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Lisa Bruttel
Tim Friehe

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Lisa Bruttel[†] Tim Friehe[‡]

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Abstract

This paper presents results from an experiment studying a two-person 4x4 pure coordination game. We seek to identify a labeling of actions that induces subjects to select all options with the same probability. Such a display of actions must be free from salient properties that might be used by participants to coordinate. Testing 23 different sets of labels, we identify two sets that produce a distribution of subjects' choices which approximate the uniform distribution quite well. Our design can be used in studies intending to compare the behavior of subjects who play against a random mechanism with that of participants who play against human counterparts.

Keywords: coordination game, experiment, mixed strategy, level k

JEL-Classification: C71, C92, D83

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[†]University of Konstanz, Department of Economics, Box 131, 78457 Konstanz, Germany. E-mail: lisa.bruttel@uni-konstanz.de.

[‡]University of Bonn, Center for Advanced Studies in Law and Economics, Adenauerallee 24-42, 53113 Bonn, Germany. CESifo, Munich, Germany. E-mail: tim.friehe@uni-bonn.de.

1 Introduction

Coordination problems abound in real life. Some examples include the width of train tracks, business locations, and gentrification (Camerer 2003). When the coordination game is pure, it is only of importance whether players coordinate at all, but not which action they coordinate on. The emergence of a convention regarding which side of the road drivers use is an illustration of a pure coordination game, which has two pure-strategy equilibria and one payoff-dominated mixed-strategy equilibrium.[1] As a result, the players have a common interest in coordinating on some equilibrium, but the structure of the game is of no help in this regard. However, how actions are presented (or "labeled") in many scenarios introduces so-called focal points (Schelling 1960), which have proven to facilitate coordination among players.[2] The classical example in this regard refers to the task of choosing a place to meet someone in New York without being able to communicate, where the Grand Central Station turned out as the focal point (Schelling 1960).

This paper seeks to identify a labeling of actions in a pure coordination game that makes coordination as difficult as possible, that is, to effect the reverse of what is usually attempted (given the fact that pure-strategy equilibria payoff-dominate the mixed-strategy equilibrium). In addition to serving curiosity, the attainment of this objective has the following practical value for experimental economists: when a treatment variation concerns whether subjects play against a random device with fixed probabilities or against another human player, a representation of actions that induces subjects' counterpart to reliably select all options with equal probability yields a coordination probability that is comparable to that set for the random device. In our 4x4 pure coordination game, randomization of subjects according to the mixed strategy implies that the probability of successful coordination is equal to 25 percent. From a material incentive perspective, this would thus be similar to having a random mechanism with a matching probability of 25 percent. Our contribution is, thus, primarily methodological as, for example, Gürerk and Selten (2012) or Gächter and Renner (2010). The paper by Oechssler

[1]Note that indeed only the mixed-strategy equilibrium is consistent with the criterion of Harsanyi and Selten (1988) that games with the same structure ought to have the same solution.

[2]See, for example, Casajus (2000) and Sugden (1995) for formal theories of focal points.

and Roomets (2013) is similar to ours in providing a new solution to a problem faced by several experimentalists, which may be of relevance in settings allowing for probabilistic outcomes for subjects.

The salience of the label of an action is of central importance for our exploration. Because players tend to choose actions that are salient, the proposed objective of our study requires the identification of a set of labels that are distinguishable but do not offer any label that may serve as a focal point. The effectiveness of focal points for coordination was underscored by experimental work studying games with salient labels and symmetric payoffs. Mehta et al. (1994) distinguish between Schelling salience (a label is salient when it suggests itself to people who are looking for ways of solving coordination problems) and both primary and secondary salience. A label is therein called primary salient when it is directly brought to the player's mind and a label is secondary salient when it is expected to be of primary salience for the other player. For example, the city of birth may have primary salience for a subject when the question is "Name a city", but it will only be chosen as a response in a coordination task when this information is also available to many other subjects. In our inquiry, we try to make coordination hard and thus make use of rather abstract illustrations which are not proper for differentiating along these lines.

The distinction between primary and secondary salience is related to level-k models (see Crawford et al. 2013 for a recent survey). In these models, there is a non-strategic player type *L0* (behaving according to primary salience) and there are *Lk* types (with $k \geq 1$) who vary in their depth of reasoning. Type *L1* plays its best response to the behavior of type *L0* (comparable to secondary salience), type *L2* plays best response type *L1* and so on for higher k types. Crawford et al. (2008) consider pure and asymmetric coordination games and distinguish label and payoff salience. They find that a model assuming a type *L0* with a payoffs bias (i.e., one that favors payoff over label salience) together with a behaviorally plausible mixture of *L1* and *L2* players explains their results regarding the coordination rates in symmetric and asymmetric coordination games well. In our study, we have a pure coordination problem in which successful coordination pays the same irrespective of the actions chosen.

Level-k thinking has also been successfully applied to the puzzles created by data from the related hide-and-seek game (Crawford and Iriberri 2007). In this game, only one of the two players (the seeker) has an interest in coordinating with the other, while the second player (the hider) prefers failing to coordinate. Our findings are perfectly transferable to hide-and-seek games. In fact, pure coordination games provide a stronger test for the non-salience of each of the labels of the actions than the hide-and-seek game: in the coordination game, both players will tend to coordinate when one of the labels is focal. In contrast, in a hide-and-seek game, one focal label cannot be expected to yield a pure-strategy equilibrium (given that the hider may – depending on the applied strategic thinking – consider playing any of the three non-salient labels).

With respect to predicting which labels are salient, Mehta et al. (1994) used questions related to figures that allowed to predict responses according to focal principles.[3] Along similar lines, Bacharach and Bernasconi (1997) test principles such as the rarity preference (subjects should choose objects that are rarer), the symmetry disqualification (subjects should choose the odd alternative that disqualifies symmetrical ones), and trade-off (subjects should take account of the probability that an odd alternative is not recognized as such against the availability of other alternatives). In coordination games with simpler labels, intuitive focal points emerge, such as "X" when choices are labeled "X" and "Y" (Crawford et al. 2008) or "Rose" when the task asks for the name of a flower (Mehta et al. 1994). The labels used in this study were selected in order to make the identification of an alternative *as being the only one which has some conspicuous attribute* (Lewis 1969) as difficult as possible.

The structure of the article is as follows. In Section 2, we present the experimental design and procedures. The experimental results are described in Section 3. Section 4 concludes the study.

[3]The task was assigning circles to one of two squares. Focal principles in this context include closeness (assign the circle to the square that is closer) and equality (assign an equal number of circles to each square).

2 Design and Procedures

Our subjects played a sequence of pure coordination games with random rematching of players after each game. The coordination game granted both subjects the choice among four different actions, which were represented by four symbols or pictures arranged on the screen from left to right. The order of the four labels was generated by a random mechanism for each player individually, such that the representations were likely to be different for the two players. The latter feature of the design was clearly communicated to participants and disabled attempts to coordinate by simply selecting one of the actions depicted at the left- or right-hand side of the screen. Each successful coordination on the same symbol implied a positive payoff, whereas a mismatch implied a payoff of zero in that game. Subjects were informed about how often they successfully coordinated with the other players at the end of the experiment.

The labels we used in our experiment are illustrated in Figure 1. Our search for labels may be characterized as a trial-and-error process. The set of labels used first (series 1-12, n=62) also included ones with more easily distinguishable elements and was tested in a separate experiment. After these tests did not yield a satisfactory set of labels, we opted for the use of only one symbol, creating a sequence of four by rotating it by multiples of 90 degrees. These sequences were played as an appendix to other experiments (series 13-18 and 23: n=37; series 17-23: n=53).[4]

INSERT FIGURE 1 HERE

The experiment was computerized using z-Tree (Fischbacher 2007). A total of 169 students from various disciplines recruited via ORSEE (Greiner 2004) took part in our experiments. As we appended some of our experiments to different preceding experiments, some subjects participated more than once in our experiment. In these cases, we include only the choices from their first participation in our analysis, ending up with 152 observations. The experiment took place in the *Lakelab*, the laboratory for experimental economics at the University of Konstanz, in December 2011 and January 2012. The experiment lasted less than 20 minutes, including

[4] Series 23 was tested in both latter groups.

the time for reading the instructions and answering a short post-experimental questionnaire. Subjects received 2 Euros for each match. In the stand-alone experiment, they additionally were paid a show-up fee of 3 Euros. On average participants earned 10.35 Euros (including the show-up fee) in our initial experiment with 12 choices and 3.91 Euros in the two short appended experiments asking participants to make 7 choices. Before the start of our experiment, subjects first received written instructions on their computer screen.[5] At the end of each session, participants were individually called to the exit. They received their payment in cash outside the laboratory with sufficient time between two participants to ensure privacy with respect to the amount of money received.

3 Results

In this section, we report the performance of our different label sets. In order to judge how well a label set performed, we use three measures. Most importantly, we are looking for a distribution which minimizes the sum of differences between each of the four observed frequencies and the frequency of 25% that we would obtain when subjects randomize as prescribed in the mixed-strategy equilibrium, thus coming closest to the uniform distribution of choices across options (column "Diffs."). Additionally, we compute the hypothetical frequency of a match with the choice of one of the other players in the population (column "Prob."). This criterion is similar to the so-called coordination index introduced by Mehta et al. (1994). Finally, we also include the standard deviation ("SD").

The two sets of labels using the inkblot and the rings illustration are the most successful ones with respect to the sum of deviations from the uniform distribution, having an outcome equal to 8 or 9 percent.[6] These sets are simultaneously the best ones regarding the second and third criterion, which is the probability of a successful coordination and the standard deviation of the frequency distribution of choices.

[5] See the Appendix for a translated version of our instructions.

[6] Note that the entries in columns 1-4 are rounded to two decimal places, such that the results for "Diffs", for example, cannot be calculated directly from our table.

	Version							
Series	1	2	3	4	Diffs.	Prob.	SD	Short description
1	0.35	0.18	0.27	0.19	0.26	0.2700	0.0817	Yellow red blue green
2	0.16	0.29	0.21	0.34	0.26	0.2690	0.0796	Two triangles
3	0.34	0.34	0.13	0.19	0.35	0.2836	0.1058	Angles
4	0.19	0.48	0.18	0.15	0.47	0.3241	0.1572	Orange and pink dot
5	0.34	0.23	0.13	0.31	0.29	0.2763	0.0936	Black rectangle
6	0.44	0.18	0.18	0.21	0.37	0.2966	0.1246	Hook
7	0.13	0.47	0.26	0.15	0.45	0.3231	0.1561	Triangles colored
8	0.15	0.21	0.13	0.52	0.53	0.3481	0.1808	Diagonale
9	0.16	0.15	0.50	0.19	0.50	0.3345	0.1679	Blue hexagon with gap
10	0.45	0.13	0.26	0.16	0.42	0.3132	0.1452	Pink purple green orange
11	0.40	0.24	0.23	0.13	0.31	0.2888	0.1137	Semi circle
12	0.23	0.35	0.19	0.23	0.21	0.2653	0.0715	Puzzle pieces
13	0.43	0.14	0.19	0.24	0.36	0.3002	0.1294	Eyes
14	0.11	0.41	0.14	0.35	0.51	0.3178	0.1503	Coffee bean horizontal
15	0.43	0.32	0.08	0.16	0.51	0.3251	0.1582	Leaf
16	0.30	0.41	0.22	0.08	0.41	0.3061	0.1367	Basketball
17	0.30	0.22	0.16	0.32	0.24	0.2674	0.0762	Modern art brown
18	0.17	0.31	0.33	0.19	0.29	0.2714	0.0844	Coffee bean vertical
19	0.23	0.26	0.28	0.23	**0.09**	**0.2524**	**0.0283**	Inkblot
20	0.21	0.26	0.26	0.26	**0.08**	**0.2524**	**0.0283**	Rings
21	0.32	0.34	0.23	0.11	0.32	0.2823	0.1038	Noodles
22	0.15	0.25	0.36	0.25	0.22	0.2716	0.0849	Galaxy
23	0.18	0.18	0.34	0.30	0.29	0.2719	0.0853	Modern art black/blue

Table 1: Frequency distribution of choices

Whereas we took great care in selecting labels which seem to have no conspicuous attribute, subjects in many cases made notably asymmetric selections. For example, the sequence using rotated versions of the eye performed surprisingly bad. The set of labels using the diagonal (series 8) allowed our subjects to coordinate in 35 percent of the games, which is considerably above the 25 percent we would obtain in the mixed-strategy equilibrium. In general, it appears that pictures having an accentuated diagonal (no. 8, 11, 14, 15, 17, 18, 23) from the lower left to the upper right corner, are selected more often (in about 60 percent of the cases) than other pictures in the same set of labels including those with the diagonal from the upper left to the lower right corner.[7] Having a prominent element in one of the two upper corners generally facilitates coordination between players. When we consider the subset of sequences which have one label with a more or less prominent element in one corner (no. 1, 3, 4, 5, 6, 9, 10, 12, 13, 16, 20, 22), we find the following distribution of average choices across all of these series: 60 percent of the subjects choose one of the two pictures with the prominent feature in the left (31 percent) or right (29 percent) upper corner, 22 percent take the lower right, and only 19 percent the lower left corner. What also works poorly in obtaining a random distribution are series in which the four pictures do not have the same coloring as can be seem from series 4 and 7 with the pink and orange colored dots or with the differently colored triangles. Interestingly, for those pictures which have an original orientation (e.g., the artwork), this "correct" version on average was not chosen more frequently than the other three rotated ones, but with only 26 percent probability.

4 Conclusion

Players in pure coordination games make use of salient actions, thereby improving their matching probability. Allowing players to coordinate is usually considered efficiency-enhancing, because the mixed-strategy equilibrium is payoff-dominated. In this paper, we intentionally sought to arrive at the mixed-strategy equilibrium for our population of subjects by using action la-

[7] It is surprising that this attraction effect of one diagonal is not present in the two "modern art" pictures where the variants with a lower-left-to-upper-right diagonal are selected only in 49 percent of the cases.

bels that are distinguishable but barren regarding potentially salient elements. From our data, we suggest that rotating the same picture by different multiples of 90 degrees to obtain the four different representations has proven to meet our demands when the following additional constraints are fulfilled: the labels should not vary the occurrence of a prominent element in the upper and lower half of the pictures and not put emphasis on the diagonals.

This paper is meant to have practical value for experimental economists. Our results can be used in future research comparing play against a random mechanism with interactions between humans counterparts. In such scenarios, the difficulty is in predicting the probability of matching for two subjects. For a set of labels that clearly provokes randomization of subjects, it is much less problematic to suppose that the probabilities of matching are comparable across treatments. Our data supports the hypothesis that labels selected according to the above criteria will effectively hinder coordination among participants. Nevertheless, we recommend pretesting in the local subject pool before using a specific picture series, because what exactly people perceive as salient may differ across populations.

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Appendix: Instructions

Welcome to the Lakelab.

Today you will take part in a decision experiment. When you read the following instructions carefully you can earn money. The amount you get depends on your decisions and on chance, but not on the other participants' decisions. For showing up you receive 3 Euros, in addition to your later earnings from the experiment.

It is not allowed to communicate with other participants during the experiment, therefore we ask you not to talk with each other. A violation of this rule leads to exclusion from the experiment and any payment.

Please read the instructions carefully. If you have any questions or if anything is unclear, please raise your hand. We will then come to your place.

This experiment consists of 12 rounds. After you took part in all 12 rounds of the experiment, we will add up all your earnings.

On the next page we will explain you the details of the experiment. The experiment will not start until all participants are entirely familiar with its procedures.

In each round you will be randomly matched with another participant.

You and the other participant see a sequence of four symbols or pictures. Note that the order of the symbols on screen has been generated by a random mechanism, such that the other participant very likely sees them in a different order than you.

You and the other participant will select one of the four symbols by clicking on it. Please note that you definitely decide for one of the symbols in this round once you click on it. There is no possibility to change your mind after clicking.

It is in your and in the other player's interest to select the same symbol.

If you both select the same symbol, you and the other participant receive 2 Euros in that round.

If you select different symbols, none of you will receive a payment in that round.

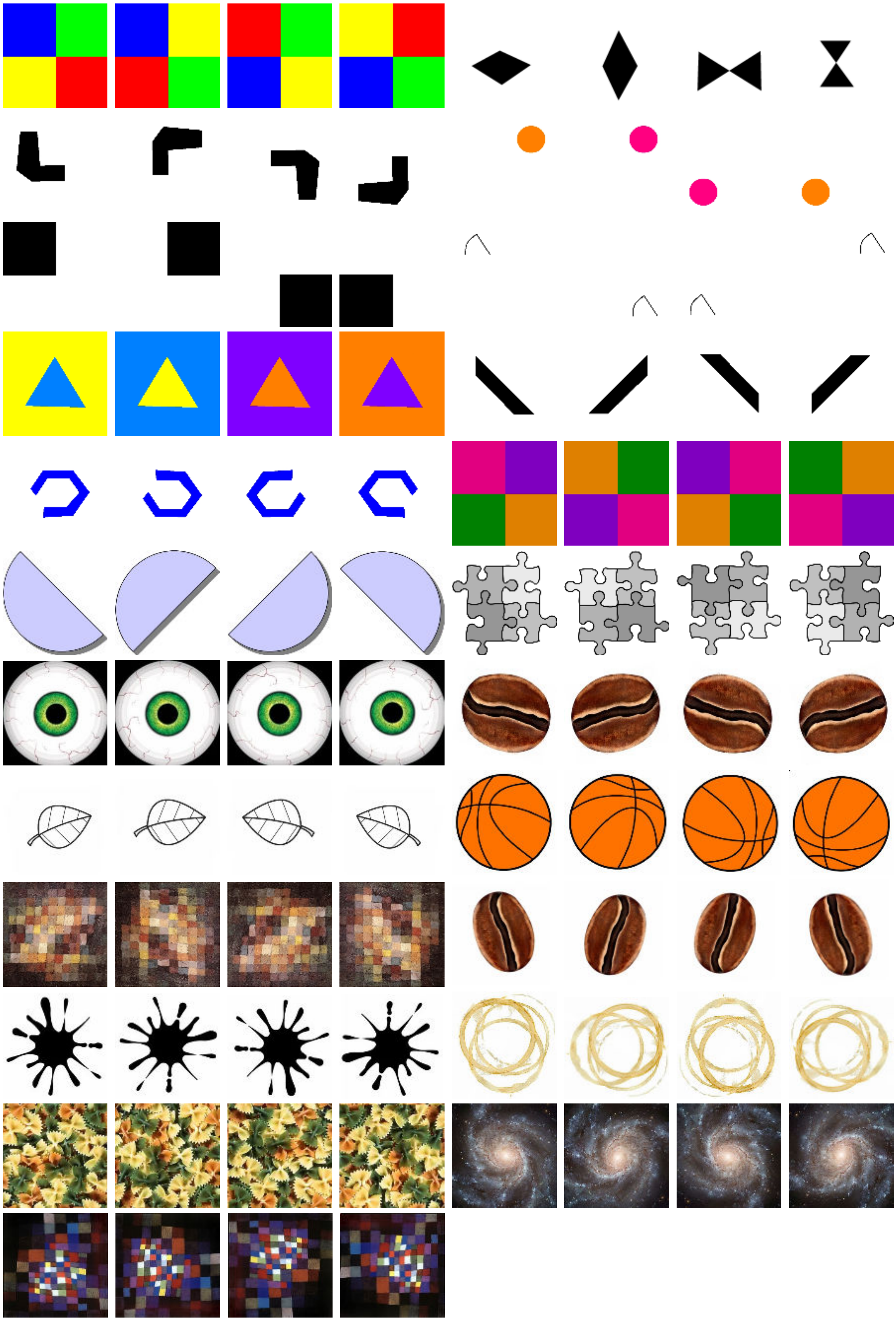

Figure 1: Sets of labels tested in our experiment.

THURGAU INSTITUTE
OF ECONOMICS
at the University of Konstanz

Hauptstr. 90
CH-8280 Kreuzlingen 2

Telefon: +41 (0)71 677 05 10
Telefax: +41 (0)71 677 05 11

info@twi-kreuzlingen.ch
www.twi-kreuzlingen.ch