

# Learning in Coordination Games

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# Learning in Coordination Games\*

## I. Introduction

Problems exist when a game contains multiple Nash equilibria. A number of selection principles have been suggested to deal with these problems. Vincent Crawford's dynamic theory is one recent proposal on how to do this for order statistic games. In this paper, two of Crawford's propositions will be examined. The first asserts that if the initial actions and the group size are held constant, an increase in the order statistic will bring about a statistical increase in the values of the players' actions and in the value of the summary statistic. The other deals with changes in the group size, stating that holding the initial actions and the order statistic constant, increasing the group size will result in a decrease in the values of the players' actions and in the value of the order statistic. Sections II through IV contain background information. Section V introduces Crawford's theory. Section VI discusses the experimental design and VII the experimental results. Conclusions are provided in section VIII.

## II. Background

A game takes place whenever people interact. Examples range from driving on busy streets to negotiating international trade agreements. These two situations can be used to illustrate the division of games in game theory. In noncooperative game theory, the focus is

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\*ACKNOWLEDGEMENTS: Dr. John Van Huyck taught me economics is a science and provided the theoretical background. Dr. Raymond Battalio taught me these ideas and information in this paper and helped me put it together. Eric Battalio provided the computer programming to create and run this experiment. The office of Honors Programs and Academic Scholarships and the National Science Foundation provided funding.

on the individual as a unit and his<sup>1</sup> decisions. The individual attempts to maximize his utility inside the defined description and rules of the game. In contrast, cooperative game theory involves situations in which the players negotiate before the game is played. It is assumed that the players conclude their bargaining by signing a binding agreement.<sup>2</sup> Therefore, the group becomes the unit of analysis.<sup>3</sup> I will restrict myself to examining only noncooperative games.

Noncooperative games can be further subdivided. One class of these games is pure conflict games; in such a game what one player gains his opponent loses. An example, matching pennies, is provided in table 1.

		Column Player	
		HEADS	TAILS
Row Player	HEADS	1,-1 r1,c1	-1,1 r1,c2
	TAILS	-1,1 r2,c1	1,-1 r2,c2

TABLE 1

In this game each player has a penny. The two simultaneously toss their coins. If both coins come up on the same side (the pennies match), then the row player gets both the pennies. Thus, row player has gained one penny and the column player has lost one penny. This

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<sup>1</sup>Throughout this paper, the male pronouns will be used. This is no way meant to be discriminatory. Instead, in my thinking "he" is representative of one of mankind which includes all individuals.

<sup>2</sup>Kenneth Binmore (1992)

<sup>3</sup> David M. Kreps (1990)

scenario is represented in both the upper left cell (r1,c1), and the lower right cell (r2,c2), of the payoff table.<sup>4</sup> If, however, the coins come up on different sides (one heads, the other tails) then the column player gets both the pennies. In either case, what one gains, the other loses.

There are also games of pure coordination. In these games, the players aims are identical; there is no conflict in goals. Such a game is presented in table 2.

		Column Player	
		1	2
Row Player	1	0,0	3,3
	2	3,3	0,0

TABLE 2

In the cells (1,2) and (2,1), the payoffs are 3 for both players. However, neither player knows which of these two could his opponent is trying to reach. For this reason, it is quite possible that the two will end up in one of the two more undesirable cells--either cell (1,1) or (2,2).

Noncooperative games can also be mixed motive games; they combine both conflict and cooperation. If players act in strictly their own interest, they will actually receive a payoff that is less than the payoff if they could cooperate and sign a binding agreement. This is illustrated in the game given in table 3 below.

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<sup>4</sup>The titles listed before each row represent the action choice of the row player, and the titles listed above each column indicate the action of the column player. These numerals in each cell provide the payoff to each player. The first one is the payoff to the row player; the second the payoff to the column player. In table 1, in addition to containing the payoffs to each player, the cells also hold a r's or c's followed by an 1's or 2's. This shows what each cell represents. r1,c1 shows that these would be the payoffs if the row player chooses his first action and the column player chooses his second action; this cell is referred to as (1,1).

		Column Player	
		1	2
Row Player	1	4,0	2,2
	2	3,3	0,4

TABLE 3

If both players attempted to get the payoff of 4, the game would end up in row 1, column 2, which has a payoff of 2 for each player. If the players could somehow strike a deal, they could reach row 2, column 1, and both receive a payoff of 3.

Nash equilibrium analysis has served as perhaps the most important tool in analyzing games. A Nash equilibrium is a point at which no player wishes to alter his strategy given the other players' strategies. More precisely, a vector  $(\sigma_1, \sigma_2, \dots, \sigma_n)$  of strategies is a Nash equilibrium in a n-player game if  $\sigma_i$  is a best reply to  $(\sigma_1, \dots, \sigma_{i-1}, \sigma_{i+1}, \dots, \sigma_n)$  hereby referred to as  $\sigma_{-i}$ . This is equivalent to requiring that the inequality  $\pi_i(\sigma_i, \sigma_{-i}) \geq \pi_i(\sigma_i', \sigma_{-i})$  hold where  $\sigma_i$  is a best response to  $\sigma_{-i}$  and  $\pi$  represents each player's payoff.<sup>5</sup>

A serious problem can arise when there are multiple Nash equilibria and players fail to coordinate on the same equilibria. There are two types of coordination failure. The first is individual coordination failure where an individual fails to correctly predict the equilibrium which will be selected by the other players. As a result, that individual decision maker regrets his individual choice, because the outcome is not a mutual best response for all decision makers. The second type of coordination failure can be observed when the equilibria can be Pareto ranked. Each player in the group best responds, yet collectively the group regrets this outcome. No one player would be willing to change his action. However, if the

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<sup>5</sup>Ken Binmore (1992)

players could collectively change their individual choices, they could arrive at a new equilibrium which would be preferred by all the players to the current equilibrium.

There are a variety of selection principles which have been suggested to reduce the number of equilibria in a game with multiple equilibria. Security is one selection principle. In choosing an action based on security, a player acts to guarantee himself the largest payoff no matter what the other players do. A game in which security could produce an unique equilibrium is given in table 4.

		Column Player	
		1	2
Row Player	1	1,0	3,3
	2	3,3	0,1

TABLE 4

Two Nash equilibria exist in this game --row 1, column 2 and row 2, column 1. If both players use security as a solution concept in their attempts to decide which action to choose, the row player sees that he will receive a minimum payoff of 1 if he selects an action of 1 and the column player sees that he will receive a minimum payoff of 1 if he selects an action of 2. In the case that security governs both players' actions, the outcome of the game will be the Nash equilibrium row 1, column 2, and the payoffs to both players will be 3.

Efficiency (payoff dominance) can also be used at times to help select a unique solution. In using the selection principle of efficiency, each player chooses an action that would maximize his payoff in the resulting equilibrium, and he expects other players to do the same. An example of a game in which efficiency would probably be salient is given in table 5.

		Column Player	
		1	2
Row Player	1	0,0	3,3
	2	2,2	0,0

TABLE 5

Here there are two Nash equilibria, but with efficiency imposed a single Nash equilibrium is left; that of row 1, column 2.

In games where only one refinement is relevant, these refinements could function as predictive equilibrium solutions. However, if two or more refinements exist, the refinements solve nothing. Which refinement should be used? How do the players decide which to use? Upon which equilibrium will the players coordinate?

The Stag game is useful in illustrating such a problem. In this game the players' payoffs are based on the minimum of the individual efforts of all the players. A simplified version of this game is given in table 6.

		Minimum Effort of All Players	
		1	2
Your (Player i) Choice	1	1	1
	2	0	2

TABLE 6

In this version of the stag game<sup>6</sup>, there are two pure-strategy Nash equilibria. One where both players choose 1, the other where both select a 2. Efficiency would predict that both

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<sup>6</sup>Vincent P. Crawford (1992)

players play a 2. However, in each player choosing to play a 2 there is some risk that some other player will not do the same (strategic uncertainty) and the payoff will be zero. In order to reach the efficient outcome, all players must play a two. Security can also be used to solve this coordination problem. A player who selects a strategy of playing a 1 can guarantee himself a payoff of 1. Either of these can solve the problem of an individual coordination failure in the stage game, but coordination is necessary to arrive at an equilibrium.

An experiment based on Bryant's stag hunt game<sup>7</sup> was conducted by Van Huyck, Battalio, and Beil (1990). Their results show that the equilibrium at which the group arrives could be correlated to the number of players. With two players, the efficient equilibrium was sometimes reached. In both the small and large groups, equilibrium was not achieved in the first period. Players do not initially know upon which equilibrium to coordinate, but must learn to coordinate.

### **III. Evolutionary Game Theory**

Evolutionary game theory is one recent approach used to try to explain how groups learn to coordinate. These concepts originated in biology, but have been extended to economic game theory. In situations (games) where strategic uncertainty plays a part in shaping the players' beliefs, past experience in similar games may well also have a role in the formulation of a player's beliefs about how the other players will act. Thus, past experience has a place in determining a player's choice of strategy. One model for evolutionary game theory<sup>8</sup> stipulates that the dynamics of these coordination games possess the property that those

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<sup>7</sup>John Bryant (1983).

<sup>8</sup>Vincent P. Crawford (1991).



strategies with current higher *relative* payoffs will increase in frequency over time. This leads to certain strategies being considered evolutionary stable. That is, a strategy is said to be evolutionarily stable if, when played by all members of a large population, it has a strictly larger payoff than any mutant strategy that enters the population in sufficiently small numbers.<sup>9</sup> The mutants enter the game and play a different strategy, which by definition has a lower payoff (smaller fitness). As a result, the number of each new mutant in the population will go to zero over time. The Evolutionary stable strategy (ESS) is uninvadable and after time the entire population will be playing that ESS again. Thus, the Evolutionary stable strategy can be thought of as a refinement.

Evolutionary game theory varies from traditional game theory in at least one very important respect. In traditional game theory, players' choices of strategies are based on deductive equilibrium principles. Players use the description of the game and the knowledge they possess about the game prior to its start, in order to select their strategies. All players act in such a way; thus, the first play should be mutually consistent for all players. This provides no room for strategic uncertainty. It is the experience of the players in that game and ones similar to it that determines their strategy choices. The players "learn" to play the game.

#### **IV. Evolutionary Interpretation of Van Huyck, Battalio and Beil's Minimum Game**

Two experiments conducted by Van Huyck, Battalio, and Beil (1990, 91) have subjects playing coordination games repeatedly. Here, I will focus on Bryant's stag hunt game

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<sup>9</sup>John Maynard Smith (1982).

mentioned earlier.

Each player's payoff in each period was determined by two factors: a simple summary statistic of the players' actions (the minimum), and each player's own action. In this game, information (payoff functions, payoff tables, possible strategies) were made known to each player and publicly discussed, so as to establish the description of the game as common knowledge. No communication was permitted among the players and the summary statistic was announced after each period. Each player's strategy set ranged from (1,...,7). There were seven strict Nash equilibria, any n-tuple where all players selected the same action ((1,...,1),(2,...,2),..., (7,...,7)). Vincent Crawford (1991) conducted analysis on the results of this experiment and found that the results were compatible with predictions of evolutionary game theory.<sup>10</sup> In the game, deductive equilibrium analysis provides an efficient equilibrium point, everyone selecting a 7. However, this larger payoff must be traded off against the strategic uncertainty that everyone will not do so, since playing a smaller value is a more secure action. Such uncertainty was mentioned earlier in regard to the stag game.

In the minimum game, the relevant summary statistic is the minimum of the players' actions each period. The payoff function and parameters follow:

$$\text{PLAYER'S PAYOFF} = a*[\text{the minimum}] - b*[\text{player's individual choice}] + c, \quad (1)$$

where  $a=.20$ ,  $b=.10$ , and  $c=.60$ . The payoff table is given in table 7:

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<sup>10</sup>Smith (1982).

		Smallest Value of X Chosen						
		7	6	5	4	3	2	1
Your Choice of X	7	1.30	1.10	0.90	0.70	0.50	0.30	0.10
	6	--	1.20	1.00	0.80	0.60	0.40	0.20
	5	--	--	1.10	0.90	0.70	0.50	0.30
	4	--	--	--	1.00	0.80	0.60	0.40
	3	--	--	--	--	0.90	0.70	0.50
	2	--	--	--	--	--	0.80	0.60
	1	--	--	--	--	--	--	0.70

TABLE 7

In the minimum game, with large groups ( $n=14$  to  $n=16$ ) the players' initial actions were widely dispersed, but quickly converged to the lowest action of 1. This  $n$ -tuple of  $(1, \dots, 1)$  is the only ESS. Any other equilibrium where the  $n$ -tuple is greater than 1 is unstable because evolutionary game theory would predict that the  $n$ -tuple is invadable by a mutant playing any value less than an equilibrium value of 2 through 7. The nature of the minimum game exacerbates the influence of strategic uncertainty. It takes only one player to move the other players into disequilibrium. The rate at which the strategic uncertainty causes the minimum to fall is greater than the rate at which the players learn to coordinate; thus, the game ends up at the lowest equilibrium.

Results were quite different when the game was played with a group size of two, with players placed in random pairs<sup>11</sup>. Despite the fact that the pairs had just come out of large groups where play had converged to the secure outcome of 1, the players were sometimes able to coordinate on the payoff-dominant equilibrium with both players in a pair playing a 7.

<sup>11</sup>Each player is paired with another for one period. After that period of play, the players are repaired randomly. Each player has a  $1/(n-1)$ ,  $n$  being the population size, of being paired with his partner from the previous period.

Players seem to feel it is less risky to play a high effort in a small group. In a pair, if a player is not determining the minimum, he knows his partner is determining the minimum. In pairs, the players know more about what the other player is doing. This information is lost by adding just one more player to a group. However, while this data is interesting, some problems exist with it. The group size of two was used after the large group size and run only six periods. It was not designed to examine the equilibrium behavior of the game for group size two. In spite of these problems, it is quite likely that the group size of two possesses special characteristics.

Strategic uncertainty causes *individual* and *collective* coordination failure on the first play of the repeated stage game, but through repeated interaction the players do learn to coordinate, thereby solving the *individual* coordination problem.

## **V. Crawford's Model--Adaptive Dynamics in Coordination Games**

Crawford's earlier evolutionary model<sup>12</sup> doesn't explain all of Van Huyck, Battalio, and Beil's results. Strategic uncertainty affects and leads to differences in the players' initial beliefs. These initial beliefs affect the dynamics and final outcome of the games.

In addition to the minimum game, Van Huyck, Battalio, and Beil also ran a median game. This game was orchestrated in the same manner as the minimum game; however, in this case the relevant order statistic was the median (the fifth ordered choice in groups of size nine) which affected all players' payoffs. This game also used a different payoff equation and hence a different payoff table.

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<sup>12</sup>Vincent P. Crawford (1991)

$$\text{PLAYER'S PAYOFF} = a*[\text{median}] - b*[\text{median} - \text{individual player's choice}]^2 + c, (2)$$

where  $a=0.1$ ,  $b=.05$ , and  $c=.60$ . The payoff table is given in table 8 below:

		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	0.80	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	-0.50	-0.05	0.30	0.55	0.70	0.75	0.70

TABLE 8

In this game, it is a best response for the player to choose the action equal to his forecast of the median. Experimental results show that while the initial median was unpredictable, the median of every subsequent period was perfectly predictable. The medians for all of the periods 2 through 20 were equal to the median of the initial period. Here, as well as in the minimum game, the actions with higher *relative* payoffs increase over time. This data helps allow Crawford to generalize his model to any order statistic or convex combination of order statistics.

Vincent Crawford (1992) set out an additional model which is based on an evolutionary framework and, in addition, incorporates the players' choices and the role of uncertainty. This model was developed to organize any order statistic games and explains the patterns observed in data of Van Huyck, Battalio, and Beil's minimum and median games. In each period, players adjust their strategies in response to previous experience.

Learning, the updating process which takes place as a result of new information, occurs and causes the players' beliefs and actions to converge.

In Crawford's model, there are no discernable differences among players. Players can select only pure strategies. The game consists of repetitions of the stage game shown above. The relevant summary (market) statistic is announced after each period's play. Each player's payoff is determined by the player's individual choice and the current value of the summary statistic.

The summary statistic is made public after each period. This common knowledge makes up the players' shared experience. At this point the players update their beliefs and make a new choice. The new choice is based on the individual's choice last period, the current value of the summary statistic, and random shocks. Random shocks represent both the differences between the players' initial beliefs and the differences in the rates at which the different players respond to the new information that comes from past play. This updating process continues with each period. Eventually as the differences which define the random shocks come to be zero, the players' strategy choices also converge. Players arrive at some equilibrium.

From Crawford's model, several propositions follow; these propositions organize and predict results of coordination games. It is two of these theorems that this paper will examine.

**Proposition 3:**<sup>13</sup> Holding the initial actions and the group size are constant, increasing the relevant order statistic, statistically increases the values of the players' actions and the value of the relevant summary statistic.

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<sup>13</sup>Vincent Crawford (1992), p.16.

**Proposition 4:**<sup>14</sup> If the initial actions and the order statistic are held constant, an increase in the group size will cause the value of the player's choices and the value of the relevant order statistic to decrease (statistically).

The experimental design follows.

## VI. Experimental Design

The subjects are undergraduate students attending Texas A&M University and were recruited from economics classes. The instructions were simultaneously read aloud and viewed by each subject on his computer terminal in order that the description of the game be common information, if not common knowledge. [The complete instruction set is given in Appendix A.]

No preplay communication was permitted. Following each repetition of the period game, the relevant summary statistic, which was the only common historical data available to the subjects, appeared on each player's screen. In order to describe the instructions and the sequence of play, we will present a brief description of the sequence of actions each period by showing the actual information, in terms of the computer screens, the subjects saw. We will assume that we are at the beginning of period 5.

Figure 1 displays the MAIN screen a subject would see at the beginning of period 5. The top line of the main screen contains the current period number in the upper left corner and the current earnings balance in the upper right. The second line contains the words 'PROCEED', 'INSTR' and 'RECORD'. A subject can review the instructions or record sheet at any time by clicking his mouse on 'INSTR' or 'RECORD'. The subject clicks on 'PROCEED'

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<sup>14</sup>Vincent Crawford (1992), p. 16.

to confirm his current period choice.

The right side of the main screen contains the subject's choices and the market order statistics for the previous periods of play. In addition, the earnings for each period are also displayed. At the bottom are the line up, line down, page up and page down icons, which can be used to review the data for periods that have scrolled off of the screen as play proceeds. The bottom of the screen contains information to remind the subject that there are seven subjects playing a 1<sup>st</sup> order statistic game.

The left side of the main screen is where the subject actually chooses a value for the current period and can perform any hypothetical calculations desired. Each player's action set ranges from 0 to 100. Each subject makes his individual choice using the "blue box" and two "blue gutters", which are shown in figure 1. The main screen shown is for a session with 7 subjects and a 1<sup>st</sup> (minimum) order statistic. Each player can click on the blue box and slide his mouse around thus displaying the payoffs associated with any feasible outcome (any possible value for the individual choice and any possible value for the order statistic).

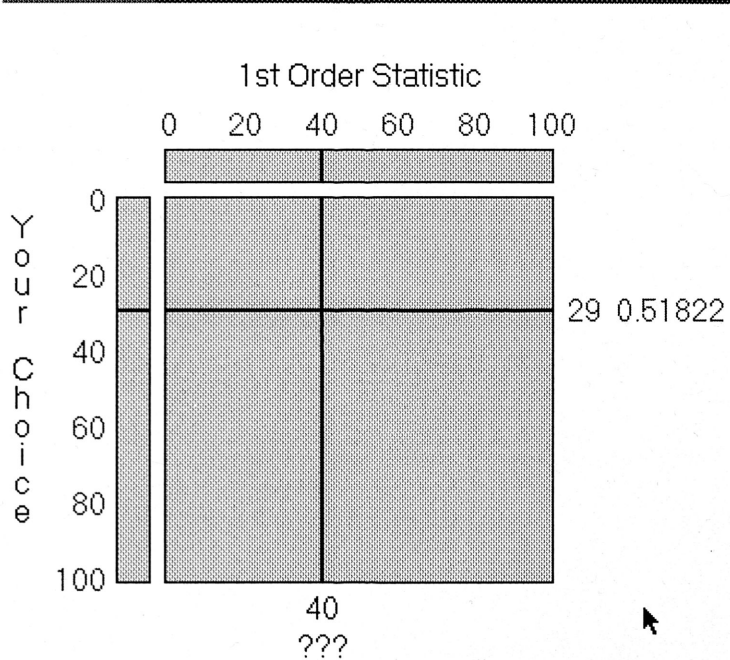
The gutter above the blue box can be set to a fixed, hypothetical, value for the order statistic. The subject can then click in the gutter on the left, your choice, and easily examine his payoffs associated with his choices for a given hypothetical order statistic. This is believed to be both an effective and efficient means for the players to search for a best response to previous play. Similarly, by clicking on the gutter on the left and selecting a value for your choice, and then moving the mouse in the upper gutter, the subject can easily check for the minimum possible payoff associated with each possible choice.

In the figure we have selected a hypothetical value, indicated by the 3 and a color of yellow on the screen, of 40 for the 1<sup>st</sup> order statistic. The subject's choice of a value of 29, colored green on the screen, would result in an earnings of \$0.51822 if the actual 1<sup>st</sup> order

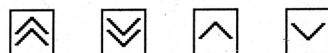


### FIGURE 1

Period: 5 MAIN Balance: \$163212  
**PROCEED INSTR RECORD**



	Your Per Choice	1st Order Statistic	Your Earnings
1	60	50	0.58200
2	55	50	0.59550
3	96	50	0.21912
4	5	50	0.23550



Ordered Participant Choices

c1	c2	c3	c4	c5	c6	c7
1	2	3	4	5	6	7

statistic was 40. By moving the mouse, the subject can examine the payoff associated with any pair of values for his choice and the hypothetical market order statistic.

When the subject has decided on a value he clicks on proceed and is asked to confirm his choice. If the choice is not confirmed the subject must make another choice. If the choice is confirmed, his choice is entered for that period.

After a choice has been entered, the WAITING screen, Figure 2, appears. This screen differs from the main screen in the label at the top, in the absence of 'PROCEED' on line 2 and in that the color of the subject's choice is now yellow. The subject can review the past data, the instructions, or the record screen or he can perform hypothetical calculations from this screen, while he is waiting for other subjects to make a choice.

When all of the subjects have made a choice, the OUTCOME screen, Figure 3, appears. The outcome screen reports the outcome for the current period. The order statistic is presented in red and the subjects choice and earnings are presented in green. At the bottom of the page the order statistic is also presented above the correct position of the ordered choices. After ten seconds subjects are switched to the main screen for the next period and the same sequence is repeated.

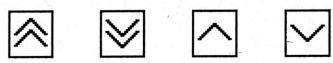
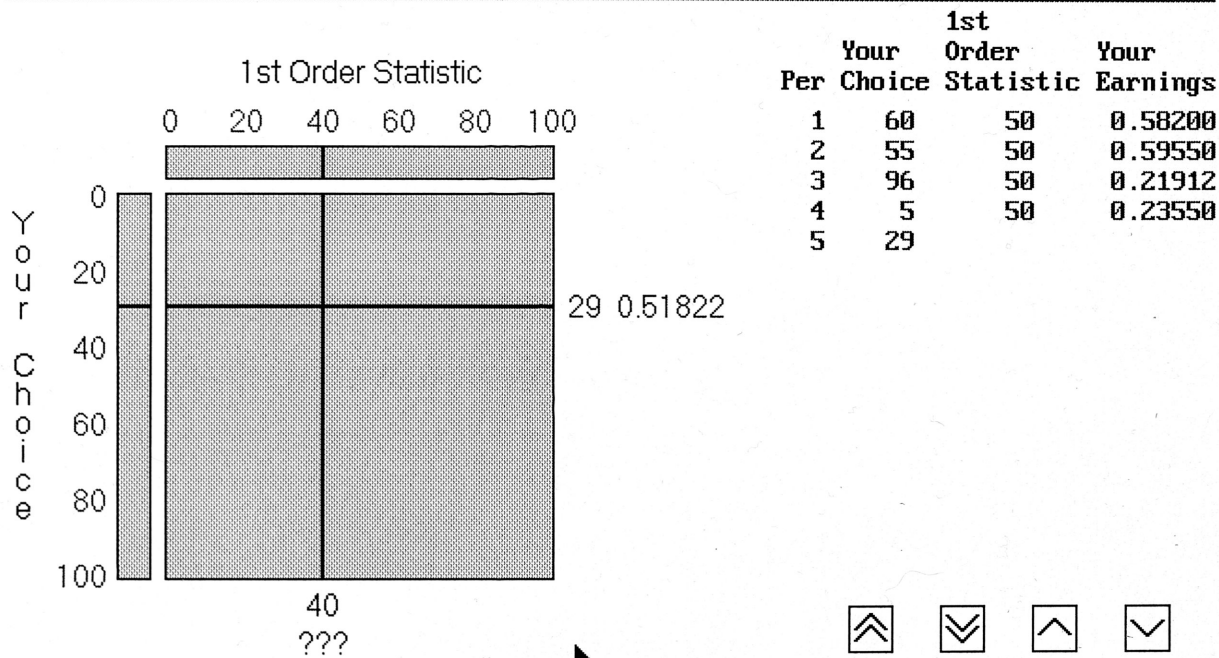
The subjects are taken through all of the screens during the instructions which last about 40 minutes. During the instructions a questionnaire, Figure 4, is administered. The subjects complete the questionnaire using the main screen blue box interface. After the anonymous questionnaires are completed they are publicly graded in the front of the room. If there are errors, the questionnaire is given out again.

The questionnaire is designed to serve a number of purposes. First, we want it to be common information that all subjects can calculate an order statistic and can calculate earnings using the blue box interface. Second, the questionnaire is designed to give the

FIGURE 2

Period: 5 WAITING Balance: \$163212

**INSTR RECORD**



Ordered Participant Choices

<input checked="" type="checkbox"/> c1	c2	c3	c4	c5	c6	c7
1	2	3	4	5	6	7



**FIGURE 4A**  
**QUESTIONNAIRE**

**1st ORDER STATISTIC**

	<b>0</b>	<b>17</b>	<b>33</b>	<b>50</b>	<b>67</b>	<b>83</b>	<b>100</b>	
<b>YOUR CHOICE</b>	<b>0</b>	(1)_____	0.34998	0.30198	_____	(2)_____	-0.44202	(3)_____
	<b>17</b>	0.24798	0.40200	0.45192	0.40398	0.25200	_____	-0.34002
	<b>33</b>	_____	0.35592	0.49800	0.54798	(7)_____	0.34800	0.09198
	<b>50</b>	-0.15000	_____	0.44598	0.60000	0.64998	0.60198	0.45000
	<b>67</b>	(4)_____	-0.04800	0.28992	(6)_____	0.70200	0.75192	_____
	<b>83</b>	-0.94002	-0.38208	_____	0.40398	0.65592	0.79800	0.84798
	<b>100</b>	(5)_____	-0.83802	-0.31002	0.15000	_____	0.74598	0.90000

## FIGURE 4B

### QUESTIONNAIRE (Cont'd)

- (1) Assume the following choices of X are made by the seven participants in a group.

<u>Participant</u>	<u>Choice of X</u>
P <sub>1</sub>	88
P <sub>2</sub>	15
P <sub>3</sub>	40
P <sub>4</sub>	72
P <sub>5</sub>	30
P <sub>6</sub>	91
P <sub>7</sub>	21

- (a) Arrange the numbers in ascending order.

c <sub>1</sub>	c <sub>2</sub>	c <sub>3</sub>	c <sub>4</sub>	c <sub>5</sub>	c <sub>6</sub>	c <sub>7</sub>
<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>

- (b) Circle the 1st order statistic in (a) above and calculate the earnings for each participant.

<u>Participant</u>	<u>Choice of X</u>	<u>Earnings</u>
P <sub>1</sub>	88	_____
P <sub>2</sub>	15	_____
P <sub>3</sub>	40	_____
P <sub>4</sub>	72	_____
P <sub>5</sub>	30	_____
P <sub>6</sub>	91	_____
P <sub>7</sub>	21	_____

subjects a 7x7 table of the payoffs that captures the global properties of the payoff surface while also making this information common. Lastly, subjects that do not have experience using a mouse will be able to feel comfortable with this interface. After the subjects have all answered the questionnaire correctly, their questionnaires were kept but they were given a completed payoff table, which is the same as equation 2 except  $c$  has been reduced by 0.40, figure 5, to help during the sessions. The similarity between figure 5 and table 7 and the difference of 0.40 can be noted.

Different sessions of the experiment had different relevant order statistics and different group sizes. Table 8 provides a summary of the experimental design. The number of sessions for each order statistic and group size is given in the table.<sup>15</sup>

### EXPERIMENTAL DESIGN MATRIX

		Group Size	
		5	7
Order Statistic	1	---	4
	2	4	4
	4	4	6

TABLE 8

Table 9 provides a detailed experimental design. Experimental sessions with the same number and "A" or "B" following the session number were run at the same time in the same room. I am aware that this makes the two sessions not independent in the same sense that

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<sup>15</sup>This research is still in progress by Dr. John Van Huyck; thus, its configuration is presently unbalanced.

**FIGURE 5****1st ORDER STATISTIC**

	<b>0</b>	<b>17</b>	<b>33</b>	<b>50</b>	<b>67</b>	<b>83</b>	<b>100</b>
<b>0</b>	0.30000	0.34998	0.30198	0.15000	-0.10602	-0.44202	-0.90000
<b>17</b>	0.24798	0.40200	0.45192	0.40398	0.25200	0.01392	-0.34002
<b>33</b>	0.10398	0.35592	0.49800	0.54798	0.49392	0.34800	0.09198
<b>50</b>	-0.15000	0.20598	0.44598	0.60000	0.64998	0.60198	0.45000
<b>67</b>	-0.50802	-0.04800	0.28992	0.54798	0.70200	0.75192	0.70398
<b>83</b>	-0.94002	-0.38208	0.04800	0.40398	0.65592	0.79800	0.84798
<b>100</b>	-1.50000	-0.83802	-0.31002	0.15000	0.50598	0.74598	0.90000

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two that were run at different times would be. There are two reasons the sessions were run together. First, they were needed for the cross-over that takes place in period 21. The data for those periods is not relevant to this paper. Secondly, since this is a coordination game, there is some concern about a rumor effect. Students who serve as subjects in one session might talk to someone about the game. Therefore, it is desirable to get through the sequence as quickly as possible.

**EXPERIMENTAL DESIGN**

<b>SESSION</b>	<b>EXP. DESIGN</b>	<b>TREATMENT*</b>	<b>DATE</b>	<b>GROUP SIZE</b>	<b>ORDER STATISTIC</b>	<b>PERIODS</b>
01A	CR1	0502	11/23/92	5	2	1-20
01B	CR1	0502	11/32/92	5	2	1-20
03A	CR1	0502	11/24/92	5	2	1-20
03B	CR1	0502	11/24/92	5	2	1-20
04A	CR1	0504	11/30/92	5	4	1-20
04B	CR1	0504	11/30/92	5	4	1-20
05A	CR1	0504	11/30/92	5	4	1-20
05B	CR1	0504	11/30/92	5	4	1-20
09A	CR1	0701	03/08/93	7	1	1-20
09B	CR1	0701	03/08/93	7	1	1-20
10A	CR1	0701	03/09/93	7	1	1-20
10B	CR1	0701	03/09/93	7	1	1-20
06A	CR1	0702	12/02/92	7	2	1-20
06B	CR1	0702	12/02/92	7	2	1-20
07A	CR1	0702	12/02/92	7	2	1-20
07B	CR1	0702	12/02/92	7	2	1-20
00A	CR1	0704	11/19/92	7	4	1-20
00B	CR1	0704	11/19/92	7	4	1-20
02A	CR1	0704	11/23/92	7	4	1-20
02B	CR1	0704	11/23/92	7	4	1-20
08A	CR1	0704	12/03/92	7	4	1-20
08B	CR1	0704	12/03/92	7	4	1-20

\* The treatment consists of four numbers. The first two tell the group size, and the last two the relevant order statistic.

TABLE 9

In addition to these sessions for periods 1-20, there were two sessions in which the players were then randomly matched<sup>16</sup> into pairs for periods 21-40. The relevant order statistic remained the same, a 1. These two sessions were a cross-over which followed the 0701 treatments on March 8 and 9, 1993, Sess09 and Sess10. The payoff table remained the same. Cross-over instructions, also contained in Appendix A, were read and the players could simultaneously follow along with the instructions appearing on their monitors. These sessions ran from periods 21 to 40. These sessions were run largely because of the questions about the equilibrium in these games which arose out of the previous pair-wise matching data.<sup>17</sup>

## VII. Experimental Results

### (A). *Market Data*

Crawford's propositions 3 and 4 make statistical predictions about the effects that changes in the group size and changes in the order statistic have on both the value of the order statistic and the value of the players' actions, *holding the initial period actions constant*. A formal, exact, test of this initial condition is not possible using available statistical procedures because of the small sample sizes. Rather, I will use an approximate test of the initial conditions that compares the mean and the standard deviations of the period 1 observations for each cell in the design matrix, table 8. The following hypothesis is examined:

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<sup>16</sup>The protocol for random pair-wise matching appears in footnote 10.

<sup>17</sup>John B. Van Huyck, Raymond C. Battalio, Richard O. Beil (1990)

**Hypothesis 1:** The means and the variances do not differ as the order statistic and group size changes.

The means and variances for each design cell are reported below in table 10.

<b>Order Statistic</b>	<b>Group Size</b>	<b>Mean</b>	<b>Standard Deviation</b>
1	7	68.04	26.11
2	5	54.25	24.51
2	7	51.50	31.48
4	5	67.75	21.29
4	7	69.33	25.99

TABLE 10

Since the largest difference in the means is less than 18 and the standard deviations are all greater than 20, it must be accepted that the distributions of initial plays are equivalent across treatments. However, this equivalence leads to differences in the value of the observed, market order statistic, depending on what the order statistic is. Therefore, the value of the observed, market order statistic moves in the same direction as the order statistic. When the order statistic is held constant and the group size increased, the value of the observed, market order statistic decreases.

Hypothesis 2 and 3 below are conditional on our acceptance of hypothesis 1 above and are made to parallel Crawford's propositions 3 and 4 above.

**Hypothesis 2:** If hypothesis 1 is accepted then, for a given group size, a larger order statistic should result in a more efficient equilibria.

**Hypothesis 3:** If hypothesis 1 is accepted then, for a given order statistic, a larger group size should lead to a less efficient equilibria.

We begin by looking at the data for period 20 and examining hypothesis 2. Table 11 contains the outcomes for period 20 for all of the sessions with seven subjects.

		Value of Period 20 Order Statistic			
		0-20	21-79	80-100	
Order Statistic	4	0	2	4	6
	2	1	3	0	4
	1	4	0	0	4
		5	5	4	14

TABLE 11: Group Size = 7

Using a two-tail, Fisher's exact test we reject the hypothesis that the value of the order statistic makes no difference, (c.v. = 0.003). A comparison of each pair of order statistics also rejects equality at a two-tail 10 percent level of significance for order statistic the pair 1 and 4 and the pair 2 and 4. The pair 1 and 2 has a two-tail critical value of 0.143. It follows that a one-tail test would reject at less than 10% for all pairs.

The data for the sessions with five subjects is given below in table 12.

		Value of Period 20 Order Statistic			
		0-20	21-79	80-100	
Order Statistic	4	0	0	4	4
	2	0	3	1	4
		0	3	5	8

TABLE 12: Group Size = 5

The associated critical value for the Fisher exact two-tail test is 0.143 and 0.071 for the one-tail test.

Taken together, the data provide relatively strong support for hypothesis 2 (Crawford's P3). The results could be strengthened if additional replications continued to give similar distributions.

The data for hypothesis 3 is much more ambiguous. Tables 13 and 14 present the data for changing group size while holding the order statistic constant.

	Value of Period 20 Order Statistic			
	0-20	21-79	80-100	
<b>Group Size</b> 5	0	3	1	4
7	1	3	0	4
	1	6	1	8

TABLE 13: Order Statistic = 2

	Value of Period 20 Order Statistic			
	0-20	21-79	80-100	
<b>Group Size</b> 5	0	0	4	4
7	0	2	4	6
	0	2	8	10

TABLE 14: Order Statistic = 4

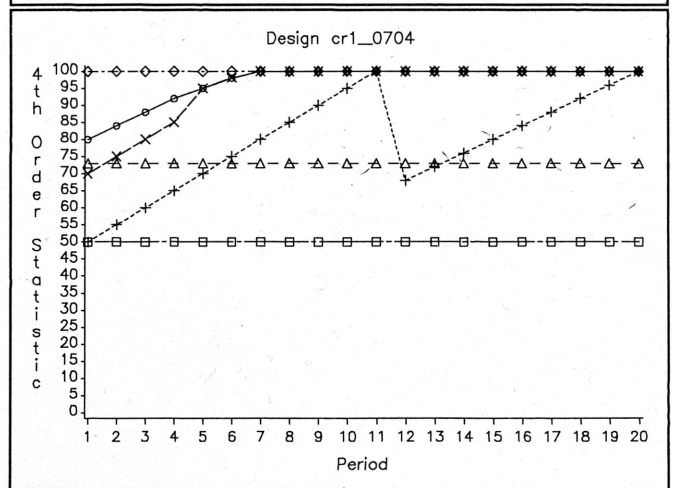
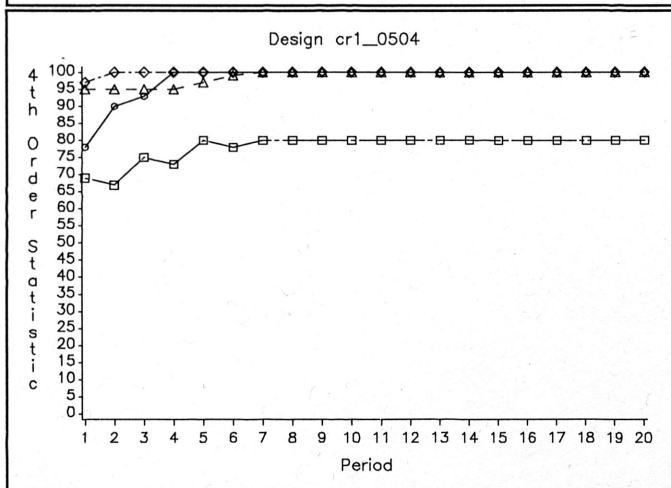
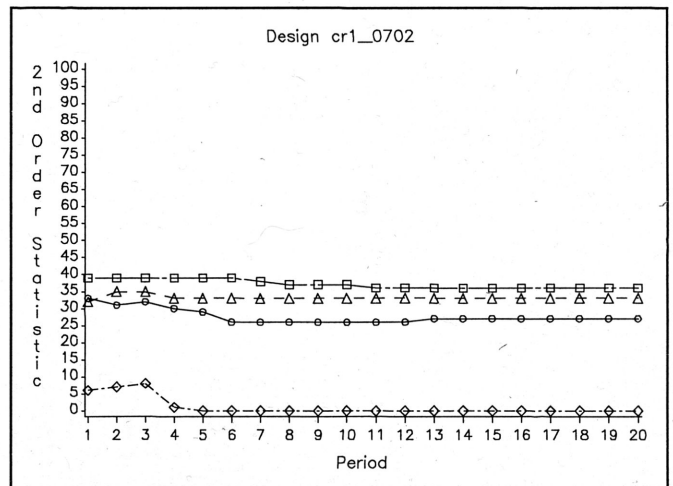
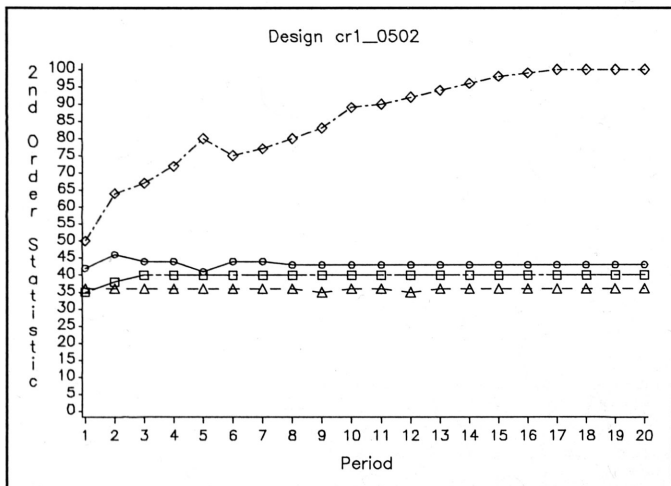
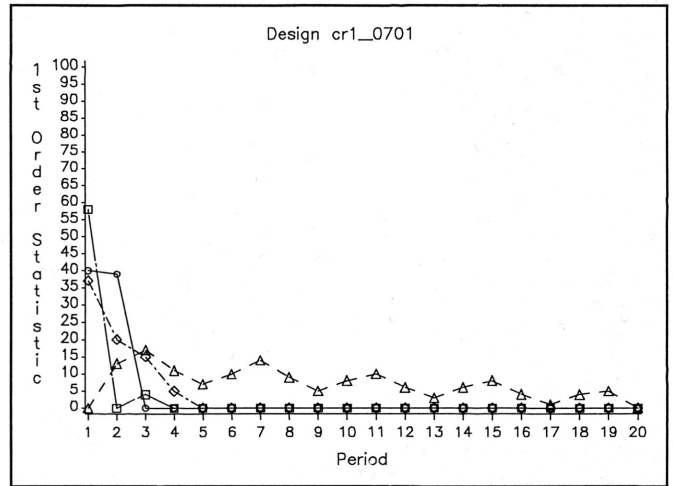
The observed similarity in the rows of the two tables is reflected in the associated Fisher exact test in that all of the critical values, for a two-tail test, are greater than 0.45. Based on these results, additional sessions, with a greater difference in the group sizes would seem to be called for in order to further examine hypothesis 4.

Figure 6 presents the data for the order statistic for all 20 periods. (Appendix B contains this data in its entirety.) Given a group size of 7, the outcome of play seems to vary with the order statistic. In the case that the relevant order statistic was the minimum (Treatment 0701), all four sessions ended with the value of the market order statistic at zero. This is considerably worse than the result of play in the 0702 sessions. In those sessions, the value of the market order statistic decreased in 3 of the 4 sessions; however, only 1 went to zero. The value of the order statistic seemed to stay in relatively the same vicinity as it began. In the treatment where the order statistic was 4 while in group size 7, four of the six sessions were able to reach 100. The other two, the value of the order statistic remained constant. The median began and ended at 50 in session 00B and 73 in session 02B.

A similar pattern emerges across the treatments with a group size of 5. When the order statistic was equal to 2, one session finds its way to the efficient equilibrium while the other three keep a value of the order statistic that is close in value to the value of the order statistic with which the session began. This can be contrasted with the 0504 treatment. In the 0504 treatment, all four sessions showed an increase in the value of the order statistic. Three of the four reached the efficient equilibrium by period 10 and remained there throughout.

The experimental data for hypothesis 4 is more ambiguous, as indicated above. When the 0502 and 0702 treatment are compared, there is not a great deal of difference in the path of play. With the group size of 5, three remain fairly constant, while one reaches the efficient

FIGURE 6





equilibrium. In the instance where the group size is 7, three sessions are remaining relatively constant, and one goes to the secure equilibrium.

In both the 0504 and 0704 treatments, there was a tendency for the value of the market order statistic to go to 100. In the 0504, three of the four sessions reached 100; all four showed an increase in value of the order statistic. With the 0704 treatment, four of six sessions ended with the value of the order statistic equal to 100 while two sessions remained at their original value for the order statistic.

(B). *Individual Data*

The individual subject data for sessions 00 to 10 are shown in figure 7a through 7f. The large circle indicates the value of the order statistic for each period. Looking at these figures, we see a general tendency for the subject's actions to converge toward the order statistic with the magnitude of the deviations decreasing. In some instances, for example the 0702 session, it looks like more periods might have been useful. By the time we reach period 20 a majority of the subjects are best responding to the previous period order statistic in those cases where the order statistic has been constant over the last four periods. It is of interest to note that in session 08A a majority of subjects best respond to a median that is increasing by four each of the last five periods.

The majority of those players, who are not best responding, are playing an action which costs them less than two cents in regard to their payoff if they had best responded. Such actions could be a result of the discrete nature of the choice space of the payoff matrix.

(C). *Random Pairwise Matching*

In sessions 09 and 10, after the first 20 periods ended, subjects were placed in one

FIGURE 7A

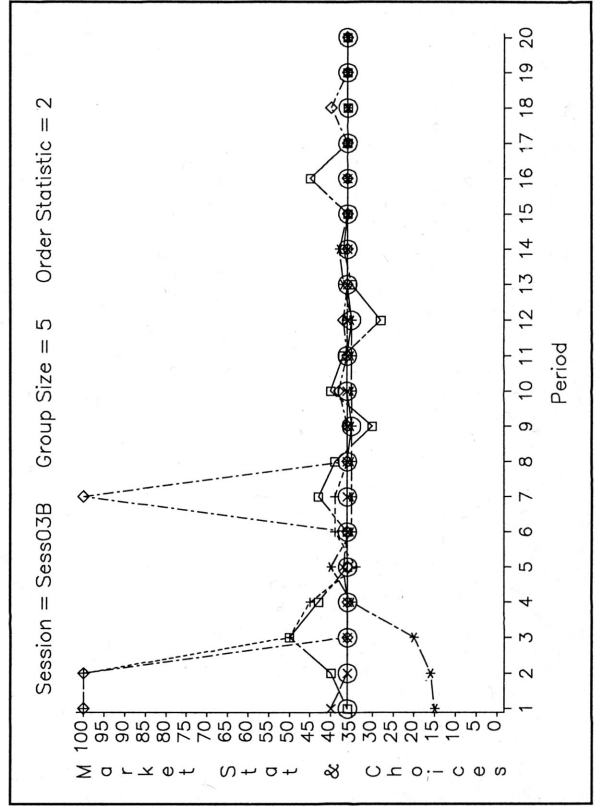
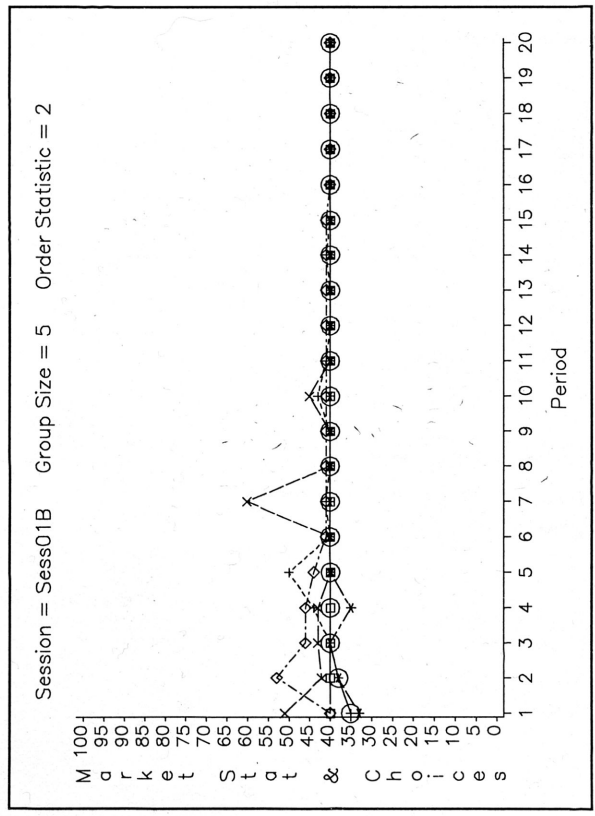
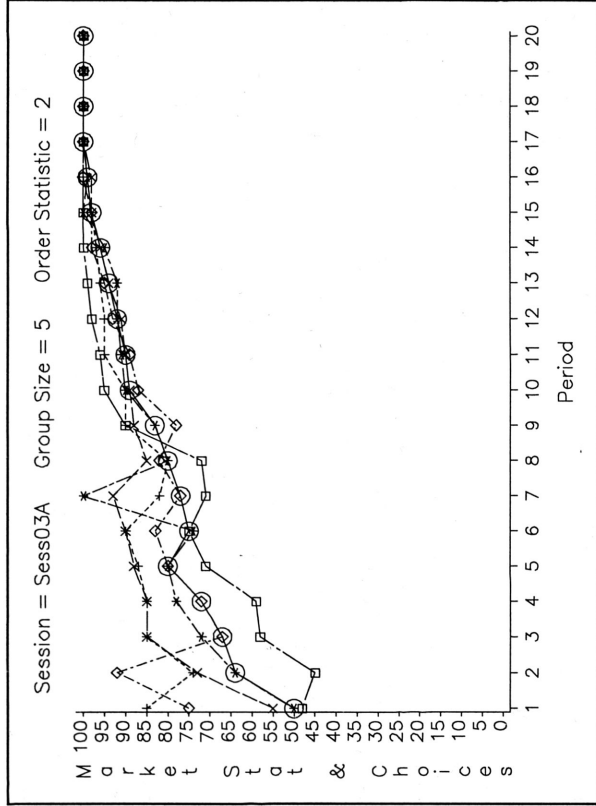
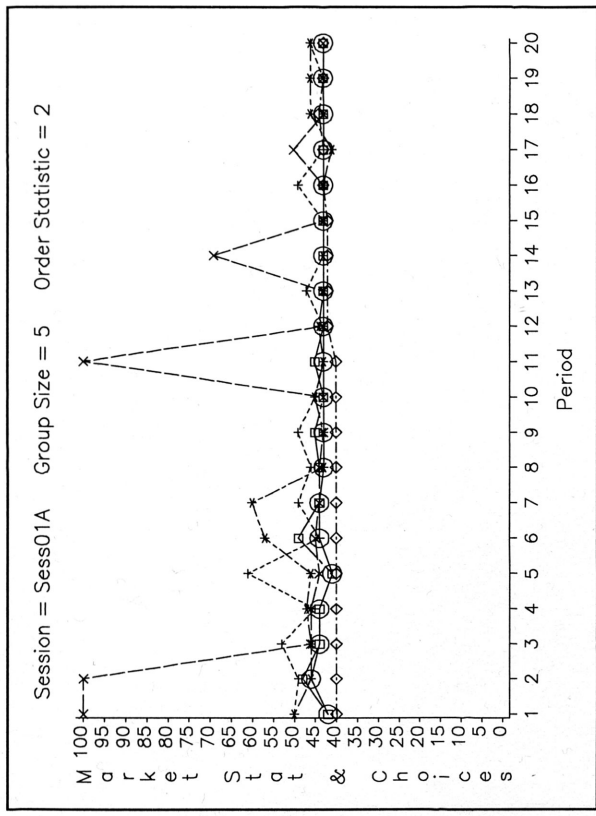


FIGURE 7B

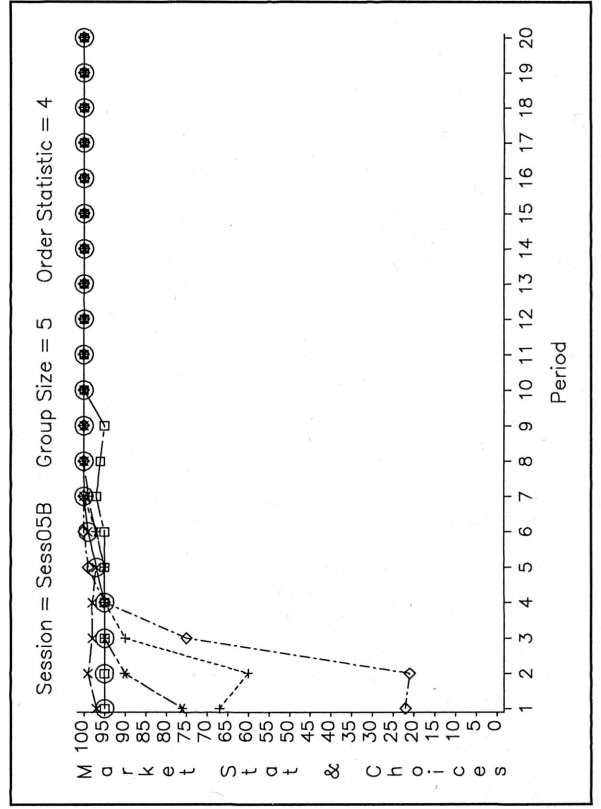
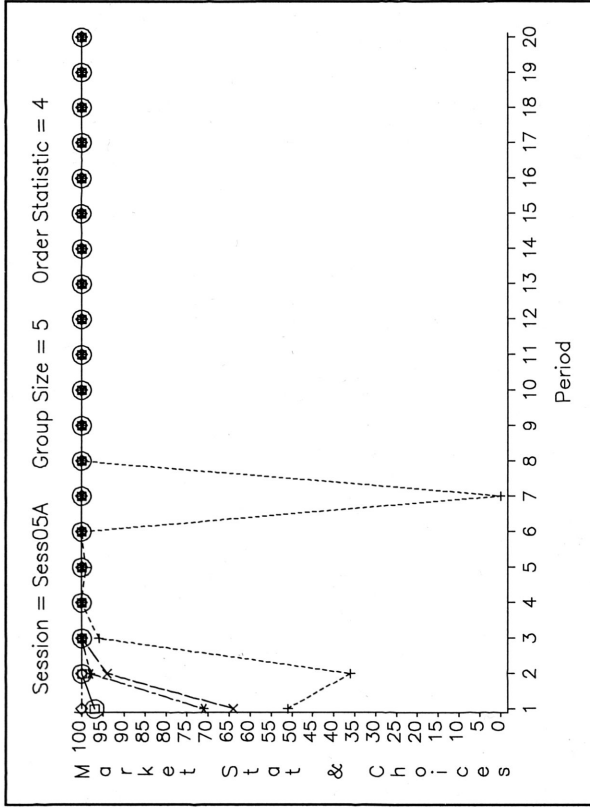
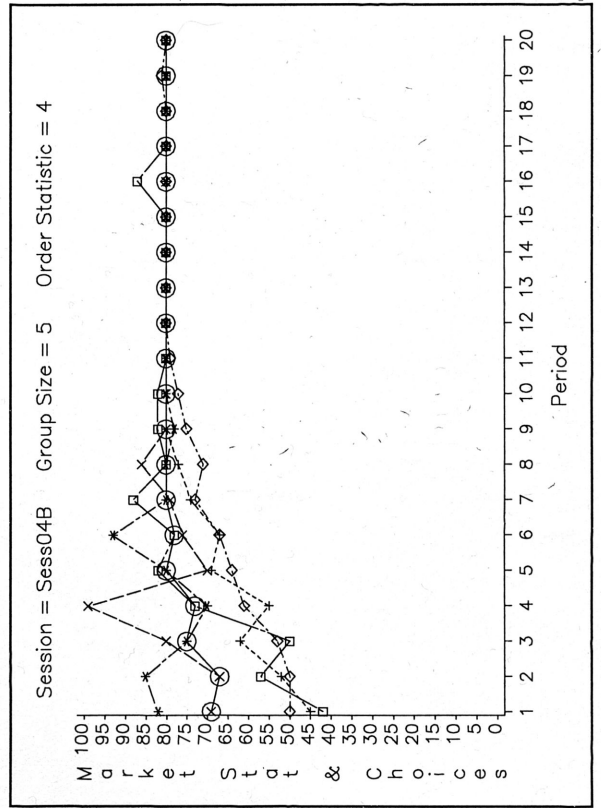
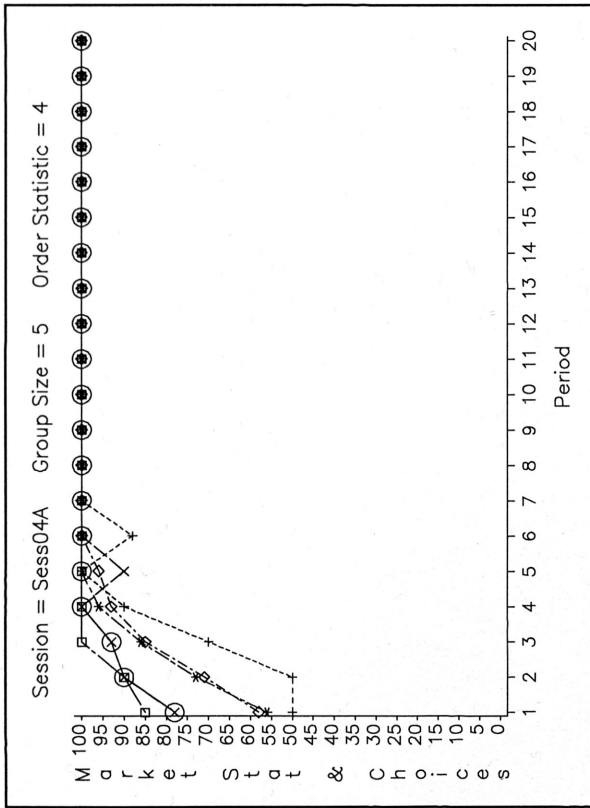


FIGURE 7C

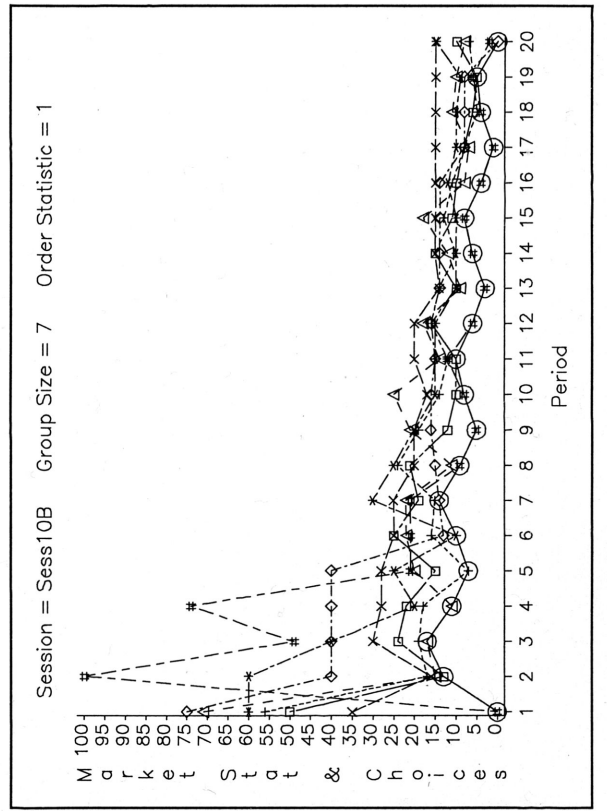
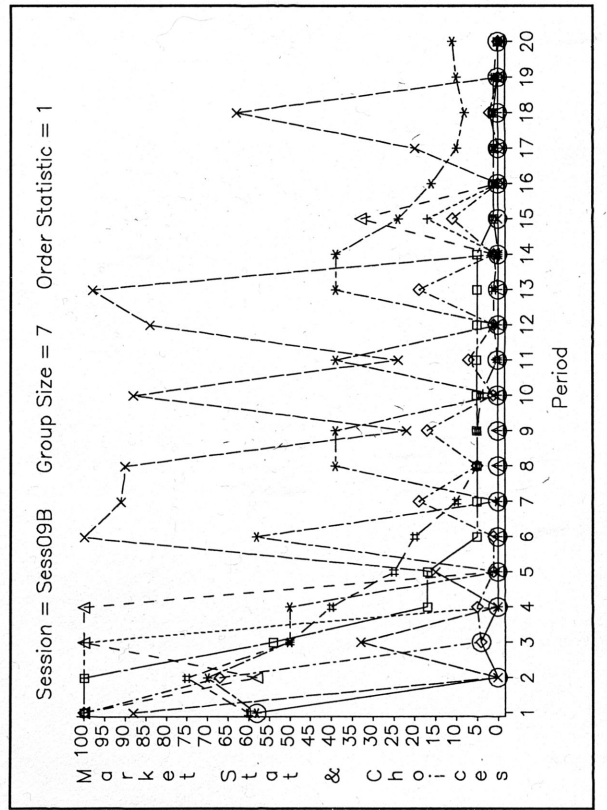
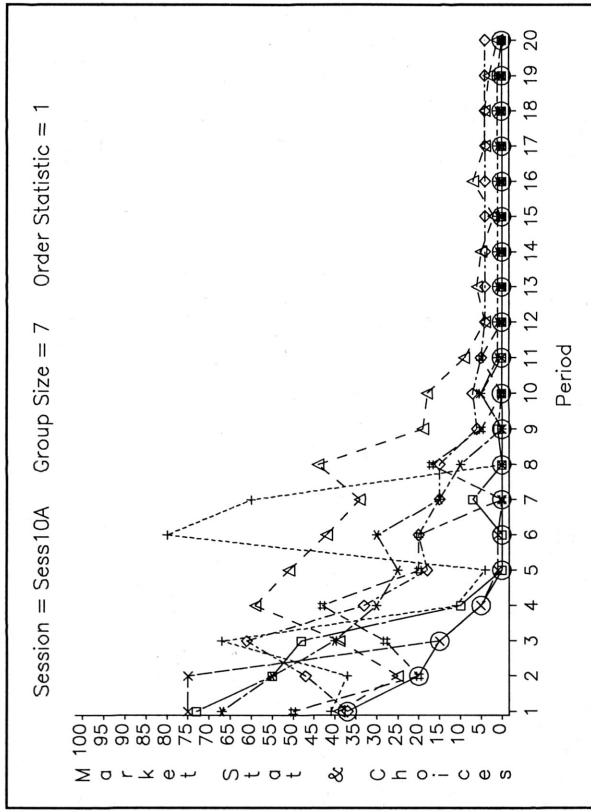
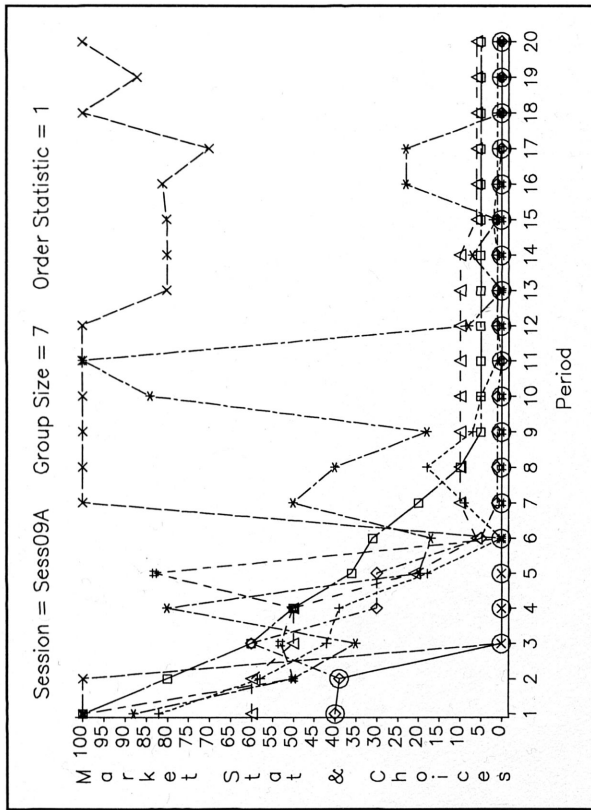


FIGURE 7D

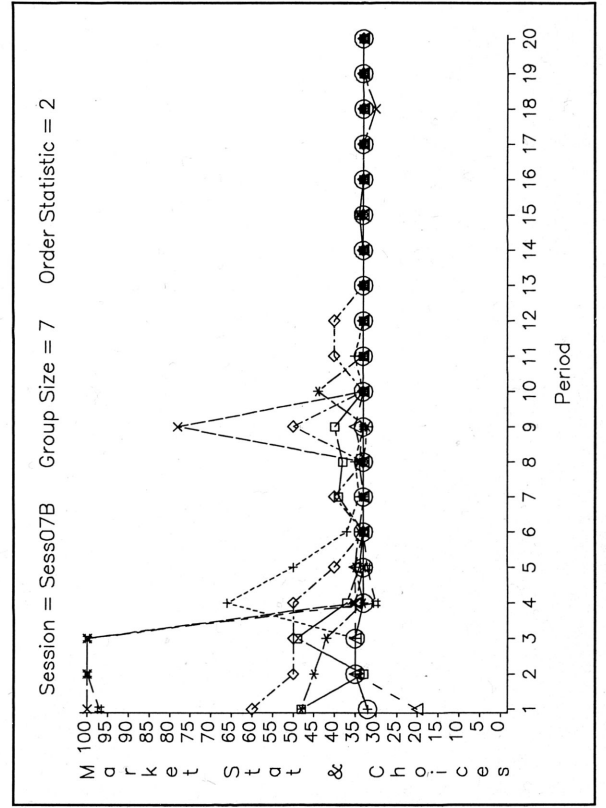
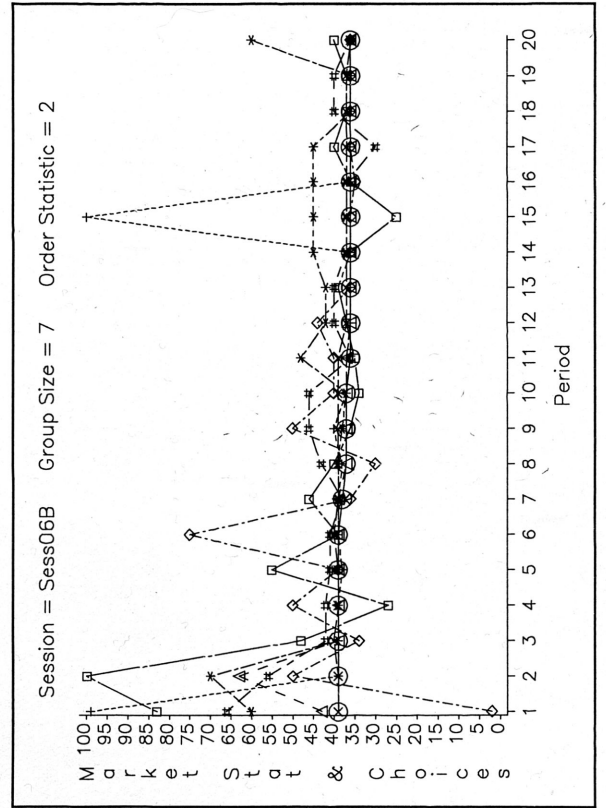
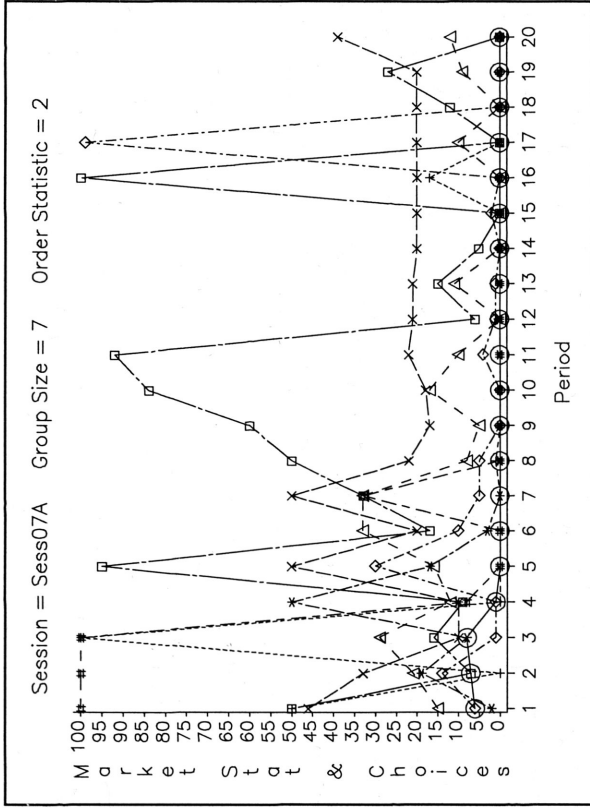
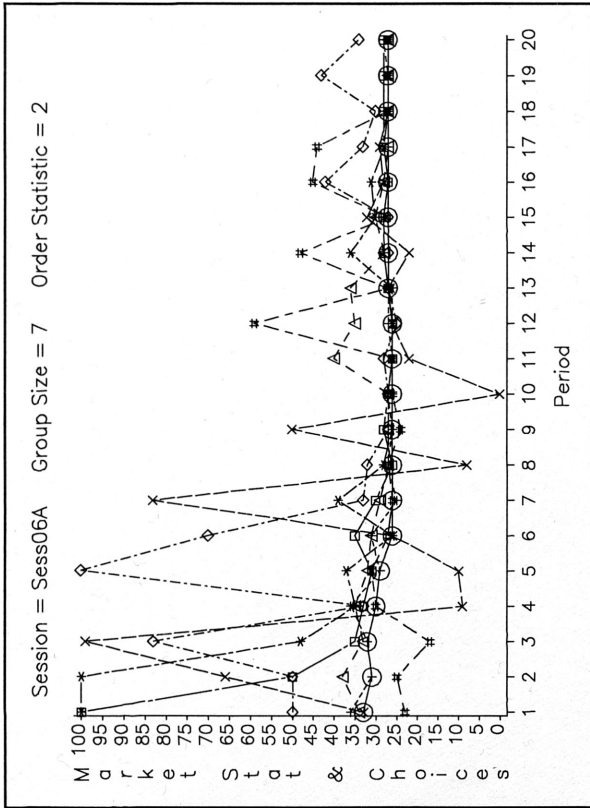


FIGURE 7E

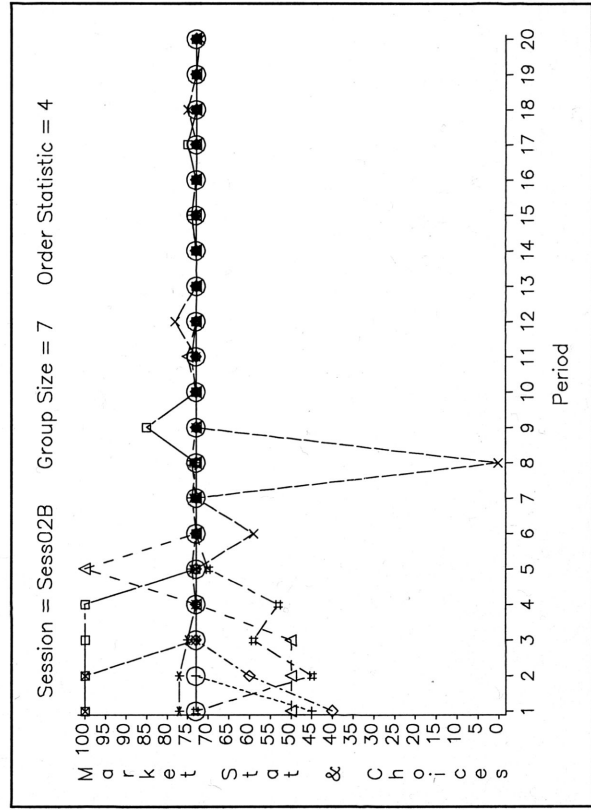
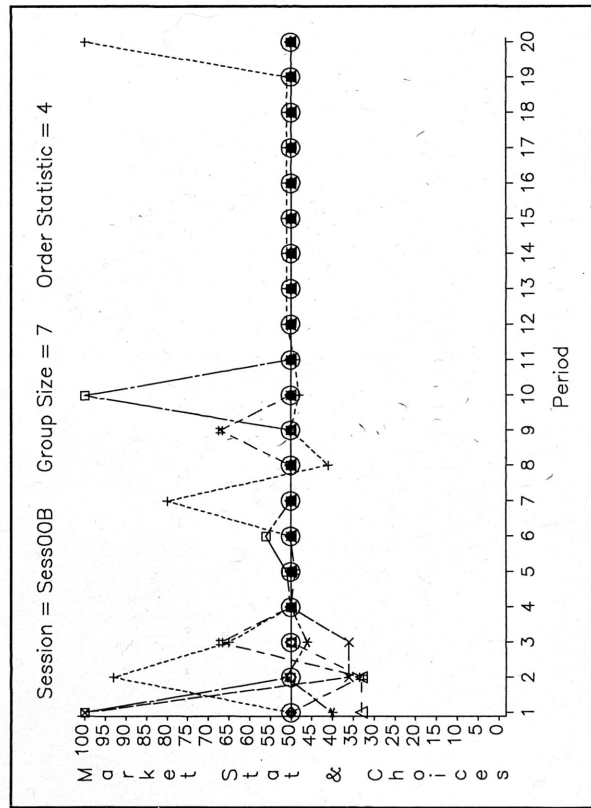
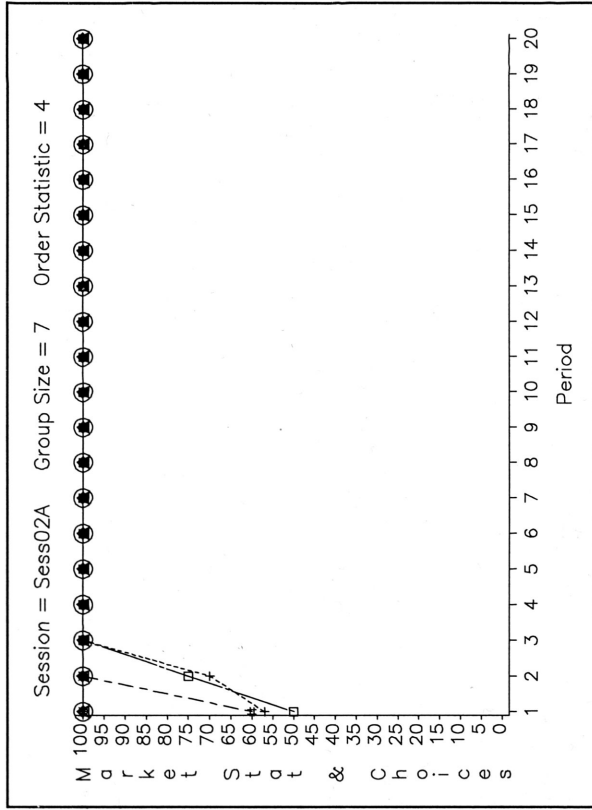
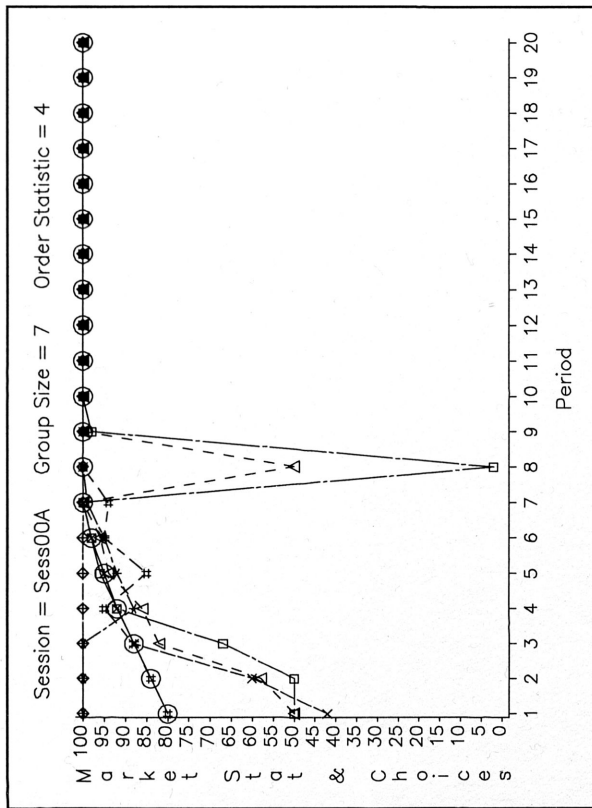
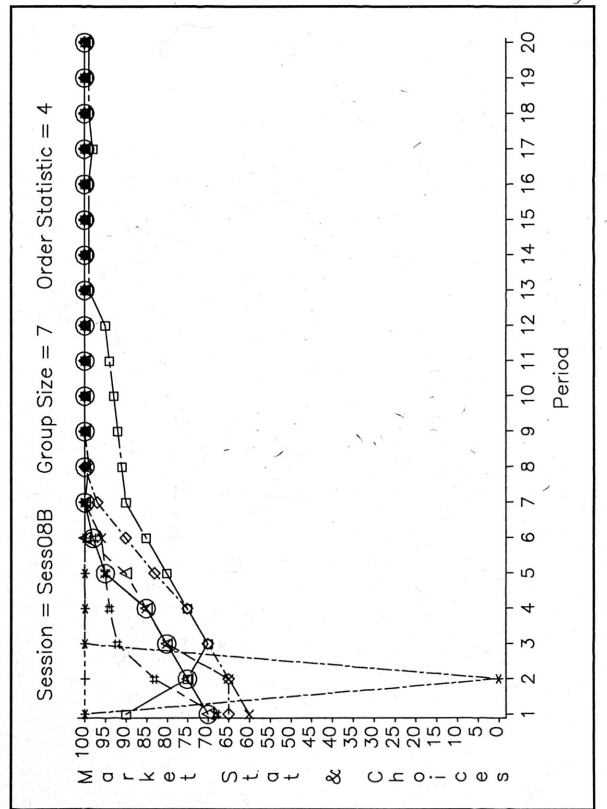
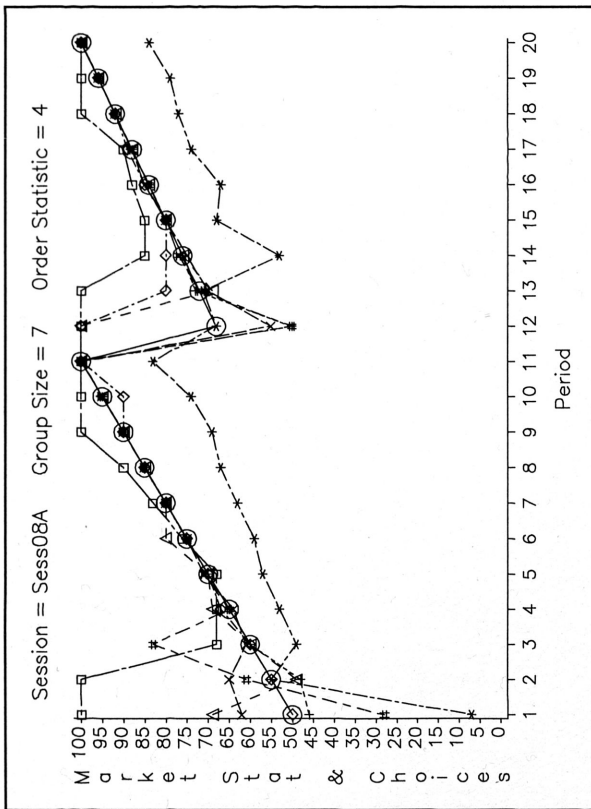


FIGURE 7F



group of size 14 and were randomly paired each period. The order statistic remained the minimum. The primary purpose of this treatment was to let this treatment run for a longer number of periods than in the earlier research by Van Huyck, et. al. (1990) to see if the distributions of actions would converge.

A jump in the players' action from period 20 to period 21. In period 20, 50% of the players choose an action of zero. After the cross-over, play shifts up. In period 21, 3.6% of the players [1 out of 28] choose an action of zero. This is captured in the top two graphs of figure 8.

Beyond this initial shift, from period 21 to period 40, a climb toward efficiency appears to be occurring. This is displayed in the two bottom graphs of figure 8. In these, period 31 data is included to provide a little more information on the time path of the distribution of actions. In general, higher levels of a choice of action are seen with each subsequent period. This suggests that the next replication of this treatment should run longer than twenty periods.

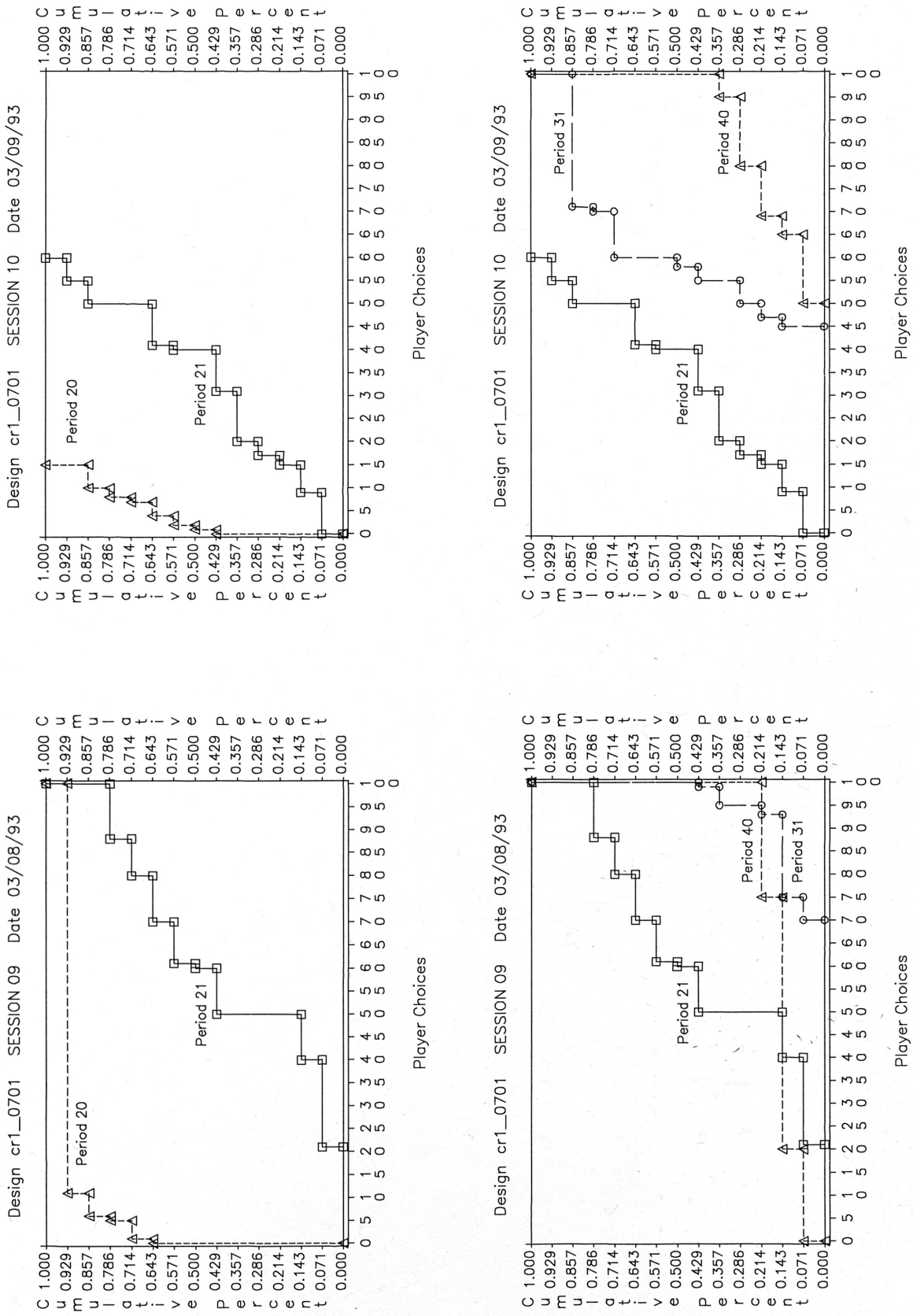
## **VII. Summary and Conclusions**

From this data, the strongest result is that an increase in the order statistic, holding the group size constant, brings about a more efficient equilibrium after twenty periods of play. Also consistent with this result is the result that adjustment over time is likely to move towards efficiency with a larger order statistic. These results provide initial confirmation for Crawford's dynamic theory.

The results from changes in the group size, holding the order statistic constant are ambiguous. It could be hypothesized that the period 20 outcomes are the same. However, in order to do this additional data would be necessary. At present, the data we have



**FIGURE 8**



compares group sizes 5 and 7. These numbers are not all that different. Data from a group size larger than 7 is needed to draw any conclusions about Crawford's hypothesis on the effects of group size.

From this data it appears that individuals are best responding. They are capable of solving the individual coordination problem, but not the collective coordination problem. The random pairwise matching data also brings up an interesting point. The change in players' action choices in period 21, seem to indicate that when only two people are involved in a game, deductive principles factor into a player's action choice. This may be a special property of the additional information that group size 2 brings to a game. Further testing would be necessary to test this hypothesis.

Crawford's propositions are reasonable for a first attempt at a dynamic theory. However, more testing is needed, especially in regard to the effects of group size on outcome selection, holding the order statistic constant.

## REFERENCES

- Binmore, Ken, *Fun and Games: A Text on Game Theory*, Lexington, Massachusetts: D.C. Heath and Company, 1992.
- Bryant, John, "A Simple Rational Expectations Keynes-Type Model," *Quarterly Journal of Economics* 525-528, 1983.
- Cabrales, Antonio, "Stochastic Replicator Dynamics," unpublished manuscript, 1992.
- Crawford, Vincent P., "Adaptive Dynamics in Coordination Games," unpublished manuscript, 1992.
- Crawford, Vincent P., "An 'Evolutionary' Interpretation of Van Huyck, Battalio, and Beil's Experimental Results on Coordination," *Games and Economic Behavior* 3, 25-59, 1991.
- Kreps, David M., *Game Theory and Economic Modelling*, Oxford: Clarendon Press, 1990.
- Smith, John Maynard, *Evolution and the theory of Games*, New York: Cambridge University Press, 1982.
- Van Huyck, John B., Battalio, Raymond C. and Beil, Richard O., "Strategic Uncertainty, Equilibrium Selection and Coordination Failure in Average Opinion Games," *Quarterly Journal of Economics*, August 1991.
- Van Huyck, John B., Battalio, Raymond C. and Beil, Richard O., "Tacit Coordination Games, Strategic Uncertainty, and Coordination Failure," *The American Economic Review*, 80:1, March 1990.

## **APPENDIX A\***

### **INSTRUCTIONS**

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\*These instructions are here for the (1) replicability and (2) for the careful reader; they let him know exactly how we interpreted and applied the theory. Both are important to economics as a science.

**INSTRUCTIONS**

This is an experiment in the economics of strategic decision making. Various agencies have provided funds for this research. If you follow the instructions and make appropriate decisions, you can earn an appreciable amount of money. At the end of today's session, you will be paid in private and in cash.

It is important that you remain silent and do not look at other people's work. If you have any questions, or need assistance of any kind, please raise your hand and an experimenter will come to you. If you talk, laugh, exclaim out loud, etc., you will be asked to leave and you will not be paid. We expect and appreciate your cooperation.

You will be making choices on a Logitech mouse, which is located on the mouse pad in the middle of your table. You may move the pad to the right or left if this would be more comfortable. Hold the mouse in a relaxed manner with your thumb and little finger on either side of the mouse. Rest your wrist naturally on the table surface. When you move the mouse, let your hand pivot from the wrist. Use a light touch. Your cursor (a white arrow on your screen) should move when you slide the mouse on the mouse pad. If it does not, raise your hand.

To participate, you must be able to move the cursor onto an object and click any one of the mouse buttons. We will call pointing at an object and then clicking your mouse "clicking on" an object displayed on the screen. Click on the page down icon located below to display the next page.

PAGE 1

**GENERAL**

In this experiment you will participate in a market of seven people. At the beginning of period one, each of the participants in this room will be randomly assigned to a group of size seven and will remain in the same group for twenty periods. That is, you will remain grouped with the same six other participants for the next twenty periods.

In each period, every participant will pick a value of X. The values of X you may choose are any one of the 101 integers 0, 1, 2, . . . , 98, 99 or 100. The value you pick for X and the value of the 1st order statistic of the X's, (jointly determined by ALL SEVEN participants, including yourself), will determine the payoff you receive for that period.

Click on the page down icon to display the next page for a discussion of how to calculate the 1st order statistic.

PAGE 2

**THE 1st ORDER STATISTIC**

The 1st order statistic is determined as follows. Each period the choices made by all seven participants will be ordered from the smallest to the largest in numerical order. The 1st order statistic for that period is the smallest of the ordered choices.

To find the first order statistic, first (i) arrange the numbers in ascending order and then (ii) counting from the smallest, find the first number of the ordered numbers and that is the 1st order statistic.

For example, to find the 1st order statistic for the following seven numbers

252, 292, 270, 208, 259, 270, 281

Arrange the numbers in ascending order - -

c1	c2	c3	c4	c5	c6	c7
208,	252,	259,	270,	270,	281,	292
1	2	3	4	5	6	7

Then, counting from the smallest, find the 1st number of the ordered numbers, and that is the 1st order statistic. In this example the 1st order statistic is 208. The 1st order statistic is also identified by 'c1' over the number 208 and '1' under the number 208.

PAGE 3

## MAIN SCREEN

We will now view the main screen. You will use the main screen to make your choices each period. While you view the main screen I will read the description of the main screen contained in the next four pages. You can review the text that I am reading at any time during the experiment by returning to the instructions. Click on the word "MAIN" located on the second line down from the top of the screen now. (The second line is the light blue line on your screen).

The top line of the main screen displays the current period number, the title of the screen and your current balance. The second line has the word "PROCEED", the abbreviation "INSTR" and the word "RECORD" on it. During the session you will be able to return to these instructions by clicking on "INSTR." You will also be able to view the history of play by clicking on "RECORD", which I will explain in a moment.

The remainder of the screen contains: (1) Two blue bars and a blue box that will help you understand how your choice and the 1st order statistic influences your earnings each period, (2) A historical record of your past choices, the past 1st order statistics and your earnings for each period of this session, and (3) A bar that represents all seven participant's ordered choices and highlights the 1st order statistic in light blue.

Please look at the monitor at the front of the room while I demonstrate how to use the two blue bars and the blue box to calculate hypothetical earnings and how to enter your choice each period.

PAGE 4

Click on the blue bar labelled 1st ORDER STATISTIC and notice that the mouse cursor is replaced by a yellow vertical line and that a yellow vertical line also appears in the blue box. Immediately below the blue box the current value that you have chosen for the hypothetical 1st order statistic appears as a yellow number. Directly below the value for the hypothetical 1st order statistic are three yellow question marks, ????. The question marks are there to remind you that you DO NOT select the 1st order statistic. During the experiment the 1st order statistic will be jointly determined each period by ALL SEVEN participants in your group.

By moving your mouse left and right you can select any value between 0 and 100 for your choice of the hypothetical 1st order statistic. Click the mouse a second time to select a value for the hypothetical 1st order statistic and to restore the cursor.

Now click on the blue bar labelled YOUR CHOICE. Your mouse cursor is replaced by a green horizontal line and a green horizontal line also appears in the blue box. Immediately to the right of the blue box your current choice and your earnings associated with your current choice of X and the current hypothetical 1st order statistic appears in green. By moving your mouse up and down you can read off the earnings associated with all of your feasible choices and the currently selected hypothetical 1st order statistic. Click the mouse a second time to select a value for your choice and to restore the cursor.

PAGE 5

Now click again on the blue bar labelled 1st order statistic. By moving the mouse left and right you can read off the earnings associated with all of the possible values for the 1st order statistic and your currently selected choice of X. However, remember that during the experiment the 1st ORDER STATISTIC is jointly determined by the values of X chosen by ALL SEVEN participants. Your actual payoff will only correspond to a hypothetical payoff if the actual 1st order statistic corresponds to the hypothetical 1st order statistic. Now click the mouse to select a value and to restore the cursor.

Now click on the blue square. Notice that moving the mouse here lets you change both YOUR CHOICE of X and the hypothetical value of the 1st ORDER STATISTIC. Click the mouse a second time to select a value and to restore the cursor.

In summary, the difference in the three active boxes is in what they control. Clicking on the horizontal bar allows you to change the hypothetical value of the 1st order statistic, while leaving the value of your choice unchanged. Clicking on vertical bar allows you to change the value of your choice by moving its green line up or down with the mouse while leaving the hypothetical value of the 1st order statistic unchanged. Clicking on the blue box allows you to change both values simultaneously.

PAGE 6

The four columns on the right side of the screen contain the period number, under the label 'Per', a history of your past choices, under the label 'Your Choice', the value of past 1st order statistics, under the label '1st Order Statistic', and your earnings for each past period, under the label 'Your Earnings'. When the history fills all of the available lines, only the most recent lines will be displayed. You may use the page up, page down, line up and line down icons at the bottom to review the earlier records.

At the bottom of the main screen is a representation of the ordered participant's choices, in order from smallest to largest (c1, c2, c3, c4, c5, c6, c7). The 1st order statistic is highlighted in light blue and enclosed with a light blue box. The number 1 is also highlighted in blue.

When you are ready to enter a choice for a period you do so by clicking on "PROCEED", located on the second line of the main screen. Click on "PROCEED" now and notice that the message 'DO YOU WANT TO PROCEED' in appears in yellow. To proceed you click on the word "YES", in green at the right side of the line. If you want to change your choice at this point you would click on the word "NO", in red. Click on "NO" now and notice that the choice you had entered is canceled and you must now make another choice to proceed.

Now click on the blue square. Click the mouse a second time to select a value and to restore the cursor. Click on "PROCEED" now. If you click on "YES" your choice for the period will be entered. Please click on "YES" now to return to the instructions.

PAGE 7

#### **WAITING SCREEN**

During a session a waiting screen will appear after you have made a choice. While you are waiting, you can use the two blue bars and the blue box to perform hypothetical calculations that will help you understand how your choice and the 1st order statistic influences your earnings each period, similar to the calculations that you can make on the main screen. NOTICE: the vertical line, your choice and earnings and the horizontal line and hypothetical value for the 1st order statistic are ALL IN YELLOW. This color coding is to remind you that you have already made your choice and are currently waiting for other participants to make their choices. NOTICE: the second line DOES NOT contain PROCEED.

In addition to making hypothetical calculations, you may also view the instructions and the record screen by clicking on "INSTR" or "RECORD." When all participants have made a choice for the current period you will be automatically switched to the outcome screen. The choice displayed on the WAITING SCREEN is the choice that you made during the demonstration of the main screen. You will automatically return to the instructions in twenty seconds. Click on "WAITING" now.

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#### **OUTCOME SCREEN**

During a session, after everyone has made their choices, the outcome screen will appear. The outcome screen summarizes what happened each period for ten seconds. Your choice and period earnings will be highlighted in ^CKAgreen^CPA. The 1st order statistic, jointly determined by all seven participants in your group, will be highlighted in ^CEA^Elred^E0^CPA. At the bottom of the OUTCOME SCREEN the value of the 1st order statistic for the current period will also be shown in light blue with a light blue outline. The number '1' is also highlighted in light blue.

During the experiment, after the period 1 outcome screen has been displayed for ten seconds, you will automatically advance to period 2. Your main screen for period 2 will appear and you may then make a choice for period 2 whenever you are ready. After the outcome screen for period 2 has been displayed for ten seconds you will automatically advance to period 3. This will continue for twenty periods.

The outcome screen is not active and, therefore, your mouse cursor will not be present while the outcome screen is displayed. Click on "OUTCOME" now. The value displayed on the outcome screen for YOUR CHOICE is the selection that you made earlier during these instructions. Two different values of the 1st order statistic will each be displayed for ten seconds during this demonstration. I have arbitrarily chosen the values of 25 and 75 for the 1st order statistic during these instructions. You will automatically return to the instructions in twenty seconds.

PAGE 9

**RECORD SCREEN**

The record screen records the period outcomes and updates your earnings balance. The record screen contains all of the information contained in the past history on the MAIN SCREEN and the WAITING SCREEN plus an additional column labelled Balance that has your balance at the end of each period. At the beginning of the first period your balance is zero. At the end of each period your current period earnings will be added to your balance. At the end of this experiment you will be paid your ending balance, (the sum of all of your period earnings), in cash.

Click on the word "RECORD" located on the second line down from the top of your screen now. As the experiment proceeds the records for the earlier periods will scroll off the top of the record screen. You may review the earlier records by clicking on the page up, page down, line up and line down icons located at the bottom of the record screen. Click on RETURN to leave the RECORD SCREEN.

**QUESTIONNAIRE**

We will now pass out a questionnaire to make sure that all participants understand how to use the two blue bars and the blue box and to make sure that all participants know how to calculate the 1st order statistic and their earnings. Please fill out the questionnaire now. Do not put your name on the questionnaire. Raise your hand when you are finished and we will collect it. If there are any mistakes on any questionnaire, I will go over the relevant part of the instructions again.

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**SUMMARY**

\*\*\* At the beginning of period one, each of the participants in this room will be randomly assigned to a group of size seven and will remain in the same group for twenty periods.

\*\*\* In each period, every participant will pick a value of X. The value you pick for X and the value of the 1st order statistic of the X's, (jointly determined by ALL SEVEN participants, including yourself), will determine the payoff you receive for that period.

\*\*\* You make a choice by (i) selecting a value between 0 and 100 for X using the blue bars and/or the blue box, (ii) clicking the mouse a second time, to select your choice and restore your cursor and then (iii) clicking on "PROCEED" and "YES" to enter and confirm your choice for the current period.

\*\*\* Remember that you can view the instructions or the record screen by clicking on the appropriate word on the light blue bar.

\*\*\* Your balance at the end of the session, if positive, will be paid to you in private and in cash. If your balance is negative you will be paid zero.

Click on the page down icon located below to display the next page.

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We have completed the instructions. Again, it is important that you remain silent and do not look at other people's work.

If you have a question, please raise your hand, and an experimenter will come to assist you. If there are no questions, period one of the experiment will begin.

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**TREATMENT CHANGES**

There will be twenty periods in this part of the session.

Beginning with period twenty-one, each of the fourteen participants in the experiment will be randomly re-paired with **ONE** other participant. That is, **At the Beginning** of each decision making period you will be randomly re-paired with another participant. Hence, at the beginning of each decision making period, you will have a one in thirteen chance of being matched with any one of the other thirteen participants in this experiment.

As before, in each period, every participant will pick a value of X. Similarly the value of the 1st ORDER STATISTIC of the X's chosen by you and the participant that you are randomly paired with during the current period and the value of YOUR CHOICE of X will determine the payoff you receive for that period. All of the labels on the Main Screen, the Waiting Screen, the Outcome Screen and the Record Screen have been changed to reflect that the 1st order statistic is now based on the values for two choices of X, your choice of X and the choice of X made by the subject that you are currently paired with for this period.

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**THE 1st ORDER STATISTIC**

The 1st order statistic is determined as before except that now there are only two choices of X to consider each period.

For example, to find the 1st order statistic for the following two numbers

252, 208

Arrange the numbers in ascending order - -

c1	c2
208,	252
1	2

Then, counting from the smallest, find the 1st of the ordered numbers, and that is the 1st order statistic. In this example the 1st order statistic is 208. The 1st order statistic is also identified by 'c1' over the number 208 and '1' under the number 208.

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You will start a new record screen. To review the first twenty periods click on "PREVIOUS", which will be located in the upper left corner of the new record screen. Click on "NEXT" to return to the current record screen. The other functions of the record screen work as before.

If you have any questions please raise your hand. If there are no questions click on RETURN now.

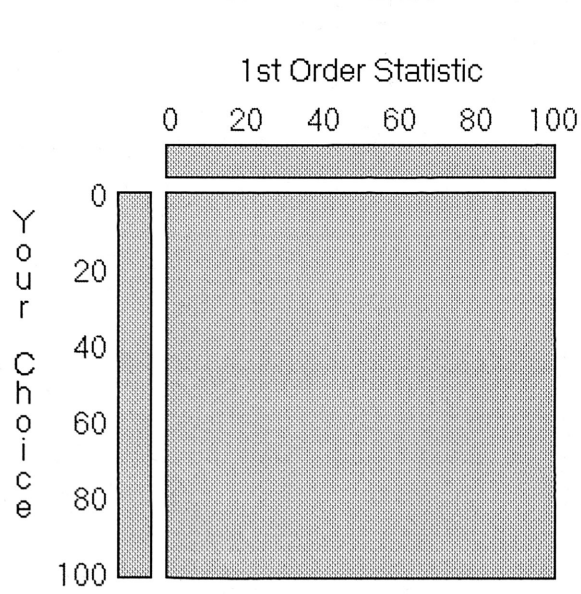
PAGE 15

Period: 0

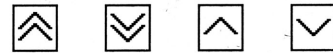
MAIN

Balance: \$ 0.00000

PROCEED INSTR RECORD



1st  
Your Order Your  
Per Choice Statistic Earnings



Ordered Participant Choices

c1	c2	c3	c4	c5	c6	c7
1	2	3	4	5	6	7

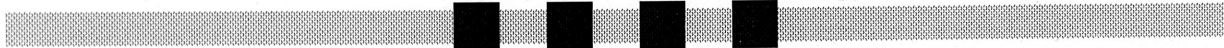
Period 6

RECORD SCREEN

Balance \$ 2.15274

RETURN

Period	Your Choice	1st Order Statistic	Your Earnings	Balance
1	60	50	0.58200	0.58200
2	55	50	0.59550	1.17750
3	96	50	0.21912	1.39662
4	5	50	0.23550	1.63212
5	29	50	0.52062	2.15274



# QUESTIONNAIRE

## 1st ORDER STATISTIC

YOUR CHOICE

	0	17	33	50	67	83	100
0	(1) _____	0.34998	0.30198	_____	(2) _____	-0.44202	(3) _____
17	0.24798	0.40200	0.45192	0.40398	0.25200	_____	-0.34002
33	_____	0.35592	0.49800	0.54798	(7) _____	0.34800	0.09198
50	-0.15000	_____	0.44598	0.60000	0.64998	0.60198	0.45000
67	(4) _____	-0.04800	0.28992	(6) _____	0.70200	0.75192	_____
83	-0.94002	-0.38208	_____	0.40398	0.65592	0.79800	0.84798
100	(5) _____	-0.83802	-0.31002	0.15000	_____	0.74598	0.90000

## QUESTIONNAIRE (Cont'd)

(1) Assume the following choices of X are made by the seven participants in a group.

<u>Participant</u>	<u>Choice of X</u>
P <sub>1</sub>	88
P <sub>2</sub>	15
P <sub>3</sub>	40
P <sub>4</sub>	72
P <sub>5</sub>	30
P <sub>6</sub>	91
P <sub>7</sub>	21

(a) Arrange the numbers in ascending order.

<u>c<sub>1</sub></u>	<u>c<sub>2</sub></u>	<u>c<sub>3</sub></u>	<u>c<sub>4</sub></u>	<u>c<sub>5</sub></u>	<u>c<sub>6</sub></u>	<u>c<sub>7</sub></u>
<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>

(b) Circle the 1st order statistic in (a) above and calculate the earnings for each participant.

<u>Participant</u>	<u>Choice of X</u>	<u>Earnings</u>
P <sub>1</sub>	88	_____
P <sub>2</sub>	15	_____
P <sub>3</sub>	40	_____
P <sub>4</sub>	72	_____
P <sub>5</sub>	30	_____
P <sub>6</sub>	91	_____
P <sub>7</sub>	21	_____

**1st ORDER STATISTIC**

**Y  
O  
U  
R  
  
C  
H  
O  
I  
C  
E**

	<b>0</b>	<b>17</b>	<b>33</b>	<b>50</b>	<b>67</b>	<b>83</b>	<b>100</b>
<b>0</b>	0.30000	0.34998	0.30198	0.15000	-0.10602	-0.44202	-0.90000
<b>17</b>	0.24798	0.40200	0.45192	0.40398	0.25200	0.01392	-0.34002
<b>33</b>	0.10398	0.35592	0.49800	0.54798	0.49392	0.34800	0.09198
<b>50</b>	-0.15000	0.20598	0.44598	0.60000	0.64998	0.60198	0.45000
<b>67</b>	-0.50802	-0.04800	0.28992	0.54798	0.70200	0.75192	0.70398
<b>83</b>	-0.94002	-0.38208	0.04800	0.40398	0.65592	0.79800	0.84798
<b>100</b>	-1.50000	-0.83802	-0.31002	0.15000	0.50598	0.74598	0.90000

## **APPENDIX B\***

### **INDIVIDUAL SUBJECT DATA**

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\*The National Science Foundation requires that all primary data be made available for any project which it funds.

INDIVIDUAL DATA, DESIGN, SESSION AND DATE

----- GROUPSZ=5 ORD\_STAT=2 SESSION=SESS01A DESIGN=cr1\_0502 DATE=11/23/92 -----

SUBJECT	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20
1	50	49	53	45	61	44	49	46	49	45	43	43	47	43	43	49	43	43	43	46
2	100	100	46	46	44	45	44	44	43	43	100	43	43	69	43	43	50	43	43	43
3	50	46	46	47	46	57	60	43	43	45	43	44	43	43	43	43	41	46	46	46
4	42	48	44	44	41	49	44	44	45	43	45	43	43	43	43	43	43	43	43	43
5	40	40	40	40	40	40	40	40	40	40	40	42	42	42	42	43	43	44	43	43
x2nd	42	46	44	44	41	44	44	43	43	43	43	43	43	43	43	43	43	43	43	43

----- GROUPSZ=5 ORD\_STAT=2 SESSION=SESS01B DESIGN=cr1\_0502 DATE=11/23/92 -----

SUBJECT	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20
6	35	38	40	44	50	40	41	40	40	43	41	40	40	41	40	40	40	40	40	40
7	51	42	43	43	40	40	60	40	40	45	40	40	40	40	40	40	40	40	40	40
8	33	38	40	35	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
9	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
10	40	53	46	46	44	41	41	41	41	41	41	41	41	41	41	40	40	40	40	40
x2nd	35	38	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40

----- GROUPSZ=5 ORD\_STAT=2 SESSION=SESS03A DESIGN=cr1\_0502 DATE=11/24/92 -----

SUBJECT	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20
1	85	74	85	85	87	90	82	80	90	90	95	95	96	97	98	100	100	100	100	100
2	55	73	85	85	88	90	93	85	88	89	90	91	94	96	98	98	100	100	100	100
3	50	64	72	78	80	74	100	80	83	90	91	92	92	95	100	99	100	100	100	100
4	48	45	58	59	71	75	71	72	90	95	96	98	99	100	100	100	100	100	100	100
5	75	92	67	72	80	83	77	82	78	87	89	93	95	98	98	100	100	100	100	100
x2nd	50	64	67	72	80	75	77	80	83	89	90	92	94	96	98	99	100	100	100	100

----- GROUPSZ=5 ORD\_STAT=2 SESSION=SESS03B DESIGN=cr1\_0502 DATE=11/24/92 -----

SUBJECT	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20
6	100	100	50	45	34	39	39	36	36	36	36	36	36	36	36	36	36	36	36	36
7	40	36	36	36	37	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36
8	15	16	20	35	40	35	35	35	35	35	35	35	37	38	36	36	36	36	36	36
9	36	40	50	43	36	36	43	39	30	40	37	28	35	37	36	45	36	36	36	36
10	100	100	36	36	36	36	100	36	36	38	36	37	36	36	36	36	36	40	36	36
x2nd	36	36	36	36	36	36	36	36	35	36	36	35	36	36	36	36	36	36	36	36



INDIVIDUAL DATA, DESIGN, SESSION AND DATE

----- GROUPSZ=5 ORD\_STAT=4 SESSION=SESS04A DESIGN=cr1\_0504 DATE=11/30/92 -----

SUBJECT	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20
1	50	50	70	90	100	88	100	100	100	100	100	100	100	100	100	100	100	100	100	100
2	78	90	93	100	90	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
3	56	73	86	96	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
4	85	90	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
5	58	71	85	93	96	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
x4th	78	90	93	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

----- GROUPSZ=5 ORD\_STAT=4 SESSION=SESS04B DESIGN=cr1\_0504 DATE=11/30/92 -----

SUBJECT	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20
6	45	52	62	55	69	67	74	77	80	80	80	80	80	80	80	80	80	80	80	80
7	69	67	80	99	70	76	79	86	80	80	80	80	80	80	80	80	80	80	80	80
8	82	85	75	70	80	93	80	80	78	80	80	80	80	80	80	80	80	80	80	80
9	42	57	50	73	82	78	88	80	82	82	80	80	80	80	80	87	80	80	80	80
10	50	50	53	61	64	67	73	71	75	77	79	80	80	80	80	80	80	80	81	80
x4th	69	67	75	73	80	78	80	80	80	80	80	80	80	80	80	80	80	80	80	80

----- GROUPSZ=5 ORD\_STAT=4 SESSION=SESS05A DESIGN=cr1\_0504 DATE=11/30/92 -----

SUBJECT	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20
1	51	36	96	100	99	100	0	100	100	100	100	100	100	100	100	100	100	100	100	100
2	64	94	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
3	71	98	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
4	97	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
5	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
x4th	97	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

----- GROUPSZ=5 ORD\_STAT=4 SESSION=SESS05B DESIGN=cr1\_0504 DATE=11/30/92 -----

SUBJECT	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20
6	67	60	90	95	95	97	100	100	100	100	100	100	100	100	100	100	100	100	100	100
7	97	99	98	98	97	99	100	100	100	100	100	100	100	100	100	100	100	100	100	100
8	76	90	95	95	95	97	99	100	100	100	100	100	100	100	100	100	100	100	100	100
9	95	95	95	95	95	95	97	96	95	100	100	100	100	100	100	100	100	100	100	100
10	22	21	75	95	99	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
x4th	95	95	95	95	97	99	100	100	100	100	100	100	100	100	100	100	100	100	100	100

INDIVIDUAL DATA, DESIGN, SESSION AND DATE

----- GROUPSZ=7 ORD\_STAT=1 SESSION=SESS09A DESIGN=cr1\_0701 DATE=03/08/93 -----

SUBJECT	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20
1	82	58	42	39	18	0	9	18	7	5	1	1	1	1	2	1	1	1	1	1
2	100	100	0	0	0	0	100	100	100	100	100	100	80	80	80	81	70	100	87	100
3	88	50	35	80	20	17	50	40	18	84	100	8	0	7	1	23	23	0	0	0
4	100	80	60	50	36	31	20	10	5	5	5	5	5	5	5	5	5	5	5	5
5	40	39	60	30	30	5	1	1	1	1	0	1	1	1	1	1	0	0	0	0
6	60	60	50	50	21	6	10	10	10	10	10	10	10	10	6	6	6	6	6	6
7	100	50	53	50	83	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
x1st	40	39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

----- GROUPSZ=7 ORD\_STAT=1 SESSION=SESS09B DESIGN=cr1\_0701 DATE=03/08/93 -----

SUBJECT	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20
8	100	100	100	0	0	0	0	0	0	0	0	0	0	0	17	0	0	0	0	0
9	88	0	33	0	15	100	91	90	22	88	24	84	98	0	0	0	20	63	0	0
10	58	70	50	50	0	58	0	39	39	0	39	0	39	39	24	16	10	8	10	11
11	100	100	54	17	17	5	5	5	5	5	5	5	5	5	1	1	1	1	0	0
12	100	67	4	5	1	1	19	5	17	1	7	1	19	1	11	0	0	2	0	0
13	100	58	100	100	0	0	0	0	0	0	0	0	0	1	33	0	0	0	0	0
14	60	75	50	40	25	20	10	5	5	4	0	1	1	0	1	1	1	1	1	0
x1st	58	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

----- GROUPSZ=7 ORD\_STAT=1 SESSION=SESS10A DESIGN=cr1\_0701 DATE=03/09/93 -----

SUBJECT	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20
1	41	37	67	11	4	80	60	0	0	0	0	0	0	0	0	0	0	0	0	0
2	75	75	15	5	1	1	0	0	0	5	0	0	0	0	0	0	0	0	0	0
3	67	55	40	30	25	30	15	10	0	5	1	1	1	1	1	1	1	1	1	0
4	73	55	48	10	0	0	7	0	1	0	0	0	0	0	0	0	0	0	0	0
5	37	47	61	33	18	20	15	15	6	7	5	4	4	4	4	4	4	4	4	4
6	39	25	39	59	51	42	34	44	19	18	9	4	6	5	2	7	4	4	3	1
7	50	20	28	43	20	20	0	17	5	0	5	0	0	0	0	0	0	0	0	0
x1st	37	20	15	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

----- GROUPSZ=7 ORD\_STAT=1 SESSION=SESS10B DESIGN=cr1\_0701 DATE=03/09/93 -----

SUBJECT	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20
8	56	17	19	18	7	16	15	24	19	14	12	16	14	10	13	11	8	5	6	7
9	35	16	30	28	28	25	25	20	20	17	20	20	14	15	15	15	15	15	15	15
10	60	60	40	20	25	10	30	25	20	15	15	15	10	10	10	12	10	10	9	15
11	50	13	24	22	15	25	19	21	12	10	10	16	10	15	11	10	8	6	5	10
12	75	40	40	40	40	13	14	15	16	16	15	16	14	14	14	14	8	8	8	0
13	71	15	17	11	20	22	22	11	21	25	14	18	9	12	18	8	7	11	10	8
14	0	100	49	74	21	21	21	9	5	8	12	6	3	6	8	4	1	4	6	2
x1st	0	13	17	11	7	10	14	9	5	8	10	6	3	6	8	4	1	4	5	0

INDIVIDUAL DATA, DESIGN, SESSION AND DATE

----- GROUPSZ=7 ORD\_STAT=2 SESSION=SESS06A DESIGN=cr1\_0702 DATE=12/02/92 -----

SUBJECT	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20
1	36	31	32	36	29	31	25	27	26	27	26	27	27	28	28	27	27	27	27	28
2	33	66	99	9	10	26	83	8	50	0	22	26	27	22	32	28	29	27	27	27
3	100	100	48	35	37	26	39	28	26	26	26	26	26	36	30	31	28	27	27	27
4	100	50	35	33	31	35	30	26	28	27	26	26	27	28	28	27	28	28	28	28
5	50	50	83	33	100	70	33	32	27	27	28	25	27	27	27	42	33	30	43	34
6	34	38	33	35	32	31	29	27	27	27	40	35	36	28	30	28	27	27	27	27
7	23	25	17	30	31	27	26	27	24	26	26	59	27	48	27	45	44	27	27	27
x2nd	33	31	32	30	29	26	26	26	26	26	26	26	26	27	27	27	27	27	27	27

----- GROUPSZ=7 ORD\_STAT=2 SESSION=SESS06B DESIGN=cr1\_0702 DATE=12/02/92 -----

SUBJECT	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20
8	99	39	39	39	38	39	39	38	40	37	37	36	36	36	100	36	36	36	36	36
9	39	39	40	39	39	40	39	39	39	39	39	37	37	37	37	37	37	37	37	36
10	60	70	39	39	39	39	39	39	38	37	48	42	42	45	45	45	45	36	36	60
11	83	100	48	27	55	39	46	40	36	34	35	37	39	36	25	36	40	37	37	40
12	2	50	34	50	39	75	36	30	50	40	40	44	36	36	36	35	36	36	36	36
13	43	63	39	39	39	39	39	37	37	37	37	36	36	36	36	36	36	36	36	36
14	66	56	42	42	41	41	38	43	46	46	36	40	40	37	37	37	30	40	40	36
x2nd	39	39	39	39	39	39	38	37	37	37	36	36	36	36	36	36	36	36	36	36

----- GROUPSZ=7 ORD\_STAT=2 SESSION=SESS07A DESIGN=cr1\_0702 DATE=12/02/92 -----

SUBJECT	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20
1	50	0	100	0	0	0	0	1	0	0	0	0	0	0	0	17	0	0	0	0
2	46	33	10	10	50	20	50	22	17	18	22	21	21	20	20	20	20	20	20	39
3	2	19	8	50	17	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	50	7	16	9	95	17	33	50	60	84	92	6	15	5	0	100	0	12	27	0
5	6	14	1	1	30	10	5	5	0	0	4	1	1	0	2	0	99	0	0	0
6	15	21	29	12	16	33	33	8	5	17	10	0	11	0	0	0	10	0	9	12
7	100	100	100	8	0	0	33	0	0	0	0	0	0	0	0	0	0	0	0	0
x2nd	6	7	8	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

----- GROUPSZ=7 ORD\_STAT=2 SESSION=SESS07B DESIGN=cr1\_0702 DATE=12/02/92 -----

SUBJECT	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20
8	32	35	35	66	50	37	34	35	33	33	35	33	33	33	33	33	33	33	33	33
9	100	100	100	35	33	33	33	33	78	33	33	33	33	33	33	33	33	30	33	33
10	48	45	42	33	35	34	33	33	32	44	33	33	33	33	33	33	33	33	33	33
11	48	33	49	37	34	33	39	38	40	33	33	33	33	33	34	33	33	33	33	33
12	60	50	50	50	40	33	40	33	50	33	40	40	33	33	33	33	33	33	33	33
13	20	35	35	35	35	33	33	33	35	33	33	33	33	33	33	33	33	33	33	33
14	97	100	100	30	32	33	33	34	33	33	33	33	33	33	34	33	33	33	33	33
x2nd	32	35	35	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33

INDIVIDUAL DATA, DESIGN, SESSION AND DATE

----- GROUPSZ=7 ORD\_STAT=4 SESSION=SESS00A DESIGN=cr1\_0704 DATE=11/19/92 -----

SUBJECT	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20
1	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
2	42	60	88	92	95	98	100	100	100	100	100	100	100	100	100	100	100	100	100	100
3	100	100	100	88	92	95	99	100	100	100	100	100	100	100	100	100	100	100	100	100
4	50	50	67	92	96	98	100	2	98	100	100	100	100	100	100	100	100	100	100	100
5	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
6	50	58	82	86	94	96	100	50	100	100	100	100	100	100	100	100	100	100	100	100
7	80	84	88	95	85	95	94	100	100	100	100	100	100	100	100	100	100	100	100	100
x4th	80	84	88	92	95	98	100	100	100	100	100	100	100	100	100	100	100	100	100	100

----- GROUPSZ=7 ORD\_STAT=4 SESSION=SESS00B DESIGN=cr1\_0704 DATE=11/19/92 -----

SUBJECT	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20
8	50	93	65	50	50	50	80	41	50	48	49	51	51	51	51	51	51	51	51	100
9	100	36	36	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
10	40	51	46	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
11	100	50	50	50	51	56	50	50	50	100	50	50	50	50	50	50	50	50	50	50
12	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
13	33	33	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
14	50	33	67	50	49	50	50	50	67	50	50	50	50	50	50	50	50	50	50	50
x4th	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50

----- GROUPSZ=7 ORD\_STAT=4 SESSION=SESS02A DESIGN=cr1\_0704 DATE=11/23/92 -----

SUBJECT	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20
1	57	70	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
2	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
3	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
4	50	75	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
5	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
6	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
7	60	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
x4th	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

----- GROUPSZ=7 ORD\_STAT=4 SESSION=SESS02B DESIGN=cr1\_0704 DATE=11/23/92 -----

SUBJECT	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20
8	45	73	73	73	73	73	73	73	73	73	73	73	73	73	74	73	73	73	73	73
9	100	100	73	73	73	59	73	0	73	73	73	78	73	73	73	73	73	75	73	72
10	77	77	75	73	74	73	74	73	73	73	73	73	73	73	73	73	73	73	73	73
11	100	100	100	100	73	73	73	73	85	73	74	73	73	73	74	73	75	73	73	73
12	40	60	73	73	73	73	73	73	73	73	73	73	73	73	73	73	73	73	73	73
13	50	50	50	73	100	73	73	73	73	73	75	73	73	73	73	73	73	73	73	73
14	73	45	59	53	70	73	73	74	73	73	73	73	73	73	73	73	73	73	73	73
x4th	73	73	73	73	73	73	73	73	73	73	73	73	73	73	73	73	73	73	73	73

INDIVIDUAL DATA, DESIGN, SESSION AND DATE

----- GROUPSZ=7 ORD\_STAT=4 SESSION=SESS08A DESIGN=cr1\_0704 DATE=12/03/92 -----

SUBJECT	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20
1	46	48	60	65	70	75	80	85	90	95	100	50	73	76	80	84	88	92	96	100
2	62	65	61	64	71	75	80	85	90	95	100	55	70	75	80	85	88	92	96	100
3	7	55	49	53	57	59	63	67	69	74	83	68	71	53	68	67	74	77	79	84
4	100	100	68	68	68	76	83	90	100	100	100	100	100	85	85	88	90	100	100	100
5	50	55	60	67	70	75	80	85	90	90	100	100	80	80	80	85	89	92	96	100
6	69	49	60	69	70	80	80	85	90	95	100	100	69	76	80	84	88	92	96	100
7	28	61	83	65	71	75	80	85	90	95	100	50	72	77	80	84	88	92	96	100
x4th	50	55	60	65	70	75	80	85	90	95	100	68	72	76	80	84	88	92	96	100

----- GROUPSZ=7 ORD\_STAT=4 SESSION=SESS08B DESIGN=cr1\_0704 DATE=12/03/92 -----

SUBJECT	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20
8	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
9	60	65	80	85	95	96	100	99	100	100	100	100	100	100	100	100	100	100	100	100
10	100	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
11	90	75	70	75	80	85	90	91	92	93	94	95	99	99	99	99	98	99	99	99
12	65	65	70	75	83	90	97	100	100	100	100	100	100	100	100	100	100	100	100	100
13	70	75	80	85	90	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
14	68	83	92	94	95	98	100	100	100	100	100	100	100	100	100	100	100	100	100	100
x4th	70	75	80	85	95	98	100	100	100	100	100	100	100	100	100	100	100	100	100	100