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Eric van Damme (Eds.)

With the help of Martin Strobel

Understanding Strategic Interaction

Essays in Honor of Reinhard Selten

With 86 Figures

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Preface

On the 5th of October, 1995, Reinhard Selten celebrated his 65th birthday. To honor his scientific contributions, his influence and encouragement of other researchers the editors have asked prominent scholars for contributions. We are rather proud of the result, but the reader may judge this for her- or himself. Also on behalf of my co-editors I thank all authors who helped us to honor Reinhard Selten by contributing to this volume.

The main burden (most of the correspondence and all technical work) of editing the volume has rested on the shoulders of Martin Strobel who has been responsible for all technical aspects as well as for part of the correspondence involved. I gratefully acknowledge his kind help and fruitful cooperation, also as an inspiring co-author and as a co-interviewer.

Among my co-editors Eric van Damme has been most helpful by refereeing the papers like the others, but also by approaching authors and especially by interviewing Bob Aumann on the occasion of the Jerusalem Conference in 1995. Without the help and assistance of my co-editors the book would not be as interesting as it is - in my view - now.

Given the prominence of the laureate there was a considerable risk of overburdening the volume. To avoid this it was decided not to ask his present and former colleagues at the universities of Bonn, Bielefeld, Berlin and Frankfurt/M., nor his present and former assistants for contributions. So what the volume tries to accomplish is mainly a recollection of the scientific disputes, in which Reinhard Selten was actively and partly dominantly involved, as well as the methodologal approaches of a core group of researchers who continuously enjoyed the close cooperation with Reinhard Selten.

Initially our attempt was to have separate sections for game theory, applications of game theory, experimental economics and evolutionary game theory. Instead the contributions now are ordered more loosely in this way. The introductory essay offers a finer partitioning and provides some overview and guidance for the more selective readers.

Berlin, 1996

Werner Güth

Naive Strategies in Competitive Games[1]

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Abstract. We investigate the behavior of players in a two-person competitive game. One player "hides" a treasure in one of four locations, and the other player "seeks" the treasure in one of these locations. The seeker wins if her choice matches the hider's choice; the hider wins if it does not. According to the classical game-theoretic analysis, both players should choose each item with probability of .25 . In contrast, we found that both hiders and seekers tended to avoid the endpoints. This bias produces a positive correlation between the players' choices, giving the seeker a considerable advantage over the hider.
J.E.L Classification numbers: C7,C9.

1. Introduction

In this article we investigate the behavior of players in several two-person competitive (i.e., zero-sum) games. In each game, one player "hides" a treasure in one of four locations, and the other player "seeks" the treasure in one of these locations. The seeker wins if her choice matches the hider's choice; the hider wins if it does not. Because the game has only two possible outcomes, and each player would rather win than lose, a rational player should maximize the probability of winning.

This game has a unique Nash equilibrium with mixed strategies: Each player selects the four alternatives with equal probability (i.e. .25). The proof of this proposition reveals the strategic considerations induced by this game. In equilibrium, player 2 (the seeker) does not choose any alternative unless she believes that it is (one of) the most likely alternatives to be chosen by player 1. Similarly, in equilibrium, player 1 (the hider) does not choose any alternative unless he believes that it is among the alternatives that are least likely to be chosen by player 2. Thus in equilibrium the probability of any alternative that may be chosen by player 2 cannot exceed .25 . Consequently, player 2 (and analogously player 1) selects each of the alternatives with equal probability, and player 2 wins with probability .25 .

The following study compares the solution prescribed by game theory to the choices made by subjects. In particular, we explore the effects of three factors : the spatial position of the alternatives (endpoint versus middle point), the relative distinctiveness of the alternatives (focal versus non-focal items), and the role of the player (hider versus seeker). Although these factors are not considered in the formal game theoretical analysis, there are reasons to believe that they might influence the players' choice.

2. Method

The subjects in the present study were undergraduate students at Stanford University who had taken an introductory psychology course, and were required to participate in a few experiments. All subjects were presented with the same form, consisting of six sets with four items each, as shown in Figure 1.

The six sets of items, each of which corresponds to a different game, were constructed as follows. Three of the sets consist of pictorial items (sets 1,3 and 5), and the other three of verbal items (letters or words). Each set includes one distinctive (focal) item. We constructed three types of focal items: neutral (sets 1 and 4); positive, on the background of negative items (sets 5 and 6); and negative, on the background of positive items (sets 2 and 3). Each type consists of one verbal and one pictorial set. We also distinguish between the items in the two ends, called endpoints, and the two items in the middle.

Each participant in the competitive games was assigned to play either the role of the hider or the role of the seeker in all six games. The players were informed that they will be randomly paired with a person playing the other role. They were told that the hider's task is "to hide the treasure behind one of the four items", whereas the seeker's role is "to guess the location of the treasure". If the seeker guesses correctly - she wins $10 and the hider receives nothing; if the seeker does not guess correctly - she receives nothing and the hider receives $10. The participants were told that "both players are informed of the rules of the game". They were promised that five pairs of players will be selected at random and will be paid according to the outcome of the game.

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[1] This paper replaces working paper "Naive Strategies in Zero-Sum Games", The Sackler Institute of Economic Studies, Tel-Aviv University, No. 17-93 (September, 1993).

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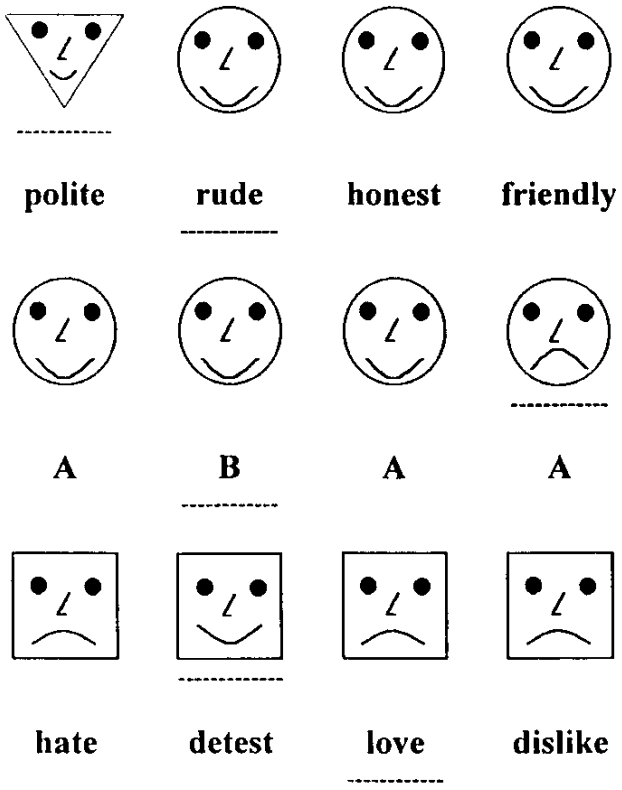

Figure 1. The six sets of items used in all games. The focal item is marked in each set.

We also investigated two non-competitive two-person games based on the same sets of items. In the coordination game, both players receive $10 if they select the same item, and nothing if they select different items. In the discoordination game, both players receive $10 if they select different items, and nothing if they select the same item. Two different groups of subjects played the coordination and discoordination games. As before, subjects were told that they will be randomly paired with another player, and that five pairs of players will be selected at random and will be paid according to the outcome of the game.

3. Results

We first describe the results of the non-competitive games, and then turn to the analysis of the competitive games, which is the focus of this paper.

Non-Competitive Games

Tables 1a and 1b present the percentage of subjects who chose each of the four items in each of the coordination and the discoordination games, respectively.

1a - **Coordination Games (N=50)**

Set	1	2	3	4	p
1	**86**	0	10	4	0.001
2	6	**54**	12	28	0.001
3	6	6	14	**74**	0.001
4	8	**76**	16	0	0.001
5	6	**88**	6	0	0.001
6	2	6	**88**	4	0.001

1b - **Discoordination Games (N=49)**

Set	1	2	3	4	p
1	39	14	18	29	NS
2	28	**20**	32	20	NS
3	17	27	23	**33**	NS
4	6	**20**	55	18	0.001
5	17	**40**	29	15	0.05
6	16	29	**26**	29	NS

Table 1. Percentage of subjects who chose each of the four items in each of the six sets, in the coordination games (1a), and the discoordination games (1b). The focal item in each set appears in bold face. The significance level associated with the Chi-square test of each set is denoted by p.

The data in table 1a show, as expected, that in all six coordination games, the majority of subjects (overall mean=78%) chose the focal item. The hypothesis that each item is selected with equal probability (i.e., .25) is rejected by a Chi-square test as indicated by the p-values in the right hand column. The pattern of

responses in the discoordination games , displayed in table 1b, is quite different. Here, there is no tendency to select the focal item, and the distribution of choices in most games, does not depart significantly from random selection.

To investigate individuals' responses, we counted for each player the number of games (from 0 to 6) in which the player selected the focal item. Figure 2 presents, for both the coordination and discoordination games, the distributions of these values, along with the binomial distribution (with p=.25), that is expected under the hypothesis that all items are selected with equal probability.

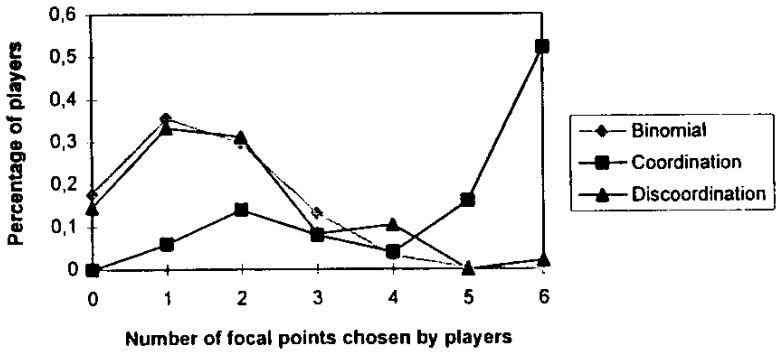

Figure 2. Distribution of patterns of focal point choices for the coordination and discoordination games compared to the predicted binomial distribution.

Figure 2 shows that in the coordination game the distribution of choices was markedly different than expected by chance. In particular, more than 50% of the players selected the focal item in all six games. In the discoordination game, in contrast, the distribution of choices of the focal item is very similar to that expected under random selection. These data indicate that in the presence of a single distinctive item, subjects were able to achieve a reasonable level of coordination (about 65%). In the absence of an effective method of achieving discoordination, players chose more or less in random.

Competitive Games

Tables 2a and 2b present the results of the competitive games for the seekers and the hiders respectively. The data show that, contrary to the game theoretical analysis, the players did not choose the four items in each game with equal probability. A Chi-square test indicates that with only one exception (set 3 for the hider) all the distributions of choices depart significantly from random selection.

We next discuss, in turn, the effects of endpoints, focal items, and the players' role.

2a - **Seeker (N=62)**

Set	1	2	3	4	p
1	**29**	24	42	5	0.001
2	8	**40**	40	11	0.001
3	7	25	34	**34**	0. 01
4	13	**31**	45	11	0.001
5	16	**55**	21	8	0.001
6	20	21	**55**	14	0.001

2b - **Hider (N=53)**

Set	1	2	3	4	p
1	**23**	23	43	11	0.01
2	15	**26**	51	8	0.001
3	21	26	34	**19**	NS
4	9	**36**	40	15	0. 01
5	15	**40**	34	11	0.01
6	11	23	**38**	28	0.05

Table 2. Percentage of subjects who chose each of the four items in each of the six sets, in the Competitive games (2a : Seeker, 2b : Hider). The focal item in each set appears in bold face. The significance level associated with the Chi-square test of each set is denoted by p.

Perhaps the most striking feature of these data is players' tendency to avoid the endpoints. Overall, the two endpoints were selected by the hiders and the seekers on 31% and 28% of the games, respectively, significantly less than the 50% expected under random choice ($p<0.001$). The tendency to avoid the endpoints is even stronger in sets 2,4,5,6 in which the endpoint is not a focal item.

To investigate individuals' choices, we counted for each player the number of games (from 0 to 6) in which the endpoint was selected. Figure 3 presents, for the hiders and seekers separately, the distributions of these values, along with a binomial distribution (p=0.5) expected under random choice. It is evident from the figure that both hiders and seekers were reluctant to select the endpoints: Avoiding the endpoints in all six games was the single most common pattern, selected by 28% of the hiders and 37% of the seekers. The probabilities of obtaining such results by chance are vanishingly small.

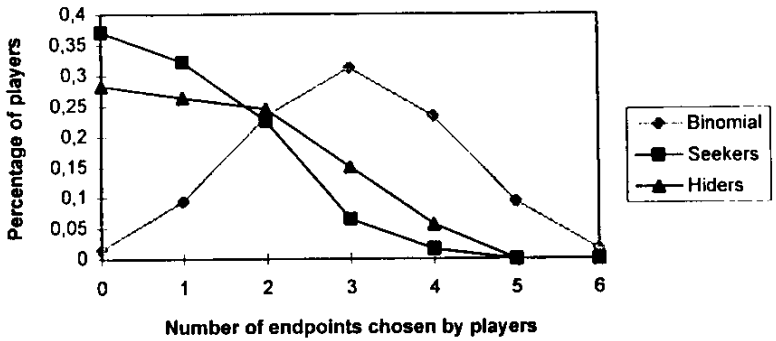

Figure 3. Distribution of patterns of endpoint choices for seekers and hiders compared to the predicted binomial distribution

We have initially hypothesized that hiders will tend to avoid the focal item, in order not to be "predictable". Thus, we expected the hiders to choose the focal item less frequently than the seekers and less frequently than expected by chance (i.e., 25%). The results of the present study support the former hypothesis but not the latter. Overall, the focal items were selected by the seekers 41% of the time and by the hiders only 30% of the time ($p<0.5$), but both groups selected the items significantly more than expected by chance.

Two factors might have contributed to this result. First, the observed tendency to avoid the endpoints is bound to increase the percentage of choice of other alternatives, including the focal items. Second, the popularity of the focal items was produced primarily by the sets that included a positive focal item. In the verbal sets (2,4 and 6), where the focal items were not the endpoints, the positive focal item (love) was selected 47% of the times (across hiders and seekers) whereas the neutral (B) and the negative (rude) focal items were selected 33% of the times ($p<.05$). The results for the pictorial sets were similar but here the comparison was problematic because the neutral and negative focal points (sets 1 and 3) were endpoints whereas the positive (set 5) was not.

To test whether the endpoint effect depends on the presence of a focal item, we conducted a follow-up study using identical procedure, except that none of the six sets included a focal item. As before three of the sets were verbal and three pictorial. In three of the sets all four items were identical, except for spatial position. In the remaining three sets all four items were distinct, but without a focal item (e.g. south, east, north, west). There were 103 subjects who were divided about equally between the two roles.

In this study too, players tended to avoid the endpoints, although this tendency was less pronounced than before. Seekers chose the endpoints 36% of the time and hiders chose it 43% of the time. Both values are significantly smaller than the value of 50% expected by chance ($p<.05$). To summarize, although the picture is not entirely clear, it appears that seekers tend to avoid the endpoints more than hiders, while hiders tend to avoid the focal point more than seekers.

4. Discussion

The main finding of the present study is that both hiders and seekers tended to avoid the endpoints, thereby departing from the classical game theoretical solution. This tendency was not observed in the coordination game, where players tended to choose the focal items, or in the discoordination game, where players chose more or less at random. The tendency to avoid the endpoints has also been observed in other contexts. When people are faced with the choice among 3,4 or 5 identical items, people tend to avoid the endpoints and select the middle item. This bias has been observed in picking products from a supermarket shelf, selecting a bathroom stall, or picking an arbitrary symbol (Christenfeld, 1995).

In the context of a competitive game, the reluctance to select the endpoints has obvious strategic implications. In the present study it induces a high correlation between the choices of the hider and the seeker, which gives the seeker a considerable advantage despite the symmetry of the game. Note that if the distribution of the seeker's choices is (p_1,p_2,p_3,p_4) and the distribution of the hider's choices is (q_1,q_2,q_3,q_4), then the probability of a match is $m=p_1q_1+p_2q_2+p_3q_3+p_4q_4$, and the expected payoff of the seeker is \$10m. If either player chooses items with equal probabilities than m=.25. In contrast, the observed values of m for the six games in the main study were: .31, .33, .26, .32, .32, .31, with an average of m=.31. To interpret these values note that if the two players employ the mixed strategy (.4,.2,.2,.2), where one item is chosen twice as often than any other, then m is .28; if both players employ the strategy (.4,.4,.1,.1) then m=.34. Thus, the observed m-values reflect substantial departure from the equal-probability strategies.

A possible explanation for the seeker's advantage involves the psychological asymmetry between the hider and the seeker. Although the games are simultaneous, that is, players make their choices without knowledge of the other player's choice, it is natural to regard the seeker as "responding" to the hider's choice. Because it seems easier to contemplate the first than the second move in a game, the seeker may have a better insight into the behavior of the hider than vice versa. Thus, the seeker's tendency to avoid the endpoints could reflect her valid belief that the hider is not likely to select these items.

However, the results of a study we conducted earlier do not support this hypothesis. In that study subjects played a competitive game (using the A B A A set) in which the hider places a mine instead of a treasure. In this game the

seeker's goal is to avoid the item chosen by the hider, whereas the hider's role is to match the choice of the seeker. If the seeker has a psychological advantage, she should be able to avoid the mine more often than expected by chance. The data, however, yielded a positive correlation (m=.28) between the choices of the two players, which favored the hider over the seeker. This result suggests that the advantage of the seeker in the treasure game and of the hider in the mine game reflects a common response tendency rather than a psychological advantage of one role over the other.

In summary, our players were attentive to the payoff function, and employed different strategies in the three types of games. As expected, they selected the focal item in the coordination games, and chose more or less at random in the discoordination games. In the competitive games, however, the players employed a naive strategy (avoiding the endpoints), that is not guided by valid strategic reasoning. In particular, the hiders in this experiment either did not expect that the seekers too, will tend to avoid the endpoints, or else did not appreciate the strategic consequences of this expectation (Shafir and Tversky, 1992).

References

N. Christenfeld, Choices from identical options, Psychological Science, vol. 6, no. 1, 1995 (50-55).

E. Shafir, and A. Tversky, "Thinking Through Uncertainty: Nonconsequentialism in Reasoning and Choice". Cognitive Psychology, 24:449-474, 1992.

Induction vs. Deterrence in the Chain Store Game: How Many Potential Entrants are Needed to Deter Entry?

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Abstract. We report the results of two experiments designed to test competitively the induction against the deterrence theory in Selten's (1978) chain store game with complete and perfect information. Our major purpose is to determine the number of entrants (m) needed for rendering the deterrence argument effective. Our results show that if we increase m from 10 to 15, support for the deterrence theory increases significantly. But even with m=15, the aggressive behavior of the incumbent does not deter most entrants. We then compare these results with previous studies of the chain store game allowing for incomplete information, several choices by the same entrant, and multiple iterations of the game.

Keywords. game theory, experimental economics, chain store paradox, induction, deterrence, sequential equilibrium, reputation

1 Introduction

There is no agreement in the economic literature whether preemptive actions taken by an incumbent firm in order to maintain its monopoly in the face of threatened entry can be maintained as a viable threat. There are those who argue that predatory pricing is an irrational strategy for attempting to maintain a monopoly position and that it is, therefore, unlikely to be adopted in practice (McGee, 1958, 1980; Carlton & Perloff, 1990), and there are others who maintain the opposite position. As noted by Trockel (1986), the crucial point in this debate is the credibility of the threat. It is, therefore, important to determine analytically whether effective threatening of potential entrants by a monopolist is rational.

The first and most influential analysis of this problem is Selten's formal model known as the Chain Store game (1978). The model is presented as a noncooperative (m+1)-person game with a single monopolist (player M) and m potential entrants (players 1, 2, ... , m). The game is played under complete information over a sequence of m consecutive periods (stage games) 1, ... , m. At the beginning of period k, player k (k=1, 2, .. , m) must decide between entering the kth market (IN) or staying out (OUT). Once she has made her decision, all other players are fully informed of her