HOT VS. COLD:

SEQUENTIAL RESPONSES AND PREFERENCE STABILITY IN EXPERIMENTAL GAMES*

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Abstract: In experiments with two-person sequential games we analyze whether responses to favorable and unfavorable actions depend on the elicitation procedure. In our “hot” treatment the second player responds to the first player’s observed action while in our “cold” treatment we follow the “strategy method” and have the second player decide on a contingent action for each and every possible first player move, without first observing this move. Our analysis centers on the degree to which subjects deviate from the maximization of their pecuniary rewards, as a response to others’ actions. Our results show no difference in behavior between the two treatments. We also find evidence of the stability of subjects’ preferences with respect to their behavior over time and to the consistency of their choices as first and second mover.

1. INTRODUCTION

Experimental economists and psychologists use the laboratory to learn about people's behavior. Given the abstract character of this environment, there is a natural concern that observed actions and implicitly expressed preferences may depend on subtle cues and the method used to elicit responses. For example, the *strategy method* (Selten, 1967) has become a popular tool in experimental work, as it facilitates data acquisition at a relatively low cost. The key element of this approach is that participants state what they *would do* in hypothetical situations often involving the actions or strategies of other actors. The advantages are clear: if you have subjects specify 10 hypothetical decisions, you will obtain 10 times the data possible if the action is contingent on an actually observed choice. In addition, this procedure often makes it possible to elicit contingent decisions that cover the strategy space.

According to the standard game-theoretic view the strategy method should yield the same decisions as the procedure involving only observed actions. However, the strategy method could be criticized on the behavioral grounds that the hypothetical character makes it too psychologically *cold* to be realistic as an abstraction of the natural setting. Clearly, there is a certain element of immediacy to receiving information about an actual choice. Roth (1995) presents a short discussion of the potentially relevant issues, pointing out on pg. 323 that "having to submit entire strategies forces subjects to think about each information set in a different way than if they could primarily concentrate on those information sets that arise in the course of the game." One might expect that some actions would trigger stronger emotional responses in this *hot* environment than when the strategy method is used.

However, there is no clear consensus among practitioners about it - indeed, even this paper's co-authors had different *ex ante* expectations.

We present results from experiments with two simple and well-known games. Using both the hot and cold elicitation methods we examine to what extent subjects react to positive (negative) actions with positive (negative) responses. More specifically, we study the degree to which certain actions by the first mover are associated with second mover responses which are not own payoff-maximizing. Perhaps surprisingly, we find that expressed preferences seem to be robust to at least the mild "temperatures" available in the laboratory. The rate of non-payoff-maximizing behavior is statistically indistinguishable between the hot and cold environments. Preferences also appear stable with respect to two other factors contained in our design: subject behavior is not affected by having additional time for introspection and subject choices as a 1st (2nd) mover show a significant positive correlation with their choices as a 2nd (1st) mover.[1]

Schotter, Weigelt and Wilson (1994) also study choice invariance, by representing strategically equivalent games in either normal or extensive form. They find that presentation effects are significant particularly in the simplest and seemingly most transparent games. The central issues of their investigation are mainly of a cognitive nature, reflecting issues such as the recognition of iterated dominance or subgame perfection. More generally, they point out that the mere presentation of a situation may have a significant effect on behavior.[2] Their

[1] As will be seen in the section on design, subjects make a choice in the 1st period and then have reversed roles in the 2nd period. 1st movers in period 1 are not informed about the first period outcome prior to making a choice as a 2nd mover in period 2.

[2] In a similar vein, Rapoport (1997) finds that the order of play in some strategically equivalent games affects choices, even when no information about other choices is given.

procedure involves practice periods and repeated play (the number of periods played varied across sessions) with random matching.

Our experiments have a different emphasis. We do not examine preference stability with respect to equilibrium refinements, but instead highlight contexts where "fairness" considerations may be prominent. The experimental procedures we follow are very simple and involve one-shot interactions between subjects.

Our findings are consistent with the predictions of standard economic theory. Some social scientists may be surprised by this result, as it seems intuitive that people will have a stronger emotional reaction to a real action than to a hypothetical one. Yet, while the urge toward a response that deviates from own payoff maximization may be stronger with an observed 1st move, it is also easier to only hypothetically sacrifice money to punish or reward someone than to unconditionally give money away. So while various psychological influences may be present, these may have countervailing effects. In any case, the data shows strong preference stability across several dimensions.[3]

2. EXPERIMENTAL DESIGN

The starting point of our design was the 2x2 game-matrix, since we feel that issues of preference stability should first be studied in the simplest possible context. We used two very simple games, the Prisoner's dilemma and the Chicken game, which are shown in Figures 1 and 2. The numbers in the different cells reflect the actual payments in 100's of pesetas for the corresponding choices (150 pesetas ≅ $1, at that time). In our experiments subjects played these games sequentially, with the row player choosing first and the column player choosing second. There were two treatments for each of the two games. In the "hot" treatment, the row player first chose a row; after having been informed of row's move, the column player then chose a column. In the "cold" treatment, the row player chose a row and, simultaneously, the column player chose a column for each of the two possible choices of the row player.[4] As 1st movers in period 1 are not informed of the action of the 2nd mover prior to making a response in the second period, these responders do not have any additional information, but merely more time for reflection.[5]

Our focus is the column player's choices in response to the row player's decisions. In both games one of row's actions leads to higher payoffs for column than the other action.[6] In the prisoner's dilemma, a standard game for analyzing issues of cooperation, we focus only on the *positive* action B1, since an A2 response to B2 is quite rare and perhaps anomalous. In the chicken game, however, the column player makes a readily interpretable response to either action of the row player; the *positive* action B1 may lead to the *positive* response A2, and the *negative* action B2 may lead to the *negative* response A1.

Figure 1 - Prisoner's dilemma

	A1	**A2**
B1	4, 16	12, 12
B2	8,8	16, 4

Figure 2 - Chicken

	A1	**A2**
B1	6, 14	12, 12
B2	4, 4	14, 6

[3] In a recent paper Cason and Mui (1998) study how social influence may affect subjects' choices when making dictator allocations and find that the use of the strategy method does not significantly alter choices.

[4] In terms of temperature, we consider this to be slightly colder than row choosing 1st and column later, without having been informed of row's action (this last approach is reminiscent of the one used in relation to Newcomb's problem).

[5] Appendix A contains a copy of the instructions.

[6] This feature distinguishes the Chicken game from a standard Battle of the Sexes.

Each session tested exactly one treatment of one game. Generally, there were 16 or 18 participants in a session. For the prisoner's dilemma we ran two sessions of the cold treatment and seven sessions with the hot treatment, with 68 and 124 participants respectively.[7] For the chicken game the cold treatment comprised three sessions, 76 participants, and the hot treatment five sessions, 77 participants.

All sessions were run at the Universitat Autònoma de Barcelona. Subjects were recruited from undergraduate classes; participation was restricted to one session. All experimental sessions took place in a large classroom and subjects were seated so that they could not observe others' choices. After instructions were read aloud to all participants, subjects twice played the game, once as a row player and once as a column player. Matching was anonymous and randomly chosen for each period; however, pairings were different for the two periods and the subjects were so informed. Again, subjects were not told the first outcome before making second period choices. After both games had been played, a coin flip chose one of the two games for payment.

The objective of this procedure is to collect from each subject information about column choices and, at the same time, to preserve the one shot nature of the games. From a game-theoretic viewpoint, order and learning effects should not be an issue. However, psychological factors may lead to subjects behaving in a manner inconsistent with standard economic thinking. In our analysis we focus on these issues.

3. RESULTS

In the games under consideration, we look for responses which are not payoff-maximizing for the responder. In this paper, we do not attempt to identify precise

[7] The hot treatment is naturally more expensive since each hot session only yields some fraction of the information available in a cold session.

motivations for this behavior. The interested reader is referred to papers such as Bolton and Ockenfels (1997), Fehr and Schmidt (1997), and Charness (1998). Here we simply contrast the rates at which people express a preference which yields lower personal financial reward. Appendix B presents our results by period and game. We first discuss hot vs. cold behavior in the aggregate and then compare behavior across periods.

In the Prisoner's dilemma, people chose the hot positive response to a positive action (payoffs of [12,12] rather than [4,16], contingent on the top row being selected by the other player) with frequency .370 (10/27). The cold positive response was chosen with frequency .471 (16/34). The null hypothesis (no difference in frequencies) cannot be rejected (χ^2 = .62, n.s.).[8] In the Chicken game, the hot positive response to a positive action (choosing [12,12] over [6,14]) rate was .525 (21/40) and the cold positive response was .421 (16/38). Once again, the null hypothesis cannot be rejected (χ^2 = .84, n.s.). Observe that the direction of the discrepancy between hot and cold behavior is different for the two games. If we pool the hot/cold data for positive sequential actions across the Prisoner's dilemma and the Chicken game, even the mild difference disappears: .463 (31/67) vs. .444 (32/72).

The Chicken game also permits a peek at negative sequential responses. Negative response rates (choosing [4,4] over [14,6]) are quite low and are statistically indistinguishable across the two treatments: hot negative replies had frequency .125 (5/40) and cold negative replies occurred with frequency .105 (4/38).

The analysis in the preceding paragraph is based on pooling the data corresponding to periods 1 and 2 of our sessions. Testing for differences in 1st and 2nd period behavior in the prisoner's dilemma, we find that the fraction of hot positive responses to B1 is .462 (6/13) in period 1 and .286 (4/14) in period 2 (χ^2 = 1.5, n.s.; Z=.95, n.s.).[9] The frequency of cold positive responses to B1 are equal to .411 (7/17) in period 1 and .529 (9/17) in period

[8] For p = .05 the value of the test statistic (for d.f. = 1) is 3.84 and for p = .10 it is 2.71.
[9] While the Chi-square analysis is the cleanest statistical treatment, we also include a test of the equality of proportions (using the normal approximation to the normal distribution). As the Chi-square is a two-tailed test, we report two-tailed tests everywhere.

2 (χ^2 = .5, n.s.; Z= .73, n.s.). As these comparisons involve relatively small sample sizes, a stronger test is obtained by pooling results by period across temperatures. In this case, the fraction of positive responses to B1 is .433 in period 1 and .419 in period 2 indicating no statistical difference (χ^2 = .01, n.s.; Z=.11, n.s.).

In Chicken we can also test for negative sequential responses. We find that the results for a hot negative response to B2 are .059 (1/17) in period 1 and .174 (4/23) in period 2 (χ^2 = 1.2, n.s.; Z= 1.09, n.s.), while for cold negative responses to B2 we obtain fractions of .105 (2/17) in each of periods 1 and 2. Once again, there is no appreciable divergence in behavior.

Looking across periods, we can identify certain patterns of behavior. In particular, people generally played with "consistency" across periods. Table 1 below presents contingent probabilities of play, given choices in the first period. In the aggregate, those who responded with A2 to a play of B1 do in fact select B1 when it is their turn 25/34 times (74%), compared to 10/38 times (26%) when they had responded with A1 to B1. Those who chose B1 in the 1st period later responded A2 to B1 15/21 times (71%), compared to 15/46 times (33%) for those who selected B2 in the 1st period. The data for each game is also shown in the table.

Table 1

Aggregated over games			
B1 ⇒ A2/B1 15/21	B2 ⇒ A2/B1 15/46	χ^2 = 8.6, p < .01	Z = 3.18, p < .01
A2/B1 ⇒ B1 25/34	A1/B1 ⇒ B1 10/38	χ^2 = 16.0, p < .01	Z = 4.00, p < .01
Prisoner's Dilemma			
B1 ⇒ A2/B1 5/5	B2 ⇒ A2/B1 8/26	χ^2 = 8.2, p < .01	Z = 2.87, p < .01
A2/B1 ⇒ B1 8/13	A1/B1 ⇒ B1 2/17	χ^2 = 8.2, p < .01	Z = 2.86, p < .01
Chicken			
B1 ⇒ A2/B1 10/16	B2 ⇒ A2/B1 7/20	χ^2 = 2.7, p < .10	Z = 1.65, p < .10

A2/B1 ⇒ B1 17/21	A1/B1 ⇒ B1 8/21	$\chi^2 = 8.0$, $p < .01$	Z = 2.83, $p < .01$

Note that the clear consistency in behavior is another instance of preference stability.

4. DISCUSSION

Standard economic theory assumes implicitly that preferences do not depend on the elicitation procedure and are stable over time. In accordance with this view, we find that the strategy method does not seem to affect sequential responses, that there is little difference in choices across periods. In addition, in our experiments subjects' behavior is generally "internally consistent."

It is perhaps surprising that, given the many possible influences on choice, we observe relative consistency in preferences. Even so, one cannot safely conclude that there are no psychological influences on individual responses. Perhaps visceral forces such as anger and greed are absent in the laboratory but present in naturally occurring situations. Alternatively, perhaps psychological forces are present here, but in conflict, having little net effect.

This result may not hold in other experimental games. In some experiments,[10] subtle changes in the environment have been shown to have powerful effects on the reasoning process and individual choice. One phenomenon is called *nonconsequentalist reasoning* and demonstrates a violation of the Savage (1954) sure-thing principle, as people "often do not consider appropriately each of the relevant branches of a decision tree."[11] Timing of decisions may also have an effect: Newcomb's problem (Nozick, 1969) shows the delicate

[10] See Shafir and Tversky, 1992, Tversky and Shafir, 1992, and Croson, 1997. Note that payoffs in these experiments reflected choices actually made by subjects.
[11] Shafir and Tversky (1992), pg. 449.

issues involved in principles of choice, while Camerer, Knez, and Weber (1996) find 1st mover status can affect behavior even when 1st moves are unobservable. Given some of these results, one might have expected choice behavior in our games to be sensitive to the elicitation method. What our results show is that the net effects may be less pronounced than is perhaps anticipated by psychologists.

Our evidence shows clearly that, even among a population that often chooses not to maximize pecuniary rewards, preferences are stable and behavior consistent. The notion of preference stability is, however, far broader than the issue we analyze with our simple test and considerably more research is needed to determine the dimensions involved.

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Appendix A - Instructions

General. The purpose of this session is to study how people make decisions in a particular situation. Feel free to ask a monitor questions as they arise. From now until the end of the session, unauthorized communication of any nature with other participants is prohibited.

During the session you will make money. Upon completion of the session the amount you make will be paid to you in cash. Payments are confidential: no other participant will be told the amount of money you make.

During the session, you will be paired with another person. No one, however, will know the identity of the person they are paired with. Nor will these identities be revealed after the session is complete.

Decision task. In each pair, one person will have the role of A, and the other will have the role of B. The amount of money you earn depends on the decision you make and on the decision of the person you are paired with. The Earnings Table below describes the options available to each person and the associated earnings. You make your decision by choosing one of the options available to you and recording it on a paper form. The person in role can choose from options A1 and A2. The person in role B can choose option B1 or B2. *In the hot treatment the instructions continue saying*: B decides first, choosing between B1 and B2. Then this decision is communicated to A. Then, knowing the decision made by B, A chooses between A1 and A2. *In the cold treatment the previous sentences are replaced by:* Each person makes their decision without knowing the decision of the other. B decides unconditionally; that is, A indicates a decision for the case where B has chosen B1 and a decision for the case where B1 has chosen B2. The decision of A that counts is the one that corresponds to the decision of B. *For both treatments the instructions continue with*: Each person receives the earnings in the Earnings Table cell corresponding to the chosen options.

(*Earnings table from either figure 1 or 2 here*)

Conduct of the session. You will participate in two decision tasks, Task 1 and Task 2. Both tasks are identical to the description in the previous paragraph. For each task, you will be paired with a different person. You will have the role of A in one task, and the role of B in the other. First, you will receive a decision from for the role you have in task 1. You will complete task 1, and all the forms will be collected. You will then receive a decision form for task 2 and complete task 2. The results will not be revealed prior to completion of task 2.

Payment. You will actually be paid your earnings for just one of the two tasks. The one for payment will be chosen by a coin flip after both tasks have been completed. We will then call you one by one to receive your payment. Once you are paid you may leave.

Appendix B - Results by Period and Game

(numbers in cells indicate # of observations)

Hot Prisoner's dilemma

Period 1		
	A1	**A2**
B1	7	6
B2	47	2

Period 2		
	A1	**A2**
B1	10	4
B2	43	5

Aggregated		
	A1	**A2**
B1	17	10
B2	90	7

Cold Prisoner's dilemma

Period 1		
	A1	**A2**
B1	10	7
B2	15	2

Period 2		
	A1	**A2**
B1	8	9
B2	16	1

Aggregated		
	A1	**A2**
B1	18	16
B2	31	3

Hot Chicken

Period 1		
	A1	**A2**
B1	10	13
B2	1	16

Period 2		
	A1	**A2**
B1	8	9
B2	4	19

Aggregated		
	A1	**A2**
B1	18	22
B2	5	35

Cold Chicken

Period 1		
	A1	**A2**
B1	11	8
B2	2	17

Period 2		
	A1	**A2**
B1	11	8
B2	2	7

Aggregated		
	A1	**A2**
B1	22	16
B2	4	34