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Coordination Failure Caused by Sunspots

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Coordination Failure Caused by Sunspots

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ABSTRACT

In a coordination game with Pareto-ranked equilibria, we study whether a sunspot can lead to either coordination on an inferior equilibrium (mis-coordination) or to out-of equilibrium behavior (dis-coordination). While much of the literature searches for mechanisms to attain coordination on the efficient equilibrium, we consider sunspots as a potential reason for coordination failure. We conduct an experiment with a three player 2x2x2 game in which coordination on the efficient equilibrium is easy and should normally occur. In the control session, we find almost perfect coordination on the payoff-dominant equilibrium, but in the sunspot treatment, dis-coordination is frequent. Sunspots lead to significant inefficiency, and we conclude that sunspots can indeed cause coordination failure.

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1. INTRODUCTION

The purpose of this paper is to study experimentally whether a sunspot can lead to coordination failure, i.e. either coordination on an inferior equilibrium (mis-coordination) or to out-of equilibrium behavior (dis-coordination) in a coordination game with Pareto-ranked equilibria. Following the definition of Duffy and Fisher (2005) we think of a sunspot being an extrinsic random variable that does not directly affect economic fundamentals. While much of the relevant literature searches for mechanisms to attain coordination on the efficient equilibrium (e.g. Bornstein et al. 2002, Weber 2006, Brandts and Cooper 2006, Brandts et al. 2007), we focus on potential reasons for coordination failure. Is it possible that in a game in which coordination on the efficient equilibrium is easy and should normally occur, a sunspot could prevent subjects from coordinating on any equilibrium or even make them coordinate on an inferior equilibrium? If so, sunspots can explain coordination failures or collective choices of dominated equilibria observed in the real world such bank runs, stock market crashes or other financial turmoil (see Diamond and Dybvig 1983, Allen and Gale 2004, Harrison and Weder 2006). In addition to these macroeconomic coordination problems, coordination is also important for large organizations, in which it is necessary to synchronize the efforts of individual workers in order to avoid production bottlenecks (see Van Huyck et al. 1990, Knez and Camerer 1994). In both cases, rumors or some external news could affect the behavior of agents and lead to coordination failure.

Previous work has shown that it is not easy to generate sunspots in the laboratory that affect subjects' behavior (Marimon et al. 1993). Duffy and Fisher (2005) were the first to experimentally establish that sunspots may influence economic choices. We modify their approach in two important ways. First, we consider Pareto-ranked equilibria whereas their model has equilibria which are not Pareto-ranked. Second, we simplify the game and its presentation. The reason for this simplification and the use of Pareto-ranked equilibria lies in the goal of this paper. As mentioned before, the aim of this study is to create an environment where coordination is very likely, in fact almost sure, and investigate if a certain type of noise can lead to substantial inefficiencies. While Duffy and Fisher generate sunspots in a market setting, we use a simple three-player $2 \times 2 \times 2$ game, in which coordination on the obvious Pareto-superior equilibrium is very easy. Similar to Duffy and Fisher (2005), our sunspot is an announcement determined by the roll of a dice. We find that sunspots

influence choices and cause coordination failure even though the conditions of the experiment are such that we theoretically should not expect any effects of the sunspot. We thus show that sunspots can affect economic behavior, but also that they can do it in a very significant and welfare-decreasing way.

In the experiment, a sunspot consists of two announcements which correspond with the strategies available to subjects. Due to the very suggestive character of our sunspot, our work can be related to the literature on recommendation in games (e.g. Brandts and MacLeod 1995, Cason and Sharma 2007, Kuang et al. 2007). However, our sunspot differs from a recommendation because of its obvious random nature. The literature on recommendations shows that in some cases subjects follow a recommendation to play a strategy that leads to an inferior equilibrium. In other cases, recommendations create uncertainty about whether the other players will follow the recommendation which results in dis-coordination. Brandts and MacLeod (1995) show that if incentives are strong enough, subjects follow reasonable recommendations, but ignore unreasonable ones. In particular, recommendations to play an equilibrium that is not subgame-perfect are usually not followed. This is in contrast to our finding that subjects follow a sunspot, although it is in their interest not to do so.

Duffy and Fisher (2005) provide evidence that the semantics of the sunspot matters. Subjects are more inclined to coordinate on a sunspot, if the sunspot can be interpreted as being related to the economic problem. If the sunspot is abstract or difficult to relate to the economic problem, subjects seem to ignore it. For this reason we choose to frame our experiment as a real-work economic problem rather than using an abstract game. We consider workers' decisions to go on a strike. A strike can be seen as a coordination game, because a worker wants to join the others either striking or not striking. If a worker does not join his coworkers, he either foregoes benefits of a successful strike or he bears the costs of an unsuccessful one. It can be argued that our sunspot is very evocative in nature; however, one should note that this paper aims to study whether subjects follow random signals although it is clearly not in their interest to do so. According to Franzosi (1989), it is difficult to explain why strikes occur. Perfectly rational and informed workers and managers would generally prefer to negotiate and avoid strikes. Hence striking might be a dominated equilibrium in a coordination game and workers' decision to go on strike might be

influenced by exogenous signals that either make coordination on not striking more difficult or even ease the coordination on striking. Kaufman (1982) presents empirical evidence that non-economic attitudinal or psychological factors such as the militancy of workers, the charisma of union leaders or public opinion towards organized labor have explanatory power for the annual number of strikes and the number of workers involved in strikes in the US. Therefore, we believe that such psychological motivations for strikes could be influenced by random events.

2. EXPERIMENTAL DESIGN AND PROCEDURE

We use a coordination game in which subjects in groups of 3 people are put in the role of workers, who choose between the two actions *work* (W) and *strike* (S). The effect of sunspots is studied in a within-subject design, in which subjects play two different phases of 20 periods (a total of 40 periods) – one phase without sunspots and one with. The payment depends on performance in all the periods. The sunspot corresponds to an announcement which is made at the beginning of a period. There are two possible announcements – “work” and “strike”. The realized announcement is determined randomly by the roll of a (6-sided) dice. The two possible announcements thus correspond to the action space of the workers. In this way it is very clear how the sunspot could be used as a coordination device. Given the results in Duffy and Fisher (2005) on the significance of the sunspots’ semantics, we do not expect abstract announcements such as “green” and “red” to have an effect. The sunspot is determined by pure chance, and it is therefore not a recommendation, although it could appear to be so¹. Therefore, it should be obvious that choosing the action according to the announcement generally cannot be expected to lead to higher payoffs. In order to make the random determination of the announcement very salient to subjects, one of them rolls the dice herself and the experimenter makes the announcement about the number on the dice to the whole group.

The coordination game is very simple and the payoffs are shown in the following table:

¹ According to the participants’ answers to the questionnaire (see appendix), the random feature of the announcement was well understood by all of them.

Table 1: Payoff table

		Other Players' Decisions in Your Group		
		If BOTH of the other participants choose WORK	If ONE of the other participants chooses WORK and the other chooses STRIKE	If BOTH of the other participants choose STRIKE
Your Decision	WORK	40	10	10
	STRIKE	0	20	20

The game has the two pure strategy Nash equilibria (S,S,S) and (W,W,W) which are Pareto-ranked². Notice that the payoff-dominant equilibrium (W,W,W) is also risk-dominant³, which distinguishes our game from a typical stag-hunt game where the inefficient equilibrium is risk-dominant. This ensures that there is no conflict between risk- and payoff dominance. Moreover, expected payoff from playing W is higher than the expected payoff from playing S, as long as the randomizing strategy puts a weight greater than $1/\sqrt{5}$ on (W,W,W).⁴

Under these circumstances, we expect subjects to coordinate easily on (W,W,W) in the absence of a contradictory signal as well as in the presence of one. Indeed, even with the randomly determined announcement “strike”, conventional theory predicts that rational subjects (with common knowledge of rationality) should ignore the signal and coordinate on (W,W,W). However, a “strike” announcement might create strategic uncertainty if some subjects believe that other subjects will follow the announcement. In that case, we will observe that at least some subjects choose S instead of W. Potentially, strategic uncertainty could be so strong that all subjects coordinate on (S,S,S), whenever they receive the strike announcement. This would be a sunspot equilibrium, in which every subject believes the other subjects will follow the announcement. By playing the best response to this belief, the belief would be self-confirming.

² In addition, there is a symmetric mixed-strategy equilibrium in which players choose “work” and “strike” with probabilities $1/\sqrt{5}$ and $1 - (1/\sqrt{5})$, respectively. The expected payoff in the mixed strategy equilibrium is 16 resulting in an efficiency of 40 per cent (relative to equilibrium payoffs in (W,W,W)).

³ As the product of the deviation losses for W,W,W is the highest (Harsanyi and Selten (1988)).

⁴ This can be also observed from the probabilities of the mixed-strategy equilibrium.

In order to avoid reputation effects, the game is played as a repeated one-shot game with random matching. Another reason for random matching is to relate this experiment to a macroeconomic context where agents do not normally know each other and frequently there are new entrants into a group. Moreover, we vary the order of the sunspot phase to check for order effects. To do this, we run control/sunspot sessions (C/S session hereafter), where subjects start by playing a coordination game without announcements in the first 20 periods and play a coordination game with the sunspot in the last 20 periods, and sunspot/control sessions (S/C session hereafter), where, they start with the sunspot phase and play the pure coordination game without announcements after period 20.

We use two devices in order to avoid that the sunspot destroys the expected coordination on the superior equilibrium. The first one consists of choosing a low probability for the “work” announcement. Actually, if the “strike” announcement occurs frequently enough, subjects have many opportunities to observe the behavior of the other players and to learn that coordination failure is costly. Hence, we announce “work” only if the dice shows 1 and “strike” otherwise. With the same rationale, the second device consists of providing the subjects with the complete history of the game. After each period subjects are informed about their own decision, the decisions of the other players in the group, the earned points and the announcement, if there was one. Displaying this information for all past periods should also facilitate learning and coordination on the superior equilibrium.

The sessions for this experiment were conducted in LEEX at Universitat Pompeu Fabra (UPF) and in LEE at University of Copenhagen (CPH), using z-Tree (Fischbacher 2007). 36 undergraduate students from various departments of UPF and 48 students from various departments of CPH participated in this experiment. After receiving the instructions⁵, and prior to the start of the game, participants answered control questions to check their understanding of the game at hand. They were also asked to fill in a questionnaire, at the end of each session, to collect their comments. As mentioned above, each session consisted of two different treatments, one with an announcement (the sunspot treatment) and another without an announcement (the control treatment). In the sunspot treatments, the throw of a dice was used in order to determine which announcement was realized. At the beginning of

⁵ See appendix

each period subjects were randomly matched with others and the dice was rolled by one of the participants. Next, the number on the dice was announced out loud. Finally, according to the number on the dice that was stated, subjects received announcements of “work” or “strike” on their computer screen. All the subjects knew that they had received the same announcement, which was determined according to the roll of the dice. In order to get more independent observations from each treatment, we divided participants in each treatment into subgroups of 6 people, and the subjects from each subgroup were randomly matched with each other for the remaining periods.⁶ All participants were paid a show-up fee of 3 € (20 Danish kroner (DKK)) and moreover, received 1 € per 150 points (15 DKK per 150 points) at the end of the experiment. All the subjects were paid in cash at the end of each session and the average earnings were €15 in Barcelona and €16 in Copenhagen.

3. RESULTS

We begin this section with an analysis of the control treatments from both sessions. Firstly, we will see that without sunspots subjects coordinate on the Pareto efficient equilibrium. Afterwards, we return to the sunspot treatments, where we find that sunspots create coordination failure.

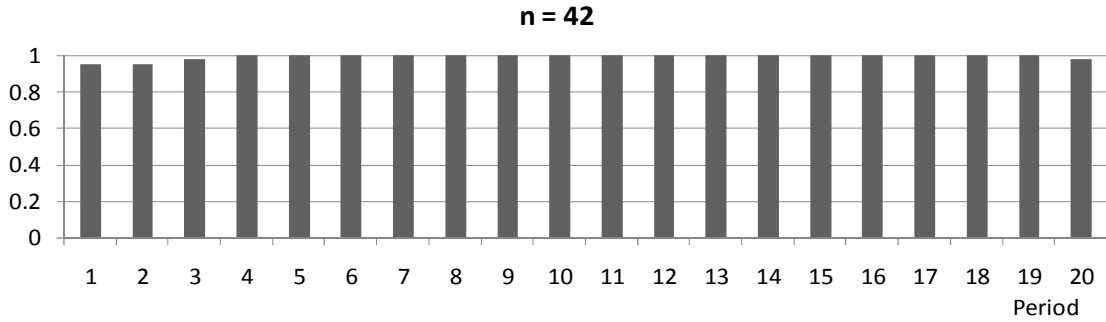
3.1 Control Treatment

Before we analyze the potential effects of the sunspot, we would like to know whether coordination took place in the absence of the sunspot. Figure 1 summarizes the share of W decisions from all treatments and sessions without announcements (both C/S sessions and S/C sessions).

We clearly see that without sunspot announcements coordination was almost perfect. Indeed, 98.6% of all 1680 decisions were W and even in the first periods W was chosen in 95.2% of all cases. In brief, the subjects almost always managed to coordinate on the payoff-dominant equilibrium.

⁶ Unfortunately, due to an allocation problem of subjects to subgroups in the control group of the Copenhagen session we are left with 5 instead of 7 independent observations for the control group at CPH.

Figure 1: Share of “W” decisions in the control treatments



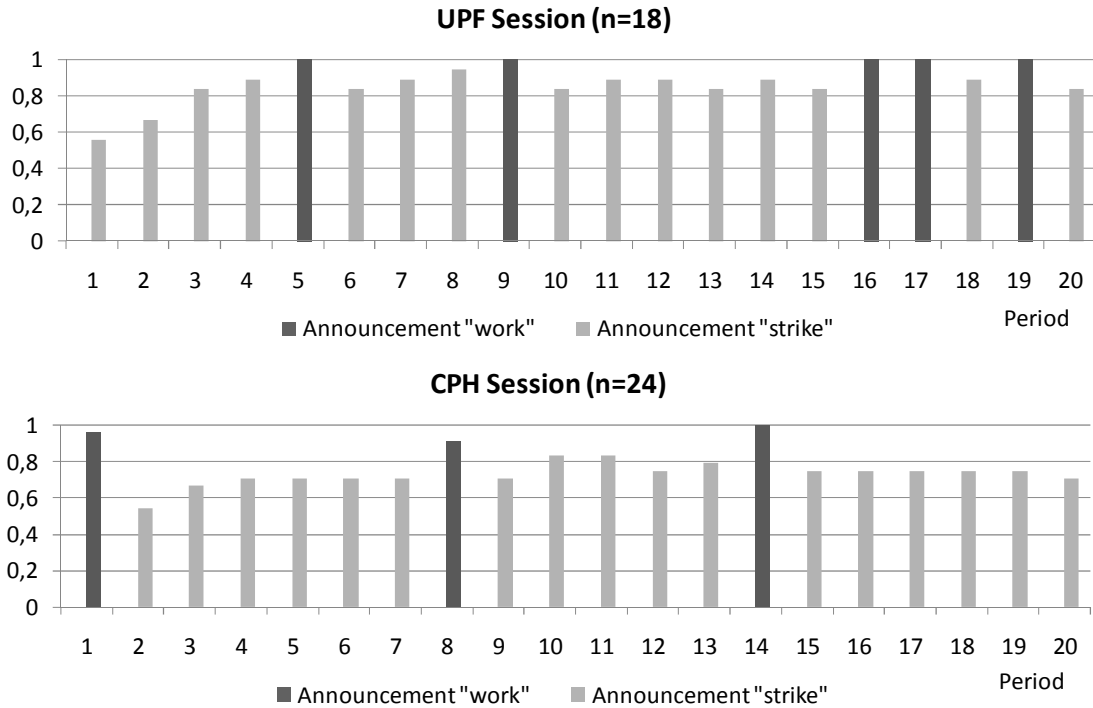
We take this finding as a confirmation that the subjects understood the game and that our game is easy enough so that coordination on the superior equilibrium (W,W,W) occurs right from the start if subjects are not influenced by sunspot announcements. In this paper we focus on sunspots as a potential explanation of coordination failure. Therefore, it is crucial, that the design is such that there is coordination in the absence of sunspots.

3.2 Sunspot Treatments

In this section, we analyze the potential effect of the sunspot on the coordination in our game. Figure 2 shows the share of W decisions in the treatments in which subjects received randomly determined announcements in the first 20 periods (S/C sessions).

The difference from the control treatment is striking. In both the session at the University of Pompeu Fabra (UPF) and in that at the University of Copenhagen (CPH), a large percentage of subjects chose S in each period with a “strike” announcement. At the UPF session, full coordination on (W,W,W) was only achieved in the cases in which there was a “work” announcement and never with a “strike” announcement. In the CPH sessions W was chosen by all subjects in only one period where there was a “work” announcement and failed to coordinate perfectly in all other periods.

Figure 2: Share of W decisions in the sunspot treatments of the S/C sessions



Taking both sessions together, the total share of W decisions was 98.1% if the announcement was “work” and 77.1% if the announcement was “strike”. As visible in Figure 2, the share of W choices was significantly lower in Copenhagen (73.0%) than in Barcelona (83.3%) if there was a “strike” announcement (Wilcoxon signed-rank test, $z=-3.262$, $p=0.0011$).

Averaging over periods and subjects within subgroups gives us five clearly independent observations in both the sunspot and the control treatment⁷ for the S/C sessions. The Wilcoxon signed-rank test applied to these average shares of work decisions confirms that there is a significant difference between the two treatments ($z=-2.03$, $p=0.04$).

⁷ As mentioned before, we are left with 5 instead of 7 independent observations for the control group of the Copenhagen session and thus two subgroups are not used and we are left with 5 independent observations for this comparison.

Another way to assess the importance of the sunspot is to estimate the following random effects panel probit model for each period t and each subject i (840 observations)

$$P(Y_{it}=1) = (\beta_0 + \beta_1 \text{STRIKE}_{it} + \beta_2 \text{PERIOD}_t + \gamma \mathbf{GD}_i),$$

where $Y = 1$ indicates the choice of W, STRIKE equals 1 if the announcement is “strike” and 0 otherwise, PERIOD is a time variable, and **GD** is a collection of dummy variables indicating the subgroups with one subgroup at UPF omitted. The time variable serves to check for learning effects and the subgroup dummies control for any group-specific effects.

We find that the announcement of “strike” reduces the probability of W by 0.098 ($p=0.001$) and that as the experiment goes on, an additional period increases the probability of W by 0.004 ($p=0.008$)⁸. This means that the strike announcement has a significant effect at the individual level, but also that individuals learn to ignore it over time (even if only slowly).

By running different sessions with different order of treatments, a significant order effect is found. Comparing the averages of the independent observations from the C/S session, in which subjects played the control treatment first and the sunspot one next, to those of the S/C session, where subjects played the sunspot treatment first and consequently the control, there are significant differences (Wilcoxon rank sum (Mann-Whitney) test, 7 observations, $z=-3.169$, $p=0.0015$). Thus, the order matters and subjects learn enough from the control treatment to avoid any inefficient decision when the sunspot is introduced, whereas when the sunspot is introduced before any experience it leads to inefficiencies.

While the sunspot appears to change the behavior of some subjects, it is not strong enough to generate a sunspot equilibrium. We never observe mis-coordination on the inferior (S,S,S) Nash equilibrium in any group, but rather dis-coordination. Thus, in our experiment the sunspot does not appear as a coordination device but rather as a source of uncertainty. This is not surprising, because strategic uncertainty appears to be very low in the control treatment, in which subjects coordinate almost perfectly on the payoff-dominant equilibrium right from the start. One should note that, 63% of the subjects in CPH S/C session, as well as 67% of the subjects in UPF S/C session are responsible for this dis-coordination for at

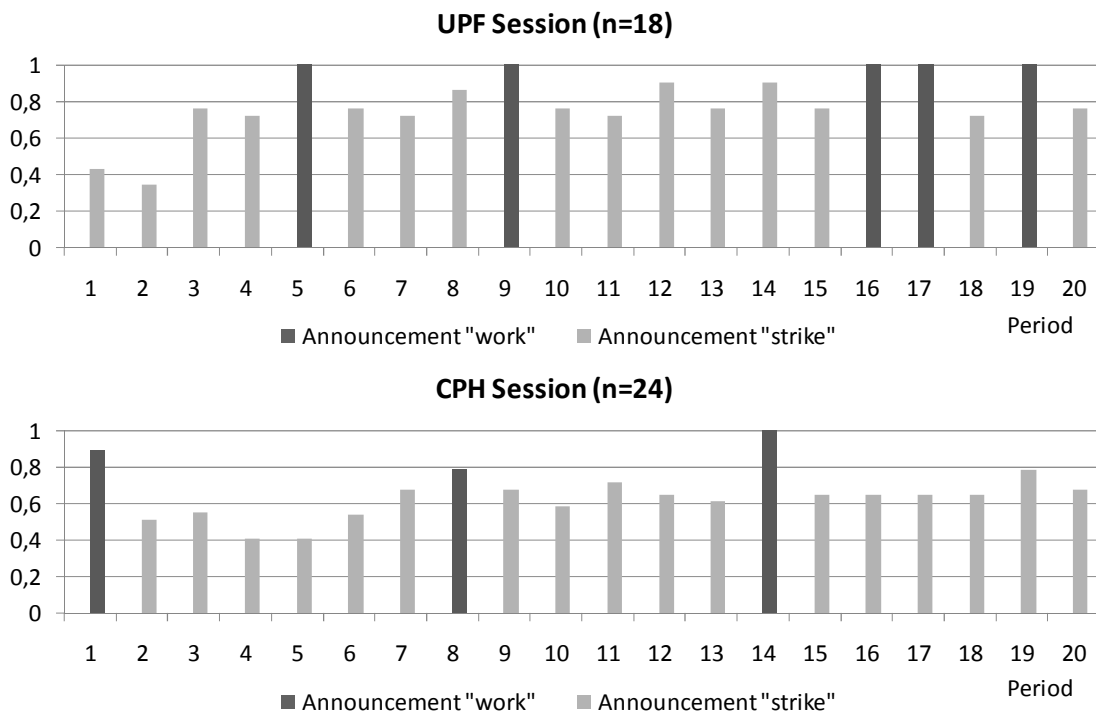
⁸ A likelihood ratio test rejects the null hypothesis of no random effects at $p<0.001$. Of the six subgroup dummy variables, two for CPH and one for UPF are significantly negative.

least 1 and up to 17 periods. Therefore, one can conclude that the dis-coordination observed in this experiment is not due to the decisions of a few subjects but rather a general phenomenon.

3.3 Efficiency

The dis-coordination caused by the sunspot is quite costly. We measure efficiency by the actual payoff per period divided by 40, which is the obtained payoff in the Pareto-dominant equilibrium (W,W,W). Figure 3 shows us the average levels of efficiency in the treatments in which the sunspot matters.

Figure 3: Average level of efficiency in the sunspot treatments of the S/C session



At the UPF session (upper panel), the average level of efficiency is always 1 if the announcement is “work”, but only three times above 0.8 if the announcement is “strike”. The mean of the level of efficiency at the UPF session with a “strike” announcement is equal

to 0.728, which is significantly smaller than 1 (Wilcoxon signed-rank test, $z=-3.936$, $p=0.0001$).

At the Copenhagen session (lower panel), losses are even greater. Here the average level of efficiency is always below 0.8 if the announcement is “strike” and the mean of the average level of efficiency in the 17 periods with “strike” announcements is equal to 0.61, which is significantly smaller than the average efficiency of 0.896 in the three “work” periods (Wilcoxon signed-rank test, $z=-3.390$, $p=0.0007$).

Overall, efficiency is significantly reduced when the sunspot is introduced in the first periods compared to periods where it is absent (0.714 vs. 0.901, Wilcoxon rank sum (Mann-Whitney) test, $z= 3.372$, $p=0.0007$). We conclude that the sunspot is relevant, as it can produce significant economic losses through dis-coordination when subjects have not learned enough about the game.

4. Conclusion

We have demonstrated that a purely random signal unrelated to the fundamentals of the game – a sunspot – produces coordination failure (and efficiency losses) among individuals who almost perfectly coordinate among themselves otherwise. This is especially remarkable because our coordination game is so simple. With only two Nash equilibria in pure strategies and with the payoff-dominant equilibrium also being risk-dominant, coordination on this superior equilibrium is made very easy, as confirmed by our control treatments. Yet the introduction of a – in terms of fundamentals – irrelevant signal has huge impact on behavior.

Our study is the second paper that shows the relevance of sunspots in a laboratory experiment. In contrast to the results in Duffy and Fisher (2005), the sunspots in our experiment do not facilitate coordination, but lead to dis-coordination. Furthermore, we introduce sunspots in a setting with Pareto ranked equilibria. In this study, rather than serving as a coordination device and reducing strategic uncertainty, the sunspot generates it and leads to coordination failure. This is a new potential impact of sunspots which has not been extensively discussed in the theoretical literature before. Thus, this study is consistent

with the view that real life coordination failures can be caused by random, exogenous signals – sunspots – rather than fundamentals.

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APPENDIX

S/C Session Instructions: (announcements in the first 20 periods)

Thank you for participating in this experiment. Your points and thus your payment at the end of this experiment depend on your decisions and the decisions of the other participants. Moreover, you will receive a show-up fee of 3 Euros. The amount you earn (that depends on the total points you receive) will be paid in cash immediately after the experiment is finished. It is very important that you read these instructions with care. From now on, you are not allowed to talk or communicate in any way with the other participants. If you have any questions, please raise your hand and one of the experimenters will answer them in private. Please do not ask your questions aloud.

This experiment consists of 40 rounds. The experiment will be divided into two sections of 20 rounds. When the first 20 rounds finish, you will receive the instructions for rounds 21 to 40. At the beginning of each round you will be randomly paired with two other participants to form a group of three. Hence, **the members of your group will be different** in each round. The members of a group are not necessarily sitting side by side. All groups in the experiment consist of three people.

Your Decision

In each round, you and the other members of your group will decide whether to **“WORK”** or **“STRIKE”**.

Announcement

Once you are assigned to a group for that round, **you and the other members of your group will receive an announcement at the beginning of each period**. The announcement will be either **“WORK”** or **“STRIKE”**, and it will be the same for all the participants in this experiment, hence for all the members of your group.

It is important that you understand that these announcements are random since they are determined by the throw of a dice. The experimenter will throw the dice in front of all the participants and will ask one of the participants to announce the number on the dice. You will receive the announcement **“WORK”** if the dice is 1 and **“STRIKE”** otherwise.

Your Payoff

Your income will be determined by the points you earn according to the payoff below and it will be based on **your decisions and the decisions of the other players in your group**. All groups in this experiment receive the same payoff table which is explained below.

Your Decision	Other Players' decisions in Your Group		
	If BOTH of the other participants choose WORK	If ONE of the other participants chooses WORK and the other chooses STRIKE	If BOTH of the other participants choose STRIKE
	WORK	10	10
STRIKE	0	20	20

In this table, rows indicate your decision of **“WORK”** or **“STRIKE”**, and columns show the decisions of the other players. Each cell indicates the points you will receive depending on your decision and the decisions of the others in your group. For example, if you choose **“WORK”**; and if both of the other members of your group choose **“STRIKE”** you receive **10**; whereas, if you choose **“WORK”**, and if both of the other players choose **“WORK”**, you receive **40**. If you have any questions please raise your hand.

Information at Each Round

After you make your decision, you will be informed about your current decision, the current decisions of your group members and your points from that round. Moreover, in each round, you can see the information from previous periods (your decisions, the announcement, the decisions of the others and your points). **Please remember that you are randomly matched with different group members at the beginning of each period.**

Each row will give information about each round. The announcement given in that period will be in the second column. Your previous decisions will be in the third column and your previous points from previous rounds will be in the last column. Column 4 will display the previous decisions of the other members of your group. The screen you will see in each round will be similar to one of the following:

ROUND	Announcement	Your decision	Decisions of the other players in your group	Your points In Round
....

Payment

The total amount of points you collect after each round will be summed up to determine your total points at the end of the experiment. This final sum will be converted into Euros and will be paid out in cash immediately after the experiment is finished. For each 150 points you earn, you will receive 1 Euro. Moreover, as it is mentioned at the beginning of the experiment, you will receive a show-up fee of 3 Euros. The payment will be made individually and anonymous.

ROUNDS 21-40⁹

Your decisions and your payoffs are the same for these rounds. The points that you will receive are determined according to the same payoff table (p.1). However, once you are assigned to a group for that round, **you will not receive an announcement.**

Information at Each Round

As before, after you make your decision, you will be informed about your current decision, the current decisions of your group members and your points from that round. Moreover, in each round, you can see the information from previous periods (your decisions, the decisions of the others and your points). **Please remember again that you are randomly matched with different group members at the beginning of each period.**

As before, each row will give information about each round. Your previous decisions will be in the second column and your previous points from previous rounds will be in the last column. Column 3 will display the previous decisions of the other members of your group. The screen you will see in each round will be similar to one of the following:

ROUND	Your decision	Decisions of the other players in your group	Your points In Round
....

Payment

The total amount of points you collect after each round will be summed up to determine your total points at the end of the experiment. This final sum will be converted into Euros and will be paid out in cash immediately after the experiment is finished. For each 150 points you earn, you will receive 1 Euro. Moreover, as it is mentioned at the beginning of the experiment, you will receive a show-up fee of 3 Euros. The payment will be made individually and anonymous.

⁹ The instructions for this part were given to the subjects as a separate sheet in the second part of the experiment.

C/S Session Instructions (announcements in the last 20 periods)

Thank you for participating in this experiment. Your points and thus your payment at the end of this experiment depend on your decisions and the decisions of the other participants. Moreover, you will receive a show-up fee of 3 Euros. The amount you earn (that depends on the total points you receive) will be paid in cash immediately after the experiment is finished. It is very important that you read these instructions with care. From now on, you are not allowed to talk or communicate in any way with the other participants. If you have any questions, please raise your hand and one of the experimenters will answer them in private. Please do not ask your questions aloud.

This experiment consists of 40 rounds. The experiment will be divided into two sections of 20 rounds. When the first 20 rounds finish, you will receive the instructions for rounds 21 to 40. At the beginning of each round you will be randomly paired with two other participants to form a group of three. Hence, **the members of your group will be different** in each round. The members of a group are not necessarily sitting side by side. All groups in the experiment consist of three people.

Your Decision

In each round, you and the other members of your group will decide whether to **“WORK”** or **“STRIKE”**.

Your Payoff

Your income will be determined by the points you earn according to the payoff below and it will be based on **your decisions and the decisions of the other players in your group**. All groups in this experiment receive the same payoff table which is explained below.

		Other Players' decisions in Your Group		
Your Decision		If BOTH of the other participants choose WORK	If ONE of the other participants chooses WORK and the other chooses STRIKE	If BOTH of the other participants choose STRIKE
	WORK	40	10	10
	STRIKE	0	20	20

In this table, rows indicate your decision of **“WORK”** or **“STRIKE”**, and columns show the decisions of the other players. Each cell indicates the points you will receive depending on your decision and the decisions of the others in your group. For example, if you choose **“WORK”**; and if both of the other members of your group choose **“STRIKE”** you receive **10**; whereas, if you choose **“WORK”**, and if both of the other players choose **“WORK”**, you receive **40**. If you have any questions please raise your hand.

Information at Each Round

After you make your decision, you will be informed about your current decision, the current decisions of your group members and your points from that round. Moreover, in each round, you can see the information from previous periods (your decisions, the decisions of the others and your points). **Please remember that you are randomly matched with different group members at the beginning of each period.**

Each row will give information about each round. Your previous decisions will be in the second column and your previous points from previous rounds will be in the last column. Column 3 will display the previous decisions of the other members of your group. The screen you will see in each round will be similar to one of the following:

ROUND	Your decision	Decisions of the other players in your group	Your points In Round
....

Payment

The total amount of points you collect after each round will be summed up to determine your total points at the end of the experiment. This final sum will be converted into Euros and will be paid out in cash immediately after the experiment is finished. For each 150 points you earn, you will receive 1 Euro. Moreover, as it is mentioned at the beginning of the experiment, you will receive a show-up fee of 3 Euros. The payment will be made individually and anonymous.

ROUNDS 21-40¹⁰

Your decisions and your payoffs are the same for these rounds. The points that you will receive are determined according to the same payoff table (p.1). However, once you are assigned to a group for that round, **you and the other members of your group will receive an announcement at the beginning of each period.** The announcement will be either **“WORK”** or **“STRIKE”**, and it will be the same for all the participants in this experiment, hence for all the members of your group.

It is important that you understand that these announcements are random since they are determined by the throw of a dice. The experimenter will throw the dice in front of all the participants and will ask one of the participants to announce the number on the dice.

You will receive the announcement **“WORK”** if the dice is 1 and **“STRIKE”** otherwise.

Information at Each Round

As before, after you make your decision, you will be informed about your current decision, the current decisions of your group members and your points from that round. Moreover, in each round, you can see the information from previous periods (your decisions, the announcement, the decisions of the others and your points). **Please remember again that you are randomly matched with different group members at the beginning of each period.**

As before, each row will give information about each round. The announcement given in that period will be in the second column. Your previous decisions will be in the third column and your previous points from previous rounds will be in the last column. Column 4 will display the previous decisions of the other members of your group. The screen you will see in each round will be similar to one of the following:

ROUND	Announcement	Your decision	Decisions of the other players in your group	Your points In Round
....

¹⁰ Ibid.

Control Questions for the C/S sessions:¹¹

- 1) In all the rounds are you in a group with the same people?
- 2) What is your payoff, if you choose "work", and if one of the other members chooses "work" and the other chooses "strike"?
- 3) What is your payoff, if you choose "strike", and if one of the other members chooses "work" and the other chooses "strike"?
- 4) Will you always receive the same announcement?
- 5) Is the announcement you receive determined randomly?
- 6) In the rounds 21 to 40, did the payoff table that you are using change?

Questionnaire for the C/S sessions:¹²

- 1) First of all we would like to get some statistical information
 1. Studies
 2. Years of study
 3. Age
 4. Sex
- 2) Please answer the following questions:
 1. The experiment was boring/interesting: 1 2 3 4 5
 2. The experiment was too short/too long: 1 2 3 4 5
 3. Would you like to participate in more experiments?
 4. Did you take any class on game theory?
- 3) Please briefly explain your decisions of "work" or "strike" in the first part.
- 4) Please briefly explain your decisions of "work" or "strike" in the second part.
- 5) Did the announcements in the second part affect your decisions?
- 6) What was more important for your decisions?
 1. Gaining more points
 2. Maintaining a safe payment
 3. They were both equally important for me
- 7) Did the previous decisions of the other participants affect your decisions?
- 8) Do you have further comments?

The experiment is finished

Thank you participating

¹¹ The control questions for the S/C sessions are the same as the C/S sessions; however, the order of questions is different.

¹² The questionnaire for the S/C sessions is the same as the C/S sessions except for question 5. The question 5 for S/C sessions referred to the announcement in the "first" part.