Exposing an individual to two types of prisoner's dilemma game matrix formats*

THOMAS L. RADINSKY†
University of Iowa, Iowa City, Iowa 52240

A study was conducted to provide direction to further research and theorizing concerning the nature of the variables that cause people to respond differentially to structurally different, but theoretically equivalent, matrix formats. Changes in the response pattern of a single individual were observed as a function of the matrix format presented. These results were interpreted as suggesting that individuals are responsive to such nonstrategic factors as format and that research should be directed at identifying and assessing the influence of these psychologically important factors.

Numerous studies have been conducted on the various factors which influence the behavior of people playing experimental games. In these studies, it has generally been assumed that the nature of the display (here termed a matrix format) used to inform the Ss about the structure and payoffs of the game is strategically irrelevant. Recent studies with the prisoner's dilemma game (PDG)¹ have shown that this assumption is incorrect (Evans & Crumbaugh, 1966; Pruitt, 1967). These investigators conducted studies in which it was found that the amount of cooperation in a PDG was significantly influenced by the matrix format used, even though these matrix formats were algebraically equivalent. These results were interpreted by Evans and Crumbaugh and by Pruitt as showing that individuals do not necessarily perceive all algebraically equal situations as psychologically equal. An individual responds differently from one matrix format compared to another because for him they are not identical situations, even though they are mathematically identical. A question that readily arises from this observation is why is it that people respond differently to theoretically identical situations? The present research was designed to provide an initial step in determining the answer to this question.

Both Pruitt (1967) and Evans & Crumbaugh (1966) used separate

groups of Ss in the experimental and control groups. In light of their findings and the implications they have for gaming research, further insight may be obtained into the nature of the variables that cause people to respond differentially to different, but algebraically identical, matrix formats by sequentially exposing an individual to different matrix formats. On the one hand, if no change in an individual's response pattern was observed contingent on a shift in the matrix format, it would suggest that the variables producing the differences in response patterns between groups, reported in the previous studies, are not present or not effective within a single person who is sequentially exposed to the algebraically equal matrix formats. On the other hand, changes in response patterns may occur. In fact, if the responses of an individual are related primarily to the matrix format, as the work of Pruitt (1967) and Evans & Crumbaugh (1966) implies, one would expect radical shifts in response patterns as a function of the matrix format being presented.

METHOD

Three types of matrix formats were used in the present study. One was the matrix format which has been used in most PDG studies. This matrix format is here designated a 2 by 2 matrix format and is illustrated in Fig. 1a. The other two, designated T1 and T2,² were variations of the decomposed matrix format developed by Pruitt (1967) and, independently, by Messick & McClintock (1968).³ The general form of the decomposed matrix format is shown in Fig. 1b. With the decomposed matrix, given any set of values for w, x, y, and z which meet the PDG requirements (see Pruitt, 1967), an algebraically equivalent 2 by 2 matrix format can be written. The reverse is not true for

Fig. 1. General forms of the 2 by 2 matrix format and the decomposed matrix format. Note: With the 2 by 2 matrix format, the row person receives the outcome under the diagonal and the column person the outcome above the diagonal. A game is a PDG if $2a > b + c > 2d$, and $c > a > d > b$. The 2 by 2 and decomposed matrix format games are the same if $w + x = a$, $x + y = c$, $w + z = b$, $y + z = d$.

all values of a, b, c, and d in the 2 by 2 matrix format which are PDGs. In addition, transformations of w, x, y, and z are possible which correspond to the same 2 by 2 matrix format game. In fact, there are an infinite number of these transformations for a given 2 by 2 matrix format equivalent.

The numerical values used in the 2 by 2 matrix format were $a = 10$, $b = 0$, $c = 15$, and $d = 5$. The numerical values used in the decomposed matrix format were $w = 0$, $x = 10$, $y = 5$, and $z = 0$ and for the T2 decomposed matrix format were $w = 5$, $x = 5$, $y = 10$, and $z = 5$.

The Ss were 112 females from introductory psychology courses at the University of Iowa who chose to participate in experiments to fulfill course requirements. They were requested not to sign up for the same experimental session that a friend did.

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†Now at the American Institutes for Research, Pittsburgh, Pa. Requests for reprints should be addressed to American Institutes for Research, 710 Chatham Center Office Building, Pittsburgh, Pa. 15219.

Table 1
Mean Individual Changes and Their Standard Deviations for Each Group
Between the Last Eight Trials of Each Part

Initial Matrix Format	Final Matrix Format		
	2 by 2	Evans- Crumbaugh Decomposed	Type 2 Decomposed
2 by 2	-0.13 (2.20)	+1.25 (2.90)	—
Evans-Crumbaugh Decomposed	-1.56 (2.32)	+0.06 (1.89)	-0.94 (4.84)
Type 2 Decomposed	—	+0.81 (3.66)	-0.81 (4.39)

Note—Positive values indicate more cooperation in the second part than in the first part, and negative values indicate the reverse. The standard deviations for the change scores are in parentheses.

The Ss were seated at opposite sides of a table, separated by a wooden partition. The E⁴ stood near the end of this partition while reading the instructions so as to be visible to both Ss. The instructions for the 2 by 2 format matrix were similar to those generally used in PDG studies (e.g., Rapoport & Chammah, 1965, Appendix I, pp. 228-229). The instructions for the decomposed matrix format were similar to those used by Pruitt (1967). The Ss were shown a display and informed how to read it. Choices were indicated by the Ss' selecting a small sheet of paper with either a 1 or a 2 on it. With the 2 by 2 matrix, the person selecting the rows had green sheets and the one selecting columns had pink sheets. With the decomposed games, one person was arbitrarily given green sheets and the other pink sheets. These sheets were pushed through a slot in a panel which ran the length of the table, and behind which the E sat during the experiment. Once the E received the sheets from both Ss, he recorded their choices and then gave each S the appropriate payoff along with the other S's response sheets. The payoffs were in the form of poker chips which represented points. In actuality, the E did not use the sheet sent by the other S, but rather he used a predetermined strategy based on the

S's own choices. The E initially made a cooperative choice and then made the same choice on the following trial as the S had made on the preceding trial.

After 15 trials, all Ss were interrupted. The displays before the Ss were changed according to a previously established random pattern, and then an abbreviated set of new instructions was read. There followed an additional 15 trials.

In all cases, in the new display the positions of the cooperative and competitive choices were reversed and the payoffs were linearly transformed relative to the former display by adding or subtracting four to each entry of the first matrix. This linear transformation did not cause any changes in the sign of the payoffs. The matrices were transformed so as to avoid the possibility that individuals would respond to the new display simply on the basis of the payoff magnitudes. The groups used in the present study are shown in Table 1.

RESULTS

The principal dependent measure was the difference between the number of cooperative choices an individual made in the last eight trials of the second part and the number of cooperative choices he made in the last eight trials of the first part. Table 1 shows the means and standard deviations of the change scores for the

individuals in each group. Only the responses during the last eight trials were scored in order to reduce the influence of initial learning and task familiarization.

Inspection of Table 1 reveals that the changes which occurred in an individual's responses were consistent with the results of the previous between-group studies. Changing to a 2 by 2 or T2 decomposed matrix format from a T1 decomposed matrix format resulted in a decrease in cooperation, while changing in the reverse direction resulted in an increase in cooperation.

A 2 by 2 analysis of variance was conducted on the data in the upper left four cells. One factor was the initial matrix format and the other, the final matrix format. Both the effects of the initial and final matrix formats were significant ($F = 4.65$ and $F = 6.07$, respectively, $df = 1/60$, $p < .05$ for both). The interaction between the two factors was not significant. Individuals became significantly more cooperative when shifted from a 2 by 2 to a T1 decomposed matrix format and less cooperative with the reverse shift relative to individuals for whom no shift was made in the matrix format.

Another 2 by 2 analysis of variance was performed on the data from the lower right four cells. There were no significant F ratios in this analysis. Inspection of Table 1 indicated that the variance in the lower right three cells was greater than in the upper left four cells. The T2 decomposed matrix format appears to elicit widely divergent responses from individuals.

Further evidence of the tendency of the T2 decomposed matrix format to elicit heterogeneous reactions is available in Table 2. Table 2 shows the mean number of cooperative choices made by each group in both parts of the experiment during the last eight trials. The mean amount of cooperation in the first part of the experiment was relatively consistent among groups for both the T1 decomposed and 2 by 2 matrix formats. However, with the T2 decomposed matrix format, the initial mean level of cooperation differed considerably for the two groups begun with this matrix format. In addition, a substantial change in the number of cooperative choices occurred with the T2 decomposed matrix format when individuals were simply shifted to a reversed transformed T2 decomposed matrix format. Further research is needed to determine the factors which underlie the diverse reactions of individuals to the T2 decomposed matrix format.

DISCUSSION

The hypothesis that individuals

Table 2
Mean Number of Cooperative Choices Made by Each Group
in Both Parts of the Experiment

Initial Matrix Format	Experiment Part	Final Matrix Format		
		2 by 2	Evans- Crumbaugh Decomposed	Type 2 Decomposed
2 by 2	First	4.19	3.31	—
	Second	4.06	4.56	—
Evans-Crumbaugh Decomposed	First	5.19	5.25	5.38
	Second	3.63	5.31	4.44
Type 2 Decomposed	First	—	3.06	5.62
	Second	—	3.87	4.81

react differently to PDGs algebraically identical but presented with different formats was supported. The results of this study indicate that the same individual will shift in his level of cooperation in a PDG when the matrix format is changed. In all groups, this shift was in the direction expected on the basis of previous research in which independent groups of Ss were used, although it was statistically reliable only for those shifts between the 2 by 2 and T1 decomposed matrix formats. Consistent with Evans and Crumbaugh's and Pruitt's arguments, these results suggest that the 2 by 2, T2, and T1 decomposed matrix formats are not the same psychologically, even though they are the same logically and mathematically.

The results of the present study support the interpretation that one factor which plays a role in influencing a person's choices is the location of the highest payoff displayed. However, the potency of this factor remains to be determined. Even though both the 2 by 2 and T2 decomposed matrix formats had the highest payoff associated with the competitive choice, behavior was considerably more variable with the T2 decomposed matrix format than with the 2 by 2 matrix format. Other research suggests that another important factor is the pairing of the chooser's and the other person's payoffs which occurs in the 2 by 2 matrix format. This pairing apparently gives rise to competitive motives, of which the desire to avoid

getting less than the other person appears to be more potent than the desire to get more than the other person (e.g., Messick & Thorngate, 1967; Radinsky, 1969).

In most research with the PDG using the 2 by 2 matrix format, individuals have been found to be very competitive (see review by Becker & McClintock, 1967). The results of the present line of research are important because they suggest that this high level of competition may not be a necessary part of all situations having the reward structure of a PDG. Rather, the PDG findings are apparently partly dependent on nonstrategic factors inherent in the 2 by 2 matrix format. Research should now be directed to identifying and assessing the influence of these nonstrategic, but psychologically important, factors.

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NOTES

1. The PDG is conceptualized as a situation in which two interdependent persons can make either a cooperative or a competitive choice. Each person has some incentive to make a competitive choice because if made unilaterally it gives an individual his highest payoff and because if a cooperative choice is made unilaterally, it gives the individual his lowest payoff. However, there is also some incentive to make a cooperative choice because if both individuals make cooperative choices, each obtains more than if they both make competitive choices.

2. For purposes of the present paper, a decomposed game in which the highest payoff is associated with the cooperative choice is designated a T1 decomposed matrix format. When the highest payoff is associated with the competitive choice, the matrix format is termed a T2 decomposed matrix format.

3. In the matrix format developed by Evans & Crumbaugh (1966), a S was asked to choose between one alternative labeled "Give him m" and another labeled "Give me n." When $m > n$, the situation has the structure of a PDG, where the first choice is the cooperative choice and the second the competitive choice. m and n correspond to x and y, respectively, in the decomposed matrix format where w and z are zero (assuming 1 is the cooperative choice and 2 the competitive choice in the decomposed matrix format).

4. About half the sessions in each group were conducted by the author and the other half by A. K. Rissman. No systematic differences were observed as a function of the E conducting the experiment.