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Classic coordination failures revisited: the effects of deviation costs and loss avoidance

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Abstract

Are communication failures common? We revisit a classic example of experimental coordination failure and explore, in a 2x2 design, the effects of deviation costs and loss avoidance. Our results provide additional insights into the parametric determinants of laboratory coordination failures, and successes.

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1. Introduction

Coordination games with Pareto-ranked equilibria have attracted major attention over the past two decades, as path-breaking experimental studies (Van Huyck, Battalio and Beil [henceforth VHBB] 1990, 1991; Cooper, DeJong, Forsythe and Ross 1990, 1992) were widely interpreted as suggesting that coordination failure -- here interpreted as failure to coordinate on the efficient equilibrium -- is a common phenomenon in the laboratory. In Devetag and Ortmann (2007), we argue that coordination failures are less common than is widely perceived (e.g., Ochs 1995 and Camerer 2003). We argue that by now it is well understood how coordination successes can be engineered in the lab and we formulate specific conjectures about the impact of deviation costs and loss avoidance (see Cachon and Camerer 1996 and Rydval and Ortmann 2005 for related studies).

To test these conjectures, we use the original version of the median action game first studied by VHBB (1991). Early results on the median action game had shown both a high frequency of coordination failure and strong history-dependence, in that the last-round median always equaled the first-round median in all treatments. In our experiments, we test the robustness of these results by manipulating two parametric determinants related to the original payoff function in VHBB (1991): the presence of negative/positive payoffs in the earnings tables; and the presence of linear/nonlinear deviation costs, i.e., the opportunity costs of deviating from the best response to a given median. The effect of the first determinant has been tested by Cachon and Camerer (1996), while the effect of lowering deviation costs has been studied by Goeree and Holt (2005) and Battalio *et al.* (2001). However, no previous study has systematically investigated the separate and joint effects of changes in these two determinants of the VHBB (1991) median action game. More specifically, and unlike the previous studies, we employ the same payoff function used in VHBB (1991) in our baseline treatment. Furthermore, we employ the same (large) group size and the same information conditions.

2. Design

In order to test our conjectures, we chose the following 2x2 design summarized in Table I, where Neg stands for earnings tables that contain negative payoffs and Non-lin stands for non-linear deviation costs:

Table I here

"A" is mnemonic for the anchor of Table I and is identical to the key earnings table in VHBB (1991) while B, C, and D are our treatments.

Specifically, the four earnings tables A – D look like this:

Table A here

Clearly, Table A features negative payoffs and non-linear deviation costs; for example, the opportunity cost of picking action 4 when the current median is 3 equals 5 cents, whereas the deviation cost rises non-linearly to 45 cents when action 6 is picked. In B, negative payoffs have been eliminated by adding 1.30 to all payoffs.[1]

Table B here

Table C shows the results from substituting the squared term in VHBB (1991):

$$\pi(e_i) = aM - b\left[M - e_i\right]^2 + c\,,$$

where M = median, i ε {1, 2,….,7}, a=0.10, b=0.05, c=0.60, with the absolute value (linearizing deviation costs), and by setting parameter b equal to .30.[2]

Table C here

In D, we have only changed the last term of the payoff function in VHBB (1991) by substituting the squared term with the absolute value.

Table D here

The elimination of the squared term results in positive payoffs.[3]

Negative payoffs in the original payoff table (A) appear in the upper right and lower left corner, which might explain the clustering of initial choices just above the secure action. Removing negative payoffs eliminates a potential reason for not picking the efficient action. Linearized deviation costs lower the opportunity costs of choices far above the current median, thus encouraging exploration in the direction of efficiency. Hence, our main hypothesis is that the absence of negative payoffs and linear deviation costs are both efficiency-enhancing features; therefore, we expect to observe a higher incidence of coordination success in the experimental treatments compared to the anchor, *ceteris paribus*. However, since in treatment C deviation costs are higher than in the baseline for "small" deviations, observing less coordination in C than in the remaining treatments is a possibility.

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1 In B, deviation costs are the same in absolute terms but not in relative terms. This seems unavoidable.

2 This way we recapture negative payoffs. The implied change in the size of the (now linearized) deviation costs seems unavoidable although we would have liked to avoid it since it was likely to affect the probability of coordination failure.

3 Again unavoidably, this change relocated the secure equilibrium from Choice 3 to Choice 1.

3. Implementation

Experiments were conducted with 16 groups of players in 8 sessions using a between-subject design. We obtained 4 independent data points for each treatment.

Table II here

We exactly replicated the design in VHBB (1991). Groups of 9 subjects played the stage game for a total of 10 rounds. Each session included 18 subjects who were seated randomly at computer terminals. The instructions specified that subjects would participate in a "market" that would last for ten rounds.[4] They would be divided into two groups randomly by the computer program at the beginning of the experiment, and the group composition would remain fixed for the whole duration of the market. Payoffs were expressed in experimental currency units, to be converted into Euros at the end of the experiment. In an effort to keep the maximum potential gain in Euros constant across treatments, the conversion rate used in B was half that of the remaining treatments. At the end of each round, each subject received information about the group median for that round and his or her resulting individual payoff. No information was given about the individual choices and payoffs of the other players throughout the experiment. Before starting the experiment, subjects had to answer some questions to ensure that everybody understood how to calculate the median of a series of numbers and how payoffs were computed on the basis of the earnings table.

4. Results

Table III reports the median and mode of choices in the first round, pooled across groups and divided by treatment. Figure 1 reports the entire distribution of first-round choices, divided by treatment (each treatment in the first round contains 36 independent observations). Table IV reports the observed medians in the first and last rounds of play; these medians are reported separately for each group and treatment and hence add a temporal dimension.

Turning to the first-round results, we have six observations: first, the median choice in treatment A reflects the typical case of coordination failure found in previous experiments (e.g., VHBB 1991, Cachon and Camerer 1996, Blume and Ortmann 2007). In contrast, in treatment D the median choice is the efficient one, confirming our key conjecture. Second, contrary to all other experiments that we know (see Devetag and Ortmann 2007), the modal choice in treatment A is the choice that induces the efficient equilibrium. The typical modal choice in the previous experiments, action 4 or 5, is less preferred in our case. Third, the efficient choice is also the modal choice for treatment D. In terms of the modal choice, although we do see the distribution of choices shift in the hypothesized direction, the hypothesized joint effect of deviation costs and loss aversion turns out to be statistically non-significant given our number of independent observations.

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4 The term "market" was also used in VHBB (1991).

Essentially, the baseline results are "too good" to allow for the hypothesized effect to materialize in a statistically significant manner given our original implementation plans. Fourth, the surprising results of treatment A also affect the hypothesized effects of treatments B and C. Specifically, using a Mann-Whitney U test, we do not get a significant difference going from A to B, or going from A to C. Fifth, we find highly significant differences going both from treatment B to D ($p<.01$, one-tailed), and from treatment C to D ($p<.01$, one-tailed). Sixth, as hypothesized, in treatment D, in which there are only positive payoffs and deviation costs are linear (and, recall footnote 2, somewhat lower than in treatment C), the percentage of players picking the efficient action 7 is the highest (55%) relative to all other treatments.

Figure 1 here

Table III here

Table IV here

The data in Table IV exhibit the inertia phenomenon that was documented in previous experiments. Specifically, in both rounds 1 and 10, the modal median is 6 for treatment A, 5 for treatments B and C, and 7 in treatment D.

In summary, in the presence of only positive payoffs and linear deviation costs (our treatment D), the modal outcome is one of successful coordination on the efficient equilibrium, which is in line with our hypothesis. The data from treatment C suggest, quite in line with our intuition, that the magnitude of deviation costs also plays a role in determining coordination success, similarly to what was obtained by Goeree and Holt (2005) for a different group size and a different matching protocol. The data from treatment B suggest, contradicting our priors, that positive payoffs alone are not sufficient to generate successful coordination.

5. Discussion

Using the original median action game first studied by VHBB 1991, we have reported experimental sessions designed to replicate VHBB's main findings and to test our conjectures on the impact of deviation costs and loss avoidance. Our replication *ceteris paribus* shows higher coordination efficiency compared to the original experiment. In addition, by and far, our results suggest that some combination of loss avoidance and low, linear deviation costs is efficiency-enhancing. In effect, it seems that when going from treatment A to treatment D, simply changing the nonlinear term of the generating function used in VHBB (1991) made the difference between coordination failure and coordination success. Our results add to our understanding of what it takes to engineer coordination successes in the laboratory.

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Table I. Experimental Design

	Neg	Pos
Non-lin	A	B
Lin	C	D

Payoff Table A

		Median value of X chosen						
		7	6	5	4	3	2	1
Your choice of X	7	1.30	1.15	0.90	0.55	0.10	-0.45	-1.10
	6	1.25	1.20	1.05	0.8	0.45	0.00	-0.55
	5	1.10	1.15	1.10	0.95	0.70	0.35	-0.10
	4	0.85	1.00	1.05	1.00	0.85	0.60	0.25
	3	0.50	0.75	0.90	0.95	0.90	0.75	0.50
	2	0.05	0.40	0.65	0.80	0.85	0.80	0.65
	1	-0.5	-0.05	0.3	0.55	0.70	0.75	0.70

Payoff Table B

		Median value of X chosen						
		7	6	5	4	3	2	1
Your choice of X	7	2.60	2.45	2.20	1.85	1.40	0.85	0.20
	6	2.55	2.50	2.35	2.10	1.75	1.30	0.75
	5	2.40	2.45	2.40	2.25	2.00	1.65	1.20
	4	2.15	2.30	2.35	2.30	2.15	1.90	1.55
	3	1.80	2.05	2.20	2.25	2.20	2.05	1.80
	2	1.35	1.70	1.95	2.10	2.15	2.10	1.95
	1	0.80	1.25	1.60	1.85	2.00	2.05	2.00

Payoff Table C

		Median value of X chosen						
		7	6	5	4	3	2	1
Your choice of X	7	1.30	0.90	0.50	0.10	-0.30	-0.70	-1.10
	6	1.00	1.20	0.80	0.40	0.00	-0.40	-0.80
	5	0.70	0.90	1.10	0.70	0.30	-0.10	-0.50
	4	0.40	0.60	0.80	1.00	0.60	0.20	-0.20
	3	0.10	0.30	0.50	0.70	0.90	0.50	0.10
	2	-0.20	0.00	0.20	0.40	0.60	0.80	0.40
	1	-0.50	-0.30	-0.10	0.10	0.30	0.50	0.70

Payoff Table D

		Median value of X chosen						
		7	6	5	4	3	2	1
Your choice of X	7	1.30	1.15	1.00	0.85	0.70	0.55	0.35
	6	1.25	1.20	1.05	0.90	0.75	0.60	0.40
	5	1.20	1.15	1.10	0.95	0.80	0.65	0.45
	4	1.15	1.10	1.05	1.00	0.85	0.70	0.55
	3	1.10	1.05	1.00	0.95	0.90	0.75	0.60
	2	1.05	1.00	0.95	0.90	0.85	0.80	0.65
	1	1.00	0.95	0.90	0.85	0.80	0.75	0.70

Table II. Experiment Implementation

	Treatment			
	A	B	C	D
Groups	4	4	4	4
Rounds	10	10	10	10

Table III. Median and modal choice by treatment

	A	B	C	D
N	36	36	36	36
median	6	5	5	7
mode	7	4	7	7

Table IV. Median in the 1st and 10th round of play, divided by group and treatment.

Treatment	A	A	A	A	B	B	B	B	C	C	C	C	D	D	D	D
Group	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1st round median	5	6	6	7	5	6	5	4	5	5	5	5	5	7	6	7
10throundmedian	6	6	6	6	5	6	5	4	5	5	6	5	7	7	7	6

Fig. 1. Distribution of first round choices in the four treatments (in percentages)