results," *American Economic Review*, 80, 218-233.
25. Cooper, R., D. V. DeJong, R. Forsythe and T. W. Ross (1992), "Communication in coordination games," *Quarterly Journal of Economics*, 107, 739-771.
26. Crawford, V. P., U. Gneezy and Y. Rottenstreich (2008), "The power of focal points is limited: Even minute payoff asymmetry may yield large coordination failures," *American Economic Review*, 98, 1443-1458.

27. Croson, R. and M. Marks (2001), "The effect of recommended contributions in the voluntary provision of public goods," *Economic Inquiry*, 39, 238-249.
28. Devetag, G. and A. Ortmann (2007), "When and why? A critical survey on coordination failure in the laboratory," *Experimental Economics*, 10, 331-344.
29. Duffy, J. and N. Feltovich (2002), "Do actions speak louder than words? Observation vs. cheap talk as coordination devices," *Games and Economic Behavior*, 39, 1-27.
30. Duffy, J. and N. Feltovich (2006), "Words, deeds and lies: Strategic behavior in games with multiple signals," *Review of Economic Studies*, 73, 669-688.
31. Duffy, J. and N. Feltovich (2010), "Correlated equilibria good and bad: An experimental study," *International Economic Review*, 51, 701-721.
32. Duffy, J. and E. O'N. Fisher (2005), "Sunspots in the laboratory," *American Economic Review*, 95, 510-529.
33. Duffy, J., E. K. Lai and W. Lim (2017), "Coordination via correlation: An experimental study," *Economic Theory*, 64, 265-304.
34. Farrell, J. (1987), "Cheap talk, coordination and entry," *Rand Journal of Economics*, 18, 34-39.
35. Fischbacher, U. (2007), "z-Tree: Zurich toolbox for ready-made economic experiments," *Experimental Economics*, 10, 171-178.
36. Georgalos, K., I. Ray and S. SenGupta (2020), "Nash versus coarse correlation," *Experimental Economics*, 23, 1178-1204.
37. Greiner, B. (2004), "An online recruitment system for economic experiments," In K. Kremer and V. Macho (eds.), *Forschung und wissenschaftliches Rechnen 2003*, Gesellschaft für Wissenschaftliche Datenverarbeitung, 79-93.
38. Heinemann, F., R. Nagel and P. Ockenfels (2004), "The theory of global games on test: Experimental analysis of coordination games with public and private information," *Econometrica*, 72, 1583-1599.
39. Lugin, C., A. Konovalov and C. C. Ruff (2025), "Manipulating attention facilitates cooperation," *Communications Psychology*, 3, Article number 39, 1-16.
40. Manzini, P., A. Sadrieh and N. J. Vriend (2009), "On smiles, winks, and handshakes as coordination devices," *Economic Journal*, 119, 826-854.

41. Marimon, R., S. Spear and S. Sunder (1993), "Expectationally driven market volatility: An experimental study," *Journal of Economic Theory*, 61, 74-103.
42. McCabe, K. A., A. Mukherji and D. E. Runkle (2000), "An experimental study of information and mixed-strategy play in the three-person matching-pennies game," *Economic Theory*, 15, 421-462.
43. McKelvey, R. and T. Page (1990), "Public and private information: An experimental study of information pooling," *Econometrica*, 58, 1321-1339.
44. Mehta, J., C. Starmer and R. Sugden (1994), "The nature of salience: an experimental investigation of pure coordination games," *American Economic Review*, 84, 658-673.
45. Moreno, D. and J. Wooders (1998), "An experimental study of communication and coordination in noncooperative games," *Games and Economic Behavior*, 24, 47-76.
46. Moulin, H. and J. P. Vial (1978), "Strategically zero-sum games: the class of games whose completely mixed equilibria cannot be improved upon," *International Journal of Game Theory*, 7, 201-221.
47. Schelling, T. C. (1960), *The strategy of conflict*, Harvard University Press.
48. Schmidt, D., R. Shupp, J. M. Walker and E. Ostrom (2003), "Playing safe in coordination games: The role of risk dominance, payoff dominance, social history, and reputation," *Games and Economic Behavior*, 42, 281-299.
49. Seely, B., J. B. Van Huyck and R. C. Battalio (2005), "Credible assignments can improve efficiency in laboratory public goods games," *Journal of Public Economics*, 89, 1437-1457.
50. Stahl, D. O. (2013), "An experimental test of the efficacy of a simple reputation mechanism to solve social dilemmas," *Journal of Economic Behavior and Organization*, 94, 116-124.
51. Straub, P. G. (1995), "Risk dominance and coordination failures in static games," *Quarterly Review of Economics and Finance*, 35, 339-363.
52. Van Huyck, J. B., A. B. Gillette and R. C. Battalio (1992), "Credible assignments in coordination games," *Games and Economic Behavior*, 4, 606-626.