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PROJECT WORKING PAPER

Teacher's Manual for Resolving Prisoner's Dilemmas*

by

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with the assistance of Akihiko Tanaka

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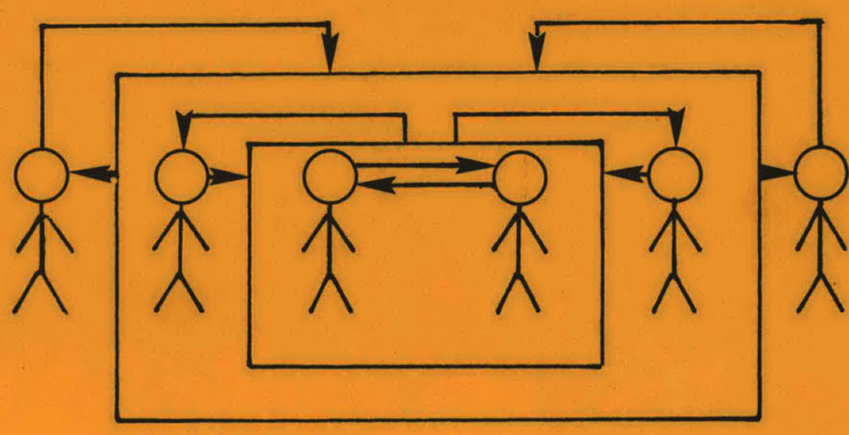
REFLECTIVE LOGICS FOR RESOLVING INSECURITY DILEMMAS



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We begin this teacher's manual with a few words concerning the possible uses of Resolving Prisoner's Dilemmas. Substantively, the module ranges across several disciplines. Optimally, we think it is relevant for many advanced undergraduates or beginning graduate students: all those who have a serious professional interest in the social sciences. Some of the PD game exercises we have used successfully with mixed groups mostly at or about the sophomore level at M.I.T. Having a smaller, more experienced group of students in the class analyze, as a course project, class behavior has also proved to be a good tactic. Not only does such an exercise recruit those with data analysis interests and abilities, it gives them a "first hand" quasi-professional training experience. And the practice of developing and tentatively applying social science generalizations to oneself and one's peers can be enlightening.

Although Chapters III - V are each relatively self-contained, it is hard to read them or our conclusions without familiarity with Chapters I and the main concepts introduced in Chapter II (and the glossary). At first, Chapter II is perhaps the most difficult because of its abstractness and special terminology. To speed up class coverage, one could omit exercises in several chapters. Or, what might be interesting, one could have class subgroups simultaneously following different paths through the module, assuming all had first read Chapter I. Each group might exclusively focus on behavioral learning, social psychological or games and decisions modes of analysis. Chapter VI, read and discussed by all, would bring the different perspectives together quite sharply. Chapter II could be skimmed at first, and read more carefullly after experience with a concrete research paradigm in Chapters III, IV or V.

At this point a few additional words on the organizational format of the student module and this manual are appropriate. This manual follows in outline the material presented in each of the chapters of Resolving Prisoner's Dilemmas. Since most of our chapters contain "exercises", the manual provides "answers" to them, as well as more general remarks on conveying the chapter's content. Since some of the exercises do not have any single "right" answer, the teacher is urged to make this point repeatedly when assigning the exercises. For natural or social science majors, the uncertainty of such matters may be disturbing or frustrating. Indeed the module profoundly challenges paradigmatic dogmatism at the same time that it tries to raise paradigm consciousness and provide evidence for the virtues of paradigmatic tenacity. In its chapter structure, it is designed to engage students in serious research traditions and then confront their different perspectives. The exercises are intended to confront their different modeling traditions and mathematical tools. Our hope is that all module users will gain both increased analytical skills and the kind of professional self-awareness that increases informed career choices on their part.

The success of the module depends heavily on the student's playing SPD games and then analyzing their own behavior in terms of the different research practices of the different paradigms we have presented. Therefore, we have included in an Appendix to this manual copies of some of the documents we have used in our own SPD exercises. Some will have to be recopied; all could be revised. Generally, some other psychological inventories — such as Kohlberg moral dilemmas, Machiavellianism or fate control tests and projective motivational stories (Thematic Aptitude Tests) -- would enrich the psychological aspect of the research experience.

Chapter I

A. Comments on Section 1A

1. Some students might want to dig further into the historial material we shall regularly cite. It of course greatly facilitates their access if at least the major books we frequently mention in the text are made available to them. Perhaps those available in the library could be put on closed reserve. A short bibliography of works we repeatedly cite appears at the end of the students manual. Exercises based on the much larger (but time-limited) abstracted bibliography of the 1965-1977 English language research literature, which we can make available in xerox form, might also be contemplated.

2. In Section I-A we have chosen not fully to explain each of the technical concepts introduced or used here, but rather to illustrate them. Luce and Raiffa give an excellent account, with much prose, many illustrations and formal criteria as well in the first 55 pages of their text. Rapoport, in his _Two-Person Game Theory_ book, covers much of the same material even more simply on pages 13-53. You may alternatively wish to assign introductory discussions in other works -- Shubik, Brams, Riker-Ordeshook and others.

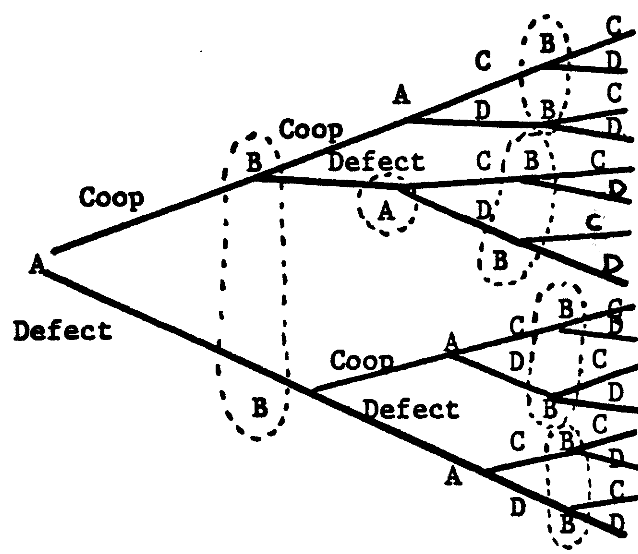
At this point a class could easily spend a week or more solving zero-sum games with out without saddle-points, etc. Given our concern to motivate the problems posed by the PD game to game theory, plus other research paradigms, we must mention and discuss (in note 5) the premises of minimax game strategy. But our desire is not to get bogged down at this point, so no exercises are offered here. In some cases, such as in courses teaching game and decision theory, a thorough review of the relevant mathematics would be entirely appropriate.

B. Answers and Comments. Exercises after Chapter I, Section A.

1. "Specifically, when a player gets the sucker's payoff S, he must be motivated to switch to the defecting strategy so as to get at least P. If he gets the cooperator's payoff R, he must be motivated to defect so as to get still more, T. If he gets the defector's punishment P, he may wish there were a way of getting R, but this is possible only if the other defector will switch to the cooperative strategy together with him." (Rapoport and Chammah, 1965, p. 34)

2. "...[I]f S + T = 2R, there is also another form of [tacit] collusion [than CC], which may occur in repeated plays of the game...The question of whether the collusion of alternating unilateral defections would occur and, if so, how frequently, is doubtless interesting. For the present, however, we wish to avoid the complication of multiple 'cooperative solutions.' " (Ibid., p. 34f)

3. We shall assume that there are two separate cases with the same options, and that penalties (jail terms) and utilities are additive across them. We switch player and option notations from those of Figure 1 to those of Figure 2. The preliminary outcomes list takes some work. It is helpful to draw the extensive form of the game (without utilities) first. Then, creating an outcomes and normal form payoff matrices is easy. Outcomes for, and payoffs to, A and B are given sequentially in parentheses:



(2 yrs., 2 yrs.) or (1.8, 1.8)
(11 yrs., 1 yr. 3 mos.) or (.9, 1.9)
(1 yr. 3 mo., 11 yrs.) or (1.9, .9)
(9 yrs., 9 yrs.) or (1.0, 1.0)
(11 yrs., 1 yr. 3 mo.) or (.9, 1.9)
(20 yrs., 6 mo.) or (0, 2.0)
(10 yrs. 3 mos., 10 yr. 3 mo.) or (.9, .9)
(18 yrs., 8 yrs. 3 mo.) or (.1, 1.1)
(1 yr. 3 mo., 11 yrs.) or (1.9, .9)
(10 yrs. 3 mo., 10 yrs. 3 mo.) or (.9, .9)
(6 mo., 20 yrs.) or (2.0, 0)
(8 yrs. 3 mo., 18 yrs.) or (1.1, .1)
(9 yrs., 9 yrs.) or (1.0, 1.0)
(18 yrs., 8 yrs. 3 mo.) or (.1, 1.1)
(8 yrs. 3 mo., 18 yrs.) or (1.1, .1)
(16 yrs., 16 yrs.) or (.2, .2)

You should note that the addition of utilities rather than their recalculation produces anomalies in the 8-11 year range.

The outcomes matrix should have 16 cells, and be 4 x 4. We indicate choice sequences as CC, CD, DC, and DD, with appropriate subscripts.

Prisoner B

Prisoner A	CC	CD	DC	DD
CC	2 yrs., 2 yrs.	11 yrs., 1¼ yrs.	11 yrs., 1¼ yrs.	20 yrs., ½ yr.
CD	1¼ yr., 11 yrs.	9 yrs., 9 yrs.	10¼ yrs., 10¼ yrs.	18 yrs., 8¼ yr.
DC	1¼ yr., 11 yrs.	10¼ yrs., 10¼ yrs.	9 yrs., 9 yrs.	18 yrs., 8¼ yr.
DD	½ yr., 20 yrs.	8¼ yrs., 18 yrs.	8¼ yrs., 18 yrs.	16 yrs., 16 yrs.

If utilities in any way preserve a rank (ordinal) correspondence with total jail years, we see that the "sure thing", "dominant" solution is to DD for both moves. Were ethics not disallowed as irrelevant, we ourselves would be tempted, however, by a certain amount of altruistic concern, to play C the first time and C or D the second, depending on the other player's first move.

Although various possibilities come to mind, it is logically exhaustive to think of A and B as having 8 strategies each, some of them dependent on the other player's first move. Cooperating and then defecting only if the other player defected on the first move could be indicated by "C& match," with subscripts if desired. $\bar{D}_A$, $\overline{D_A}$ would mean

A had the strategy of defecting on both moves, regardless of what B did, etc. Note that this normal form matrix no longer has the same size and labels as the preliminary outcomes matrix or the extensive form of the same game:

	CC regardless	C& match	C& oppose	CD regard less	DC regard less	D& match	D& oppose	DD regardless
CC regardless	(1.8, 1.8)	(1.8, 1.8)	(.9, 1.9)	(.9, 1.9)	(.9, 1.9)	(.9, 1.9)	(0, 2.0)	(0, 2.0)
C& match	(1.8, 1.8)	(1.8, 1.8)	(.9, 1.9)	(.9, 1.9)	(.9, .9)	(.9, .9)	(.1, 1.1)	(.1, 1.1)
C& oppose	(1.9, .9)	(1.9, .9)	(1.0, 1.0)	(1.0, 1.0)	(.9, 1.9)	(.9, 1.9)	(0, 2.0)	(0, 2.0)
CD regardless	(1.9, .9)	(1.9, .9)	(1.0, 1.0)	(1.0, 1.0)	(.9, .9)	(.9, .9)	(.1, 1.1)	(.1, 1.1)
DC regardless	(1.9, .9)	(.9, .9)	(1.9, .9)	(.9, .9)	(1.0, 1.0)	(1, 1.1)	(1.0, 1.0)	(.1, 1.1)
D& match	(1.9, .9)	(.9, .9)	(1.9, .9)	(.9, .9)	(1.1, 1)	(.2, .2)	(1.1, .1)	(.2, .2)
D& oppose	(2.0, 0)	(1.1, .1)	(2.0, 0)	(1.1, .1)	(1.0, 1.0)	(.1, 1.1)	(1.0, 1.0)	(.1, 1.1)
DD regardless	(2.0, 0)	(1.1, .1)	(2.0, 0)	(1.1, .1)	(1.1, 1)	(.2, .2)	(1.1, .1)	(.2, .2)

The funny business of adding utilities, not years (and then recalculating utilities) destroys the sure thing dominance of "DD regardless." But "DD regardless" still does better vs. "CC," "C& oppose," "CD regardless," "DD regardless." Two "C& match" strategies, jointly chosen, would work quite well unless some player reflects on its prominence and...

4. The game with T > R > S > P is usually called Chicken. The standard "story" has teenage hot-rodders

charging down the same white line at each other. The first to swerve is the "Chicken." Like PD, the game is adversarial, and laden with possibilities of double-cross. The story is somewhat ambiguous about cooperative possibilities; the payoff matrix pushes toward last minute accomodations, requiring considerable dynamic coordination not fully reflected in a static payoff matrix. Hence, Snyder and Diesing move toward treating T, R, S, P as the labels for and results of bargaining subprocesses in Chicken, etc. games.

5. We suggest the teacher refer to the materials in the Appendix of this manual at this time. The various aids to data collection there can be augmented or selectively used, depending on which modes of analysis (e.g. those in Chapters 3 - 5) will be given serious attention during the use of the module.

For the purposes of retrospection in Chapter 6, it would be very helpful casually and perhaps collectively to ask students to comment on any choice dilemmas they personally felt in playing the SPD game, as well as any resolutional ideas, or "solutions" they thought of in or shortly after the game. Since Chapter 6 will summarize many different resolutional ideas from Chapters 3 - 5, it is important not to have students "peek ahead" and regurgitate "clever answers." Rather, experiential data is wanted here. Without making a big show of it, whether or not the essays asked for in the Appendix are assigned, class notes on felt dilemmas and possible resolutions could be a gold mine of discussion material at the end of the module.

C. Answers and Comments Regarding Exercises IB

1. As suggested by the text, T = the slaves being set free and/or given a large cash reward; the betrayed "sucker" often loses his or her life or limb(s). So clearly T > S.

Somewhat more uncertainty surrounds R and P. This is partly due to the N-person nature of a potential revolt situation, and the difficulty of assessing the uncertain values of joint confession and joint silence, as well as the intermediate situations of a small or moderate number of confessions. Avoiding the larger problems of considering the "betray the revolt"/"support the revolt" game, it nonetheless makes good sense to argue that a situation where all revolutionaries confessed (P,...,P) would probably lead to less severe punishments than S. Hence T > P > S. Surprise slave revolts enabled by joint silence certainly produce less sure benefits than the Ts discussed above; so S < R < T. But even if such revolts had a chance to succeed is R > P or P > R? Were the slave masters more lenient with slaves who kept solidarity? And were all slaves in symmetrically equivalent situations? Our textual quotes about privileged personal slaves (with "ideologically" charged perspectives) clearly argue against this simplification. But we shall make it here, and further argue that our story suggests that freedom and/or the solidarity of the oppressed are worth striving for (R > P).

2. One can think of any exchange (for goods or cash) as having a PD aspect to it, due to the possibility that one party may deceive the other by misrepresentation or by running off when an exchange is half completed. Paying with a bad check, or selling merchandise known to contain concealed defects, without a valid warranty, would be relatively clear examples. (The doctrine of caveat emptor, or "buyer beware," however, places considerable responsibility on buyers to inspect what they buy before accepting it. Banks often say that you can't draw on a deposited check for a week or so, until it has "cleared" to prevent themselves from being the losers in bad check transactions.)

In introductory conventional economic exchange theory, the usual assumption is that voluntaristic exchanges (C,C) are mutually beneficial, otherwise they would not occur (D,D, i.e. no deal). "Temptation" and "sucker" options, such as those indicated above, do not get mentioned.

To represent formally these possibilities is quite complicated. A stage of making an agreement must be distinguished from a second order game of initial and subsequent (final) implementation. A third order sanctioning game directed toward the enforcement of possibly broken agreements may involve acts of conscience, collection services, courts and lawyers. Choice options at each move situation also need to be more complicated (including deception) than the offer/don't offer, agree to deal/ disagree dichotomies one might put into a 2 x 2 matrix!

But the game theory reductionist is probably right that one doesn't know the utilities of a potential thief or fraud perpetrator before his or her identification as such. The theorist is also correct in arguing that many of the above complications could be represented in much more complex extensive or normal game representations. The important role of context-sensitive <u>social and theoretical conventions</u> in allowing radical simplifications is not, however, an area of special or unique competence of those trained in strategic, calculating rationality.

3. Taylor's example (p. 112) is quite simple. It starts with a fairly happy game situation (with equilibrium stability, efficiency and altruistic thought all pointing to the same desirable outcome):

$$\begin{bmatrix} (2,2) & (-2,1) \\ (1,-2) & (1,1) \end{bmatrix}$$

This 2 x 2 asymmetric payoff matrix turns into a Prisoner's Dilemma using utility-computing formula (3) for two half egotistical, half rivalrous players ($N=1$, $\lambda_1 = \lambda_2 = 1/2$).

$$\begin{bmatrix} (1,1) & (-2\ 1/2,2) \\ (2,-2\ 1/2) & (1/2,\ 1/2) \end{bmatrix}$$

Altruism may be thought of in terms of weighted averages of payoffs to all players, including the self. Equal weights bring the bottom matrix, treated as payoffs, fairly close to the upper "happy" one, but in a symmetric form.

4. Snyder and Diesing's own game-theoretic interpretation of all three PD cases is on pp. 93-106. We are ourselves somewhat optimistic that the Snyder-Diesing account can be merged with other analyses of the 1914 (notably those by Choucri, North and Holsti) in a consistent, explanatory fashion.

5. There is no "correct" answer to this question to be given on an "answers" sheet. But neither is it a question merely of individual opinion. The extent to which community norms agree on certain appropriate actions energizes state action, e.g. some versions of the PD story where <u>guilt</u> is somehow <u>securely</u> known but not easily <u>provable</u> evoke a good deal of pro DA sentiment. The suggested theme of affective, value-laden or norm-guided orientations in social science research will be returned to in the concluding chapter of this 'module' and elsewhere. It is also worth noting that second order games, while not the same as iterated games, seem to imply the existence of similar reflective human capacities as were previously observed upon in our discussion of two-person games.

Chapter II

A. General Remarks on this Chapter

Two pedagogical points should be stressed regarding this chapter. First, the discussion of paradigms and programs will introduce important terminology which, alas, almost all students will find difficult. Other than the synthetic labels "research paradigm" and "paradigm complex", all of this terminology is now used by many professional philosophers and historians of science. A glossary has been provided to ameliorate this difficulty. The teacher may prefer to concentrate on Table II-1, to skim it, or to wait until the concluding discussion (in Chapter 6) of the reality of research paradigms before discussing these ideas seriously. In any case Chapters 3 - 5 give lots of concrete material for such discussions.

The main point of introducing this complexity is to break superficial, positivistic or scientistic ideas of the nature of scientific investigation. An awareness of research paradigms and their contextual situations introduces so much greater realism in the discussion of scientific alternatives, of regress and progress, that we think the effort worth its costs.

Secondly, we use this schematization again and again. Not only do the proposed standards of research evaluation in Section B of Chapter II depend onit, but the main themes of our discussions in Chapter 3 - 6 will be summarized using the research paradigm complex framework. Contemporary students and scientists often are extremely ahistorical about their own work. Using a synthesis of key ideas from recent debates on the philosophy and history of science, we have tried to help correct that deficiency.

B. Comments Relevant to Exercises at the End of Chapter II

1. Perhaps the most distinctive feature of the orientation of this chapter is its treatment of the "assessment of scientific progress" so totally as a psychological (motivational), sociopolitical (including external research contexts) and historical process. Philosophical arguments are relevant -- all of the standards in part B have philosophical pedigrees -- but they are not assumed to take place outside of some historical context in which they originate or come again to be raised. Popperian rationalism tries to argue that the truths of science are objective and eternal, existing in a "third world" of pure reason and exacting epistemological standards; sociologists of science from Marx to Merton favor more some variant of Thomas Kuhn's historical-social-psychological approach.

2. The natural science vs. social science debate is very old, engendered in part by the Galilean revolt from an Aristotelian tradition which tried to apply concepts like "laws," and "causes" and "purposes" to people, animals and inert matter. Some behaviorists take the extreme position that purposive, intentional behavior

is not a scientific phenomenon susceptible to objective investigation. In contrast, some idealistic humanists emphasize the normative realm as a distinctively human phenomenon, not susceptible to causal investigation. "Social engineering" approaches (to use Popper's phrase) allow pragmatically oriented design research as "scientific," and different from "naturalistic" investigation because of the purposes of the investigator are seen to give order and regularity to natural or social accomplishments. Many of the illustrations in the text follow from the "dialectical hermeneutic" emphasis by Apel, Habermas and others that psychoanalysis should be seen as appropriate, critically reflective models of social science, rather than the mathematical physics and formal language theory so dear to logical positivists (like A.J. Ayer, Bertrand Russell, Rudolph Carnap, Carl Hempel, etc.). Relevant bibliography is given in Alker (1978).

3. In our minds these images are associated with Robert Merton's writing on puritans and English science, Feyerabend's anarchistic <u>Against Method</u>, J.D. Bernal's discussion of "the communism of science," Derek Price's <u>Little Science, Big Science</u>, and Karl Popper's claim that "critical rationalism," as an epistemological orientation raises revolutionary questions about reality without abandoning itself to long periods of puzzle solving. If the student is interested in pursuing such arguments and analogies more systematically, he or

she should look further into the rich literature on the philosophy and history of science.

Chapter III

A. General Remarks

It should first be noted that section A of this chapter is intellectual history. It's major roles are a) to identify the research program that generated Flood's, Deutsch's and Rapoport's experimental games, as well as their modes of analysis of them; b) to illustrate concretely the nature of (research) paradigm conflict; and c) to give an in-depth introduction to the behaviorist learning research paradigm, whose significance clearly transcends its important resolutional contributions to SPD research.

The teacher should also note how certain research programs can cut across and help evaluate the fruitfulness of different research paradigms. In the light of the impressive results (including the resolutions in IIIB) of the game learning research program, partly inspired as it was by the methodological research style of the behaviorist learning paradigm, it is worth emphasizing for comparative purposes, the parsimonious, rigorous reductionism of the scientific approaches of Newton and Darwin. Also, as will be emphasized in Chapter 6, we like the dialectical way in which these results suggest their own supercession in the less reductionistic reformulations of later researchers.

The simulated discussion in the last few pages of this chapter has several purposes. First, it tries to make the resolutional ideas of this chapter personally relevant, and less academic. Besides an opportunity for a less formalistic discussion that makes fun of various views (check the initials of Rectus and Amiable, for example), the discussion also enhances tacitly the dramatic metaphor concerning paradigm conflict. Chapter 5 will broaden this perspective in its discussion narrative, and Chapter 6 will elaborate a dramaturgical perspective even further.

B. Comments and Answers to Exercises IIIA

1. **Beyond those mentioned in Table II-1 already, most of the relevant answers that the student can be expected to mention are given in Sections A.1** and A.2 of this Chapter. A few others are explicit or implicit in the discussion of "winners" in Section A.3.

As an indication of their specific relevance, we shall limit ourselves here to examples of appeals to each of the evaluative standards listed in Chapter II, Section B, but only briefly mentioned in Table II-1.

i.) Simon's attack on behaviorist learning theory is clearly motivated by his cybernetic rejection of its deep, pre-theoretical, anti-cognitivism. At a November, 1978, lecture at M.I.T. on what a learning system must have, both reinforcement-shaped "results" of its actions and knowledge of them (error feedback) were mentioned. In a hopefully benign and instructional learning environment, the capacity for causal attribution is also necessary so that hypothetical ideas of causes and effect can be entertained. His preferred view of artifically intelligent, adaptive learning systems was that they are governed by complex chains of quasi-causal "conditions → action" instructions, or "production" relations. Adaptive learning might be thought of as the insertion of new productions at appropriate places in such programs. It is therefore a plus for Skinner-Suppes theory that relations like (1) in the text are explicit, criticizeable and replaceable. On the other hand, the need for others to "get up to speed" in terms of generating empirically testable results argues against spending most of the 1950s and 1960s debating its fundamentals.

ii.) As for active support of core behaviorist ideas, ideas which appear to contradict both American popular culture, humanistic and religious "models of man," Suppes and Atkinson acknowledge inter alia support from the Behavioral Sciences Division of the Ford Foundation and the Office of Naval Research. Suppes, Atkinson, Simon, Rapoport all have served in various advisory roles in the National Science Foundation. The positivist climate of anti-Fascist and anti-Communist intellectuals in the 30s-50s should also be mentioned.

iii.) The Estes and Bush-Mosteller models correctly predicted asymptotic (long run) behavioral response frequencies in a variety of experimental contexts; Suppes and Atkinson's book is an important example of a "research program" stimulated by the earlier RAND-Santa Monica conference volume on Decision Processes (Thrall, Coombs and Davis, 1954)

iv.) Cited in Chapter 2, Rapoport's and Boulding's appeals to game theory's formal representations of conflict situations must be considered an example of an appeal to an insight-generating representational symbolism; Suppes and Atkinson's claim that they have extended learning theory modeling and estimatin procedures to new areas also invokes a similar standard of scientific progress.

v.) Von Neumann's taxonomic integration of different types of strategic games, and Suppes-Atkinson's mathematically demonstrated equivalence of stimulus-sampling learning models and simple cognitivist "hypotheses" models (Sections 1.7, 1.8) fit this standard well.

vi.) Empirically, maximum-likelihood statistical estimation (or its approximations) dominate much of the experimental gaming literature. But it is clear that Suppes and Atkinson's committment to radical ontological parsimony makes them treat failures in predicting exact move sequences as less serious flaws than would some social psychologists or game theorists. Suppes and Atkinson are relatively silent on pragmatic and normative evaluative standards, unlike most "games and decisions" theorists. Rapoport has resisted this pragmatic applications "approach", however, as likely to be oversimplified.

As an aside, it is worth noting that pragmatically Suppes was a major advocate in the 1960s of computerized foreign language instruction systems embodying a rather behavioristic philosophy.

vii.) One of the old puzzles generated by Bush-Mosteller learning models was that they didn't "learn" very well the "message" of an alternating (+,-,+,-,...)sequence of reinforcements. Stimulus sampling models "solve" this (and other) puzzles correctly, argue Suppes and Atkinson.

Suppes' recent, qualified advocacy of very Chomskean grammatical models* suggests that a revolutionary replacement of the behaviorist language learning paradigm has now taken place, although no one linguistic paradigm now rules supreme. Whether such a transformation has taken place in the game learning area is a major question addressed repeatedly in the rest of this module.

2. a.) Basically, schema (1) complicates the S→O→R "way of seeing." In multiple trial experiments, the experimenter's stimulus (s) is broken into objective reinforcements and subject-sampled stimulus elements. The conditioned subject is the O, holding onto particular stimulus elements that have been conditioned in various ways. The subjects R (response) to

*in a lecture at M.I.T. about 1977.

a particular sampled stimulus (S) thus depends on internalized stimulus conditioning (O) and the reinforcements behind the stimulus-sampling (We have tried in this answer not to use the words "choice" or "strategy," although "sampling" for us as a term also seems very much a matter of conscious deliberation and strategic choice on many occasions).

b.) Atkinson and Suppes refer to the models like Equations (2) and (3) as "pure reinforcement" models with degenerate, i.e. single element, stimulus sampling. In a sense, then, all they focus on are the probabilities of being conditioned by particular reinforcement experiences. S-CO-R-ER schema might better fit here: Stimulus leads to a Response from a Conditioned Organism, which is subsequently Experimentally/Environmentally Reinforced. A "piggy back" model of the behavioral learning of "response propensities" will be presented in the second half of Chapter 3 based in part on Equation (2).

3. a.) With the definitions in the text the Estes model is a linear additive one (see Simon, 1957, p. 275f):

$$P_1 (t + 1) = \pi_1 P_1 (t) + \left((1 - \pi_2)\ (1 - P_1 (t))\right) \quad \textbf{(A)}$$

This says that the probability of an A_1 response on trial t + 1 is the sum of the probability of previously giving an A_1 response weighted by the probability of a positive reinforcement, and the probability of a previous A_2 behavior $(1 - P_1 (t))$, weighted by the probability $(1 - \pi_2)$ that the A_2 was negatively reinforced.

b.) To get an asymptotic value for this equation, set

$P_1 (t + 1) = P_1 (t) = P_1 (\infty)$, i.e. the "at infinity value."

Solving algebraically the resulting equation

$$P_1(\infty) = \pi_1 P_1(\infty) + ((1-\pi_2)(1-P_1(\infty))) \qquad \text{(B1)}$$

$$P_1(\infty) = \frac{1-\pi_2}{(1-\pi_1)+(1-\pi_2)} \qquad \text{(B2)}$$

c.) The next trial matrix game for this problem(A's payoffs only)

NATURE

$$\begin{array}{lcc} & \text{malevolent} & \text{beneficent} \\ \text{Player A} \quad \text{persist in } A_1 & \pi_1 & \pi_1 \\ \phantom{\text{Player A}} \quad \text{change to } A_2 & 0 & 1 \end{array}$$

We assume that nature behaves in a stationary fashion when A persists in the way he or she has been responding.

Using the definition of "regret" in the text, we must look for what could have been gained if nature's "mood"/play/strategy were known ahead of time. Subtracting payoffs from column maxima gives a regret matrix

$$\begin{array}{ccc} & u & 1-u \\ p & 0 & 1-\pi_1 \\ 1-p & \pi_1 & 0 \end{array}$$

with associated response (strategy mix) probabilities in the margin. The expected regret for A is then

$$R = 0 + p\,(1-u)(1-\pi_1) + (1-p)\,u\,(\pi_1) + 0 \qquad \text{(C)}$$

Finding a minimum regret (actually a minimum of a maximum possible loss, or a minimax), we have to use the calculus. Taking partial derivatives and setting

$\frac{\partial R}{\partial u} = 0$ gives

$$\frac{p}{1-p} = \frac{\pi_1}{1-\pi_1}, \text{ or } p = \pi_1 \qquad \text{(D)}$$

Result (D) corresponds to the first term of result (A) of the learning model. A similar analysis assuming a previous A_2 response suggests shifting to A_1 with probability $1 - \pi_2$. Together these results reconstruct (A) in its entirety.

We comment here that this interpretation of nature is plausible in a laboratory where reinforcements might reasonably be expected to be under the control of the experimenter. Outside of the laboratory, a more plausible assumption might add a 3rd column to the above matrices, labeled "Nature as irresponsive" and given its own probability. When $\pi_1 < \pi_2$, players persisting in choosing A_2 should also regret that a $\pi_2 - \pi_1$ improvement in payoff was possible but had been missed, even if nature was irresponsive. In the short run, these plausible extensions strengthen Suppes and Atkinson's reluctance to be cowed by Simon's result.

4. Just as we have cautioned against believing that all Soviet politicians are applied Pavlovians, the reader should be careful not to assume that all American behaviorists accept the political philosophy of B.F. Skinner. Nonetheless, we consider William Barnett's The Illusion of Technique (1978) as worth reading on this subject. He cites an interview with a Soviet behavioral scientist who argues that the better, prior application of Pavlovian and other conditioning techniques could greatly reduce dissent there, making the inquisitors of Solzhenitsyn's Gulag Archipelago unnecessary. Rather similar views were offered by behavioralist defenders of American intervention in Vietnam. Noam Chomsky's linguistic and political writings, especially

his American Power and the New Mandarins (1969), Problems of Knowledge and Freedom (1971), and Language and Mind (1972) directly address these issues from a anti-behaviorist perspective.

C. Answers to Exercises, Chapter IIIB

1. A careful look at the definitions that Rapaport and Chammah actually give for state conditional propensities shows their consciousness of the (unequal) reinforcements involved (p. 71f). Thus x was "the probability that a player will choose cooperatively, following a play in which he chose cooperatively and received (reward)R (i.e., following a player in which both players chose cooperatively)." Similarly, $y_A = P_r(C_A | C_A D_B)$, after receiving "the suckers payoff (penalty)S." Etc.

2. First, we construct the transition matrix from the state-conditional propensities in the text using the equations telling us how the probability of being in one of 4 states at t + 1 (CC, CD, DC, DD) depend on the corresponding probabilities at time t. This, assumed to be constant transition matrix T (Rapaport and Chammah, 1965, pp. 71, 121, 162) is:

Probs. of t + 1

Probs at t	CC	CD	DC	DD
CC	.71	.13	.13	.03
CD	.15	.25	.23	.37
DC	.15	.23	.25	.37
DD	.04	.16	.16	.64

= T

For example, using x = .84, y = .40, z = .38, w = .20, the last column of transition probabilities is

$(1.-.84)(1.-.84) \cong .03$ $(1-.40)(1-.38) = .37$ (twice) $(1-.20)(1-.20) = .64$

Assuming: $P_o(CC) = P_o(CD) = P_o(DC) = P_o(DD) = 1/4$

we can calculate P_1 values using the above matrix (or equation 5). Thus

$$P_1(CC) = \tfrac{1}{4}(.71) + \tfrac{1}{4}(.15) + \tfrac{1}{4}(.15) + \tfrac{1}{4}(.04) = .26$$

Similarly $P_1(CD) = .19$, $P_1(DC) = .19$, $P_1(DD) = .35$ etc.

Asymptotically, this process converses in about 30 "iterations" with $P_{30}(CD)$, $P_{30}(DC)$ quite small. The calculations are the same as those just indicated.

3. Let Γ refer to a C "lock-in" for a player,
 Δ, a state of D "lock-in,"
 C, a state where C will next be played.
 followed by C or D, and
 D, a state leading to a D, followed by either C or D.

Then consider that each player's transitions depend on his previous state and the other player's previous move. One player cannot know the other's internal states, only her last moves. A propensity γ_A of A's getting locked into Γ and δ_A of A's getting locked into state must also be defined. Then, we can fill in the cells of a 4 x 4 transition matrix T' for player A as follows.

	Γ_A	C_A	D_A	Δ_A
Γ_A	1, 1	0,0	0,0	0,0
C_A	γ_D, 0	x_A, y_A	$1-x_A-\delta_A, 1-y_A$	0, 0
D_A	0,0	z_A, w_A	$1-z_A, 1-w_A-\delta_A$	0 δ A
Δ_A	0,0	0, 0	00	1, 1

The first cell entry denotes the transition probability when B has played C_B; the second entry corresponds to a previous D_B.

Chapter IV

A. General Remarks

1. This chapter is rather different from the earlier, being focused most of the time on a single research paradigm - social psychological research on conflict resolution. For those who have skipped Chapter 3, it nonetheless briefly contrasts this research paradigm with behaviorist learning research (see Table IV-1).

2. It might be helpful in discussion to distinguish more general ideas about social psychology (and its "border problems" vis a vis behaviorist and instrumentally rationalist approaches) from specific discussions of PD research. In any case the long list of resolutions in the heart of the chapter should be both linked to social psychological ideas re conflict resolution and contrasted with game theoretic or behaviorist PD resolutions. Sensitivity to differences in paradigm "spectacles" is an important educational goal of the first section. Try to elaborate how the "pre-theoretical" notions in Section IVA are capable of engendering the resolutions of IVB. Thus Mintz's early, metaphorical study has clear resonance with Morton Deutsch's later work, etc.

3. Finally, the chapter gives an important case of stagnation or regress in paradigmatic research. One could put the arguments in the final section of the chapter more explicitly in terms of the standards of Chapter IIB; we have not encoded it very directly in these terms.

B. Answers and Comments Exercises IVA.

1. a) Real estate entrepreneurs capitalize on such thinking in their "blockbusting" practice. Typically, one buys a house in a lower middle class white neighborhood and sells it to a black family. The white neighbors imagine their property values will erode and hasten to put their houses on the market. The panic rapidly depresses prices, but each white owner though knowing this also believes the longer he waits to sell, the more blacks will be in the neighborhood and hence his property will be worth less. The real estate entrepreneur profitted through the commissions and also through buying property in his own account and selling it later when the panic was over and the prices had stabilized. Obviously, such practice to succeed required a white population that did not want to live with blacks and believed blacks brought urban blight. They would pay dearly for their prejudices.

   b) Thomas Schelling (1971) has imaginatively shown how shifting patterns of racially segregated housing can be maintained by citizens wishing to have neighbors in racial proportions not very different from community wide fractions. "Stay" or "leave" are shown in his interpretation to have a PD-like interpretation for someone in a neighborhood with a racial composition tending away from that of the home owner.

2. In the spirit of Orcutt and Anderson (1978) the most surprising re-results we ourselves have obtained have been with students who did not know they were playing against simply constructed computer programs. A little "random noise" from a random number generator immensely complicates efforts to "psych out" one's opponent. Since deception may be involved in such experiments, it is important to have relevant "experimental designs" cleared by an appropriate college or university "human subjects" committee. Relatively informed "consent forms", appropriate alternative class activities and a good "debriefing" would normally be part of such a proposed study.

   One of the most effective ways of generating reflective insights is to have students play vs someone (or some program) that
   a) Cs or Ds with a 50 percent probability on the first move,
   b) responds exactly to the previous move of the unprogrammed play, except that
   c) perhaps 1 in 10 moves is randomly varied from such a response.

   Students may then be asked to write an essay trying to comment on the rationale of the other player and their response to him. "Responsibilities" for, and "causes of" 'good' or 'bad' outcomes could also be judged. Students who don't realize that they are playing the same "preprogrammed player" can be asked to suggest adjectives appropriate to his characterization. They are often diverse and highly projective versions of how we would see ourselves as others! One could then check these essays, or ones based on earlier game play (e.g. done in conjunction with Chapter I), for the presence of various social psychological phenomena. A related approach using "confederates" is outlined in the Appendix.

3. Looking at the game record forms in the Appendix, one can see how the data thus generated can be fed into Ackoff-Emshoff relevant programs like the one reprinted there. More advanced analyses of policy-matching and role-matching are also possible, dependent on some auxiliary hypotheses as to how expectations of other's players strategies are derived. An especially interesting exercise could analyze the move records and marginal comments from Merrill Flood's 1950 assymetric SPD data given in the Appendix.

We have mentioned moral development, Machiavellianism, liberalism, conservatism and authoritarianism (dogmatism) of relevant personality variables for additional investigation. Studying experimenter-subject interactions (as in Milgram's work or according to the Buckley-Burns metaphor) would also be quite intriguing, going beyond the effects of differently described PD games. Independent observation of experimenter-subject relations would be extremely relevant.

A third level of study is possible on the basis of verbal reports on game play. Images of the other, choice dilemmas, interpretations of his or her moves, judgments concerning the locus of responsibility for outcomes are all possible discussions. Even reflective reactions to such characterizations are possible! See the Appendix for details on how such information might easily, and anonymously be generated.

C. Answers and Comments, Exercises IVB

1. Different varieties of functionalism specify their own labels for socially normative and non-normative behavior. Though all the terms above can be given strict operational and "value-free" definition, inevitably the non-normative act acquires a perjorative label. This labelling process within the general community is part of the process by which the non-normative status of the act is specified and internalized. If an actor considers something "finking" he will probably hesitate about doing it. The real issue in resolution of the PD might be how society inculcates the moral qualms which Luce and Raiffa in their treatment of PD sweep under the rug.

From the perspective of a strict functionalism which suggests that a cooperation norm specifies a social instinct and capacity to work together, the D move is maladaptive from in terms of the task force operation   or deviant in terms of social organization of the task force. The reciprocity norm perspective redresses this one-sided reading since alleged deviances in fulfillment of supposed obligation, e.g., respect for property, might be understood as reactions to unequal exchanges, rip offs, and others' persistent violations of the actor's rights in the relationship.

Deutsch approvingly quoted the philosopher Nicolai Hartmann's claim that all social relations are based on trust. This would construe an initial non-responsiveness to the trust norm -- a general attitude of suspicion toward others -- as immoral or anti-social. Also, the lack of responsiveness to social values such as equity, loyalty, duty which have often little value to increase in personal material welfare or individual preservation, might be technically characterized as the absence of socially integrative attitude. Less technically, most persons in contemporary society might consider this morally reprehensible.

2. **A's acquisition of an altruist motive means his belief that B will act beneficially toward him can be relaxed.**

Let us suppose that the altruist motive can be represented in the payoff vectors by a term equal to the increase in B's welfare due A's cooperation.

After Kelley and Thibaut's parsing of the interdependence space, we call this FC_B = fate control in B's payoff. Hence the expected value of A's cooperation

$$V(C_A) = [p\ (C_B) \cdot R] + [(1 - p\ (C_B) \cdot S]$$

is rewritten

$$V(C_A) = p(C_B) \cdot (R_A + FC_B) + (1 - p(C_B))\ (S_A + FC_B).$$

The boundary conditions for choosing C when A does not and does have an altruist motive, $p\ (C_B)$ and $p'(C_B)$ respectively, are

$$p(R - P) \gtrless (1 - p)(P - S)$$

$$p'(R - P) + FC \gtrless (1 - p')(P - S)$$

multiplying through and rearranging

$$p(R - S) - (P - S) \gtrless 0$$

$$p'(R - S) - (P - S) + FC \gtrless 0$$

The change in belief intensity possible is

$$p - p' = \frac{FC}{(R - S)}$$

1. The more the altruist can help the other the less he needs to believe the other will also help him.

   i.e. the smaller (R - S)

2. The less the other can benefit the altruist, the less the altruist needs to believe the other will benefit him.

This apparent paradox probably explains why despite histories of children's non-reciprocation, parents have little difficulty in cooperating with them. The same relations might exist for ethnic communities in the United States such as Jews, Irish, Greeks, who sponsor their homelands' political and economic causes without receiving very much repayment either materially or spiritually.

3. We begin the discussion of conflict of interest measures in Exercise 3 with some motivating remarks omitted from the student module for pedagogical purposes -- some of these should be realized in the course of doing the exercises. Nonetheless, the points are of considerable interest. Some Rapoport and Chammah (1965) behavioral indices and associated hypotheses were mentioned in Chapter III. They note that, formally speaking, thirty interval ratios can be formed from the 4 parameter R, P, S, T; 15 are reciprocals of the other 15, and only 2 of these latter are independent. The other 13 can be derived from 2 well chosen ratios. Their choices with the T - S denominator guarantees against infinitely large values: the denominator and numerator must simultaneously vanish.

The indices are only ratios of single intervals; more complex representations of cross cutting pressure are imaginable. We specifically have in mind relations of the possible gain, the risk and cost of choosing C over D. Cost may be expressed: T - R; gain: R - P; risk: P - S. Inclination to cooperate, assuming no projection of the other's action could be inverse to risk and cost and direct with gain. Hence

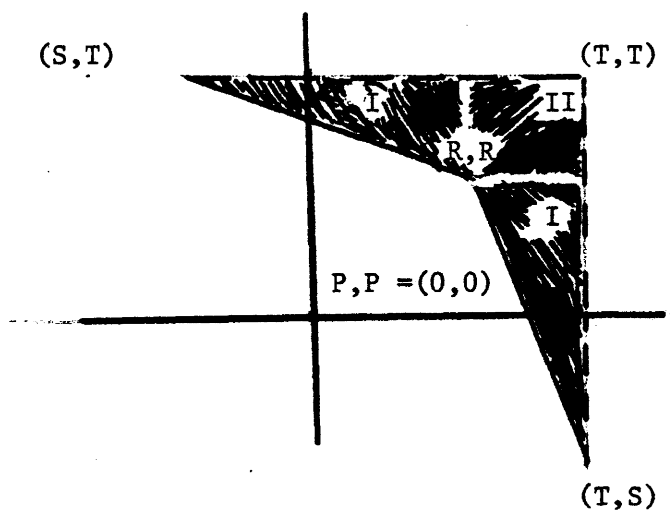
$$E_c = \frac{R - P}{(T - R)\ (P - S)} .$$

Axelrod's measure also has a conceptual basis: it summarizes a theory of bargaining difficulty applied to the PD game. As such it might be discussed in both Chapter IV and V. Its empirical success (based on implicit interpersonal comparisons) is an important example of the superiority of revisionist game theory and social context sensitivity, compared to behaviorist learning reductionism.

Figure 1D in Chapter 1 approximately presented the PD matrix as defining a bargaining space with sides (O,T)(R,R) and (R,R)(S,O) the boundary between realizable and non-realizable outcomes. A player can always guarantee himself P - (O) but a player individually can do better than R. Axelrod (1970) proposed for a symmetric Prisoner's Dilemma the "conflict of interest" is the ratio of the outlying area to the area of the rectangle (the total bargaining space -

$$\text{conflict of interest} = \frac{(T - R)\ (T - S)}{(T - P)^2}$$

The larger this ratio the less the space of feasible outcomes, hence the more difficult a coming to cooperation. The actual derivation of this index in the stated cases of the exercise procedes on the basis of the following figure



The entire shaded area is 2(1/2)(T-R)(T-S). But if we are interested in the shaded area in the northeast quadrant only, its area is composed of Area II = $(T - R)^2$ and 2 · Area I. Because the PD is symmetrical 2 · Area I = (T - R)(R - P), so the shaded area is

$$(T - R)^2 + (T - R)\ (R - P)$$

Thus a stricter conflict of interest measure is

$$C_I = \frac{(T - R)^2 + (T - R)(R - P)}{(T - P)^2}$$

but Axelrod's measure is certainly consistent for symmetrical PD's.

4.

game	R	S	T	P	r_1	r_2	E_c	Axelrod Conflict of Interest
1	9	-10	10	-1	10/20 = 1/2 (.5)	19/25 (.95)	10/9=1.11	$20/11^2$ = .17
2	1	-10	10	-9	10/20=1/2(.5)	11/20 (.55)	10/9=1.11	$180/19^2$ = .50
3	1	-2	2	-1	2/4=1/2(.5)	3/4 (.75)	2/1=2.0	$4/3^2$ = .44
4	1	-50	50	-1	2/100=1/50 (.02)	51/100(.51)	$2/49^2$=.001	49 x $100/51^2$ = 1.88
5	1	-10	10	-5	6/20=3/10(.3)	11/20 (.55)	6/9.5 = .13	$180/15^2$ = .80
6	4	-6	6	-1	5/12 (.42)	10/12=5/6(.83)	5/2.5=.50	2 x $12/7^2$ = .49

Hypotheses as to ascending - orders of difficulty of game resolution may be obtained simply be ranking games according to these indices. As to the relative merits of these indices, Axelrod (1970) shows his to predict the probability of cooperative outcomes P_{cc} outcomes better than a wide range of others, including r_1 and r_2.

Chapter V

A. General Remarks on Sections A and B.

1. Our discussion passed too rapidly over the association of game theory with classical economic thought and the consideration of both as reflections of market organized capitalism. Game theory like classical economics presupposes that methodological individualism is the correct analytic for social interaction. Marxians contend that this is a reflex of the social atomization engendered by market organization and characterize its reductionism as ideological thinking in the following senses: a) ignorance of the historical boundedness of a particular form of social organization; b) the reign of subjectivity means that social facts are reduced to natural ones and recognition of an objective social totality is absent.

However, liberals (cf. K. Popper, The Open Society and Its Enemies, 1962) argue that reduction of society to aggregations of individuals and explanation of interaction in terms of their motivations is a perennial mode of analysis in western civilization and not particular to capitalism. Furthermore, they feel that rational analysis needs to begin with such reduction but that the analysis is also tightly bound to a normative, positive concept of human freedom and liberty.

Some class discussion could be devoted to the question of where the proper starting place for social analysis is: in the intentions of individuals or socially enforced relational forms.

2. As mentioned in Chapter I, though somewhat muted in the present discussion, the exclusion of ethical/moral or social considerations is not fundamental to game theory. Luce and Raiffa (1957) contend that the final utilities a player assigns to outcomes reflect these. However, game theorists' treatment of these in zero-sum games has at best been ambiguous.

At another level, Von Neumann and Morgenstern (1964) did make ethical feelings or what they call "standards of behavior" an active operator on the interaction space (the game in normal form) for N-person games. They realized that such games actually turn into bargaining games over distribution of co-production and as such have an infinite number of solutions within prescribed boundaries. They felt that the solution which would be instantiated depended on the "standards of behavior" shared by the players, that is, the players shared ideas of just distribution commensurate with the power of each to affect the outcome. In contrast, the Aumann-Maschler solution for such games (cf. Davis, 1970) dispensed with such "standards" as does Riker's coalition theory.

The expunging of notions of distributive justice from the construction of a normative outcome in N-person and mixed motive games might have been prompted by interest to increase the rigor of paradigm propositions, but probably the ascendance of economics in the social sciences had influence. The latter influence can be judged by comparing the assessments of the individual's relation to public goods projects in Edward Banfield's The Moral Basis of a Backward Society (1958) and Mancur Olson's The Logic of Collective Action (1965). Banfield, influenced by Parsonian sociology, clearly regarded the failure to contribute to public good as social deviance. Olson, a student of Banfield's, argued on the basis of marginal utility motivation, that such failure is economically normative behavior. Olson's argument and result is easily transformed into Schelling's (1973) analysis of the N-person PD game.

3. H. Nurmi (1977a) comments that empirical refutation has had little impact on the political theorists who use the concept of the utility maximizing individual:

> I can think of no case that would better explain the failure of naive falsificationism as a descriptive model of scientific change than analytic political theory...the predictive success of the theory has been a major concern of the theorists as it seems that on purely individual rationality grounds, one cannot explain the most pervasive and important phenomena of political life: collective action and voting.

Nurmi, however, cannot account for the tenacity of theorists on behalf of the analytic theory, as opposed say, to the submission of phlogiston theorists at the beginning of the nineteenth century. This follows from his total agreement with Lakatos that the scientific community has internal standards and scientific change is not prey to mob-psychology (as Kuhn would have it). In brief, Nurmi apparently credits political theorists with the ability to separate their knowledge interests from their political commitments. Our own reading of game theory's triumph over empirical evidence however emphasizes the function of social scientific theorizing in the construction of a social reality.

The point is that the Prisoner's Dilemma paradox is not simply a logical problem but a metaphor for the contradiction between an individualistic utilitarian rationality and collective welfare aspirations. These two rationalities are not simply competing speculations about human motivation but are competing principles of social organization/administration.

B. Answers and Comments, Exercises VB.

1a. Briefly, the physicist predicts the rocket will go into orbit (unless there is an internal malfunction). He expresses the result of an empirically validated relation between moving objects and their gravitational fields. The social scientist states a statistical expectation regarding the average expected longevity of the cohort born today. The expectation need not be validated by any particular baby and bears an implicit "all other things being equal" clause, e.g., unless the black plague returns, unless cures for all our ailments are found, unless Geritol improves. The mathematician's "should" references logical implication, i.e., the result is necessary according to the rules of logic

I am using, while the clergyman's <u>should</u> references a moral/ethical obligation he assigns to each person probably on the basis of some non-testable cosmological theory. Of course, the clergyman, the mathematician, the statistician and the physicist might each also mean that they hope their respective expectations are met or otherwise each may find himself unemployed. But that just begs the question upon what basis each of them anticipates or demands the result.

1b. For purposes of the question, "rational behavior" means utility maximizing instrumental action and does not also refer to an individual's construction of his utility function. That is, we can consider a masochist to act rationally if he behaves to extract the utmost endurable grief from a situation.

A socio-biologist could reply that rational behavior is man's natural behavior evolutionarily selected because it increased the organism's survivability. Consequently, unless she is intellectually malfunctioning, a person will act rationally. The statistically oriented social scientist might interpret the question to ask why one expects a particular person to behave rationally and therefore respond that empirical evidence indicates a majority of people do attempt to maximize their utilities. Irrationality then would be read as a statistical deviation. The aware economic rationalist might respond that rational behavior is consistent with his models of economic activity (which have some empirical validation) and thus if the model is correct, people are acting rationally at least in the environment specified by the model. Finally, the social psychologist, sociologist or ethical philosopher could respond that a person has an obligation to behave rationally. This obligation can be taken in two ways. An obligation to self created by self being in a milieu where such type behavior is perceived necessary for survival, success or welfare. Second, an obligation created by membership in a group where egocentric utility maximization is considered normative behavior. Adam Smith's descriptive statement that when each person works for his own good, the general interest is promoted might then be taken as an ethical enjoining to work for one's own good. As long as no conflicts of interest are salient, this businessman's morality can be easily maintained.

To be sure, there are gradations of irrational behavior, and perhaps the "irrationality" of someone unable to perform simple personal welfare increasing acts, such as self-feeding, grooming, etc., cannot be compared to the "irrationality" of a bad decision maker in a complex situation. In the absence of a protective society, the penalty for the former type of irrationality is extinction of the individual. Penalty for the second type of irrationality varies with the type of environment in which the original act occurs. For example, market forces generally punish irrational business decisions.

2. There is really no correct answer for this question because we are ultimately dealing with how people assess the utilities of the various outcomes of the possible strategic interactions between the United States and the Soviet Union. From the American perspective, to read the interaction

space as a zero-sum game means that any increase in the U.S.S.R.'s international power or even domestic welfare that results from these interactions entails a decrease in U.S. international power and or domestic welfare. The underlying assumptions are that power or welfare is a fixed sum commodity (as more power chips are added through global economic development, the value of each decreases) and the Soviet intention is to bury the United States. To read the space as mixed-motive is to perceive that some outcomes where both sides win exist. For example, the mixed-motive game reader believes that the U.S. selling computers to the Soviet Union can increase both countries' welfare, while the zero-sum game reader seeing in this an increase in Soviet capabilities would argue there is axiomatically a decrease in U.S. power despite the money realized on the sale. Consequently, the use of the terminology adds nothing to a global understanding of Soviet-American relations.

On the other hand, game representations of the interaction space regarding particular issues may help clarify the constraints on unilateral action by one or the other actor, particularly when there is agreement on the utilities of the outcome possibilities.

For example, rivalry between the super-powers for influence over a third country or control of energy sources might be universally read as zero-sum and strategies accordingly calculated. Schelling and other strategists, on the other hand, correctly saw that armed confrontation between the super-powers due to the mutuality of the nuclear option could not be read as a zero-sum game because the respective utilities of maintaining the no-war status quo would be greater than the utility distributions after a nuclear war, even if in both cases power parity was maintained. The game was thus variable sum and symmetric. The game was also mixed motive in the sense that each actor had reasons to maintain the status quo and reasons to try to defect from it. But the conclusions that Schelling and others drew from this was the possibility of dealing with the Soviet Union.

3. The 2.1 metagame involves the first player using a W/X/Y/Z policy against the other's A/B policy where the letters are replaced by either don't confess or confess.

For consistency with convention, we set "don't confess" to C and "confess" to D. There are sixteen (16) possible policies for the first player and four (4) for the other player.

To translate the 2.1 metagame interaction into a basic game interaction look first at what player one would play (according to the policy he is considering) if he thought the other will play a particular metastrategy and then supply what the other plays (according to his 0.1 metagame strategies) when player one takes that basic strategy. From that routine we can compute the basic game outcomes:

	Prisoner B				
Prisoner A	C/C	D/D	C/D	D/C	Row **minima**
C/C/C/C	.9,.9	0,1	.9,.9	0,1	0
D/D/D/D	1,0	.1,.1	.1,.1	1,0	.1
D/D/D/C	1,0	.1,.1	.1,.1	0,1	0
D/D/C/D	1,0	.1,.1	.9,.9	1,0	.1
D/D/C/C	1,0	.1,.1	.9,.9	0,1	0
D/C/D/D	1,0	0,1	.1,.1	1,0	0
D/C/D/C	1,0	0,1	.1,.1	0,1	0
D/C/C/D	1,0	0,1	.9,.9	1,0	0
D/C/C/C	1,0	0,1	.9,.9	0,1	0
C/D/D/D	.9,.9	.1,.1	.1,.1	1,0	.1
C/D/D/C	.9,.9	.1,.1	.1,.1	0,1	0
C/D/C/D	.9,.9	.1,.1	.9,.9	1,0	.1
C/D/C/C	.9,.9	.1,.1	.9,.9	0,1	0
C/C/D/D	.9,.9	0,1	.1,.1	1,0	0
C/C/D/C	.9,.9	0,1	.1,.1	0,1	0
C/C/C/D	.9,.9	0,1	.9,.9	1,0	0
column minima	0	.1	.1	0	

The equilibria are circled. The choice should be of equilibrium strategies that bid for the higher (.9,.9) equilibrium.

Chapter VI

Since the text is fairly straightforward, we limited remarks here to the following.

A. Comments on Exercises

1. There are of course no "right" answers to this discussion or debate. Try to structure the discussion so that the issues debated are not too phoney. Picking relevant views from earlier class discussion, or asides, lends relevance. The point about new resolution ideas is intended to tap the generative "heuristics" (once called "indictive logic") of the different research paradigms. Surely a general debate among paradigms would be a bit absurd. Rather, a focused debate or argument -- something like our own simulated discussions -- at the end of Chapters III and V -- is more relevant. One might comment on which of the criteria of scientific progress in Chapter II the students have themselves invoked or modified. Clearly the focus on resolutions emphasizes the practical products of social research, although the results of scientifically idealized experiments cannot easily be transferred to complex social and political problems. The students may thus recognize the cross-paradigm commensurability problem first hand.

2. The words in this passage trigger too many references to the rest of the module for us to list them all here. But we note that the results in Chapter III on PD playing styles in different socio-political locales, incluing barrios and kibbutzim, are especially relevant.

3. More formalized evaluation questionnaires may be available from the Educational Affairs Office of the American Political Science Association. The emphasized points in our statement of purposes and easily provide a framework for teacher led discussion.

APPENDIX

This appendix contains suggestions and procedures for setting up and reflecting upon gaming experiments. Their purposes are to give the student:

a. the experience of participating in games that are often used as analogies for social conflict;

b. behavioral and other data that might be useful in the testing of of social science theories;

c. a demonstration that knowledge cumulation in social science research paradigms applies as much to social science students as it does to anonymous experimental subjects;

d. the opportunity to analyze and discuss one's own behavior in different social science perspectives.

Our methods derive from those introduced by the behaviorist learning and the social psychological conflict resolution research paradigms in their use of the PD and other games as experimental tools. We have used most of the material below for the past several years. We hope that you, the instructor, will use them because a common data generating and reporting method will enable comparison of behavior across diverse groups of students.

The materials below include:

1. Examples of games played in previous research projects, i.e. Flood's original SPD game (1952), Rapoport and Chammah (1965), and our own payoff configurations derived in part from the work of Emshoff and Ackoff (1970). Note that these include both symmetric and asymmetric matrices. During the past two years we have used asymmetric matrices since these stimulate more overt consideration by their players of the equity and power dimensions of the games.

2. Different strategies for setting up students' play of such games. These vary from free play with communication to a student's play against a computer mechanically stimulating an opponent. A set of instructions for game coordinators is also included.

3. An informed consent form. Although some schools do not monitor the use of students in experiments, we think that in all cases, students must be given the opportunity to consent or refuse to participate in the gaming experiments. Nevertheless, students who do refuse should specify their reasons in an essay of several pages. They may also be requested to help analyze the class-generated data or other relevant material.

4. A sample of a personal questionnaire that collects standardized information on the student player. Such information can later be used for testing hypotheses relating personal and attitudinal variables to behavior. Often it would be augmented by some other pscyhological inventories.

5. Game exercise record forms and illustrative results. Our form is completed by the student as he or she plays the game. Its questions help generate a move by move history of the game and relate the player's choices to his anticipations of the other player's moves. Our record form includes an end of the game questionnaire that elicits player impressions about the game and his personal performance in it. Flood's form and illustrative results are also of considerable interest.

6. Instructions to the player for writing a summary essay. The essay permits the player to describe and analyze her SPD experience. It can then be exchanged with that of the other player in the pair; each player can then be asked to comment briefly on the other's interpretation of what happened. Such procedure allows the player to reflect on the causes of her own behavior, her responsibility attribution patterns, and those of the other player as well.

7. Interview procedures. We did recorded interviews with certain pairs interviewed according to the format reproduced below. The pairs were often selected for interviewing because their game history showed either dramatic shifts in play or a consistent mutual pattern from the early stages of the game. The interviews restored direct two and three-way communication to the relationship among the players and experimenter.

8. Data analysis program description, and FORTRAN code. This section includes operational definitions for individual player parameters such as trust and trustworthiness, plus a program for their computation.

9. Besides an illustrative analysis of an interesting M.I.T. SPD run (the one summarily reported in section 5 above), we give summary results from recent SPD experiments we conducted at M.I.T.

1. EXAMPLES OF SPD AND SEQUENTIAL CHICKEN GAME MATRICES

a. In one of the games used by Flood (1952a), the payoff matrices for players AA and JW were:

$$A=\begin{Vmatrix} -1 & \frac{1}{2} \\ 0 & 1 \end{Vmatrix}, \qquad W=\begin{Vmatrix} 2 & 1 \\ \frac{1}{2} & -1 \end{Vmatrix}.$$

Source: Flood (1952a), p. 18.

The synoptic game was consequently:

Player JW

Player AA		D	C
	C	-1,2	½,1
	D	0,½	½,-1

b. PD matrices used by Rapoport and Chammah (1965).

	C	D
C	9,9	−10,10
D	10,−10	−1,−1

Matrix 7.
Game I.

	C	D
C	1,1	−10,10
D	10,−10	−9,−9

Matrix 8.
Game II.

	C	D
C	1,1	−10,10
D	10,−10	−1,−1

Matrix 9.
Game III.

	C	D
C	1,1	−2,2
D	2,−2	−1,−1

Matrix 10.
Game IV.

	C	D
C	1,1	−50,50
D	50,−50	−1,−1

Matrix 11.
Game V.

	C	D
C	5,5	−10,10
D	10,−10	−1,−1

Matrix 12.
Game XI.

	C	D
C	1,1	−10,10
D	10,−10	−5,−5

Matrix 13.
Game XII.

Source: Rapoport & Chammah (1965), p. 37.

c. Two asymmetric noncooperative games used at M.I.T.

Payoff Matrix #1
(an asymmetric PD)

		COLUMN C	COLUMN D
ROW	C	(1,3)	(-6,4)
	D	(6,-4)	(-1,-3)

Payoff Matrix #3
(asymmetric Chicken)

		COLUMN C	COLUMN D
ROW	C	(-1,3)	(-3,5)
	D	(0,-1)	(-4,-3)

2. EXPERIMENTAL STRATEGIES

After the introductory class session and outside allotted class time, the students should play an SPD or chicken series. This series should have at least 50 trials and the payoff matrix should remain invariate throughout the series. In our recent experiments the series length has been approximately 52 moves and we have used either game matrix 1 or game matrix 3 above. Players are not told before or during their play how many trials there are, but they are assured that the experiment will take at most several hours. Neither money nor grade incentives have been used, but we have sometimes awarded a six-pack of beer to the best individual performance in a particular role. The effect of this small material incentive has been, we believe, ceremonial, yet ambiguous -- one of the students who won the six-pack reported that he detested beer, while others who lost easily capitulated in the false hope of sharing the spoils.

a) Some communication options

Strategies for the experimental gaming can range from allowing the players to freely communicate with each other and with the experimenter to pitting a player against a simulated opponent. In our free play experiments on one occasion we used an inter-office telephone network to achieve physical separation and preserve the anonymity of the players, while allowing them to communicate with the experimenter. Players were seated in separate offices and had the phone number of a coordinator who was in a third office. They reported their respective trial moves to the coordinator, who would then report back to each player the trial's outcome.

Free communication between players can be established by giving each the other's phone number. Of course, in this last condition previous acquaintance between players becomes an uncontrolled influence on their play. In the Flood experimental data below, the "other player's" identity was in fact accidentally discovered.

Players can also be separated and kept from identifying one another by using a language laboratory network or more simply by seating players on either side of a partition and facing the experimenter. The players can then indicate their respective moves by holding up a card or token and the experimenter will afterward announce the trial outcome.

We have found that when players have the means to communicate with the experimenter they frequently request restatement and redefinition of the game instructions. The experimenter's responses then become an influence on their play (see Alexander and Weil, 1969). The experimenter therefore has the choice of responding freely, noting it and later scrutinizing the student's essay for indication of its effect or of just restating the original instructions. Since the primary importance of SPD and chicken gaming in the free play condition is educational, i.e., student's exposure to decision making in under-specified situations, we think the content of the experimenter's response is less important than his having the player recognize the significance of the request. The experimenter might for example begin her response with, "You are asking for clarification and redefinition of the game!" We have entered below instructions to game coordinators used in a recent (1979) gaming experiment run with the help of Lloyd Etheredge at M.I.T.

Instructions for Coordinators

1. You will be running 2 games with 4 players. You will know player numbers (two digits between 51 and 100), player parings, and a telephone extension for each player.

2. The procedure is as follows: for each round both players will call you on one of your extensions. They will announce their player number and their move - either "C" or "D". Record their moves on your sheet. When one player reports his move, tell him the other players' move, if you know it. Otherwise, telephone the other player to announce the other player's move. Also give the round number. For example, "On round 17, player 59's move was "C". Then hang up and record on your sheet that you have reported the move.

3. Things should be manageable as each call (in or out) should take only about 10-15 seconds. On our phones, you can never have more than 3 calls coming in at once; students will be alerted that you may be briefly delayed (you can put them on "hold" or let it ring, whichever you prefer). You can control the pace because the next round cannot begin for any set of players until you have reported moves on the previous round to them. It is more important to be careful than speedy.

4. Be crisp. Answer "Controller". When you get the move, simply say something like "Player 57 selected "D" on round 10, understood".

5. Do not hold each game to the same pace if some move faster. In fact in queuing for xeroxing game records it will be advantageous if some teams finish earlier.

6. Do not accept moves for other than the current round (e.g. don't accept, "I'll "C" from now on . . . can I go home?")

7. After their move is completed, tell each player their game play is over. Ask them please to report to the Xerox room on the fourth floor to xexox a record of their game play for the experimenter - and that afterward they may leave, using their own copy for essay writing purposes.

b) On the use of preprogrammed "stooges"

Since the early 1960s, social psychologists have conducted gaming experiments which featured an experimenter's confederate or "stooge" who followed a pre-programmed, sometimes reactive, strategy. The possible repertoire of the stooge has been greatly expanded through interactive computer programs; Axelrod's report (1979) on the SPD algorithm computer tournament includes the programs written in FORTRAN for strategies ranging from lagged tit-for-tat and random play to highly complex, if not particularly effective, conditional strategies. In some of our early computerized experiments, students were told they were playing against a "preprogrammed confederate". In what we privately called a behaviorist "pigeon" program, the propensity to choose C increased with the student's own choices of C. In a related exercise, a mechanical lagged tit-for-tat program returned the student's move on the present trial as it's own move in the following trial. In both cases a 10% noise factor was added. That is, 10% of the moves the machine made were determined randomly. This factor surprisingly enough helped prevent the overwhelming majority of students from correctly diagnosing either the strategies that opposed them, or their own control of their opponents.

These two programs can be approximated by simple means where computer facilities are unavailable or too expensive for use in a PD module. In such cases, however, use of the constructed stooge requires a team of administrators who if they are not volunteers will raise the costs of the experiment. Perhaps students who have already played an experimental game will become administrators/confederates on subsequent trials. As in the free play condition described above, the confederates move can be communicated to the student by telephone or similar means.

The important thing is the student not see how the confederate decides what to play. The confederate makes his or her decision by using the spinner described below. In the variable cooperative propensity mode, this device allows for variation in the probability of a C (or D) being chosen. In the tit-for-tat mode it allows for a certain random deviation for the consistent return of the student's previous move.

Instructions: Pigeon Algorithm

1. Spin to Determine Move on Each Trial

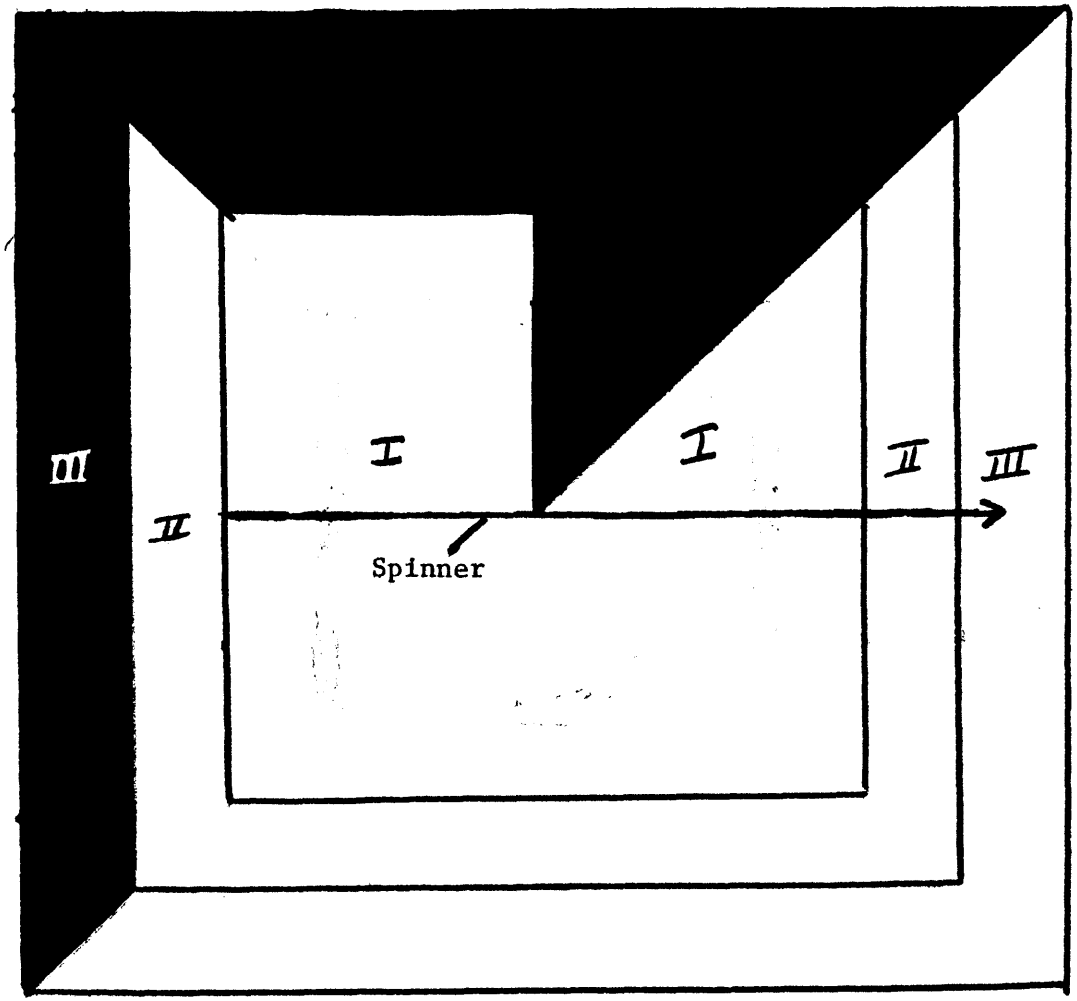
2. For 1st 4 Trials of Series, Use Outer Ring. If Tip Points to Black, Then C Otherwise D.

3. Count Number of Other's C's in the Four Trials.

4. For Trials 5 - 8:
   If Other Had 0 C in Trials 1 - 4, then C only when spinner points to black in region I (innermost frame). Otherwise D
   If Other Had 1 C, then C only when spinner points to black in region II (middle frame), otherwise D
   If Other Had 2 C, then C only when spinner points to black in region III, otherwise D
   Other Had 3 C, then C when spinner points to white in middle region (II), otherwise D
   Other Had 4 C, then C when spinner points to white in region I

5. For Trials 9 - 12 use other's moves in trials 5 - 8 as base. Repeat procedure
   And so forth for every subsequent set of 4 trials.

6. To avoid confusion at the beginning of each set of four, place a dime or other thin marker in region to be used during that set.



Tit-for-Tat Algorithm.

1. Spin.

2. If spinner points to white in region I, play the same move the other did on the previous trial. If spinner points to black in region I, play the opposite move.

3. INFORMED CONSENT FORM

Informed Consent Form

I understand that this exercise consists of:

1.) The taking of several paper and pencil psychological tests;
2.) Repeated plays of one or several two-person, mixed-interest games, and associated questions about game-related expectations and rationales;
3.) The writing of an essay on game history;
4.) The subsequent sharing of such essays with the other game player; and
5.) A taped session discussing such essays about game play.

Moreover, I understaad that alternative equivalent course work is available if I do not care to participate in such exercises; and that I may discontinue participation in this exercise at any time, without penalty.

I further understand that, while the results of this exercise may become part of a published research report, my identity will be kept confidential. The course instructors and their research assistants will, however, have have access to game records and associated information for research purposes.

____
Name

____
Date

4. PERSONAL DATA QUESTIONNAIRE

1. NAME ______________________________

2. PHONE ______________________________

3. PLAYER NO. ______________________________

4. SEX ______________________________

5. Major ______________________________

6. Year ______________________________

7. College Board Verbal Aptitude %ile ______________

8. College Board Quantitative Aptitude %ile ______________

9. What do you consider the best label for overall political orientation?

   ____
   Very liberal   Liberal   Moderate   Conservative   Very conservative

10. How important are your political views to you?

   ______ Not at all important   ______ Somewhat important   ______ Relatively important   ______ Very important

CONFIDENTIAL

GAME EXERCISE RECORDS

a) MIT form

GAME EXERCISE RECORD

Date: ______/______/______/ Page #: 1
1-2 3-4 5-6 7
Month # Day # Year

Player #: ______ 8-9 Other Player's #: ______ 10-11 Game #: ______ 12

Payoff Matrix:

		Column Player C	Column Player D
Row Player	C	(,)	(,)
	D	(,)	(,)

Payoffs are in form:
(row's points, column's points)

If you are row player, put a 1; if you are column player, put a 2 below:
______ 13

TRIAL 1

Please answer No. 2 using complete sentences:

1. What move are you going to play (C or D)? ______ 14
2. Why are you going to do that? ______________________________

____

____

Your move? ______ 15 Other's move? ______ 16
Outcomes: Your payoff? ______ 17-18 Other's payoff? ______ 19-20

TRIAL 2

What do you expect the other player to do (C or D)? ______ 21
Your move? ______ 22 Other's move? ______ 23
Outcomes: Your payoff? ______ 24-25 Other's payoff? ______ 26-27

TRIAL 3

What do you expect the other player to do (C or D)? ______ 28
Your move? ______ 29 Other's move? ______ 30
Outcomes: Your payoff? ______ 31-32 Other's payoff? ______ 33-34

TRIAL 4

What do you expect the other player to do (C or D)? ______ 35
Your move? ______ 36 Other's move? ______ 37
Outcomes: Your payoff? ______ 38-39 Other's payoff? ______ 40-41

Leave the following area blank:

42	43	44	45	46	47	48	49	50	51	52	53	54	55	56
57	58	59	60	61	62	63	64	65	66	67	68	69	70	71

A-16

Player #: ________ 1-2

Page #: 2 3-4

TRIAL 5

Please answer Nos. 1, 4 and 6 using complete sentences:

1. Why do you think the other player made the last move? ______________________________

2. How well are you doing? (Circle one)

1	2	3	4	5	6	7	
much worse than expected			as well as expected			much better than expected	___ 5

3. What do you expect the other player to do (C or D)? ___ 6

4. Why do you think he/she will do that? ______________________________

5. What move are you going to play (C or D)? ___ 7

6. Why are you going to do that? ______________________________

7. If the other player were in your current situation, what move do you think he/she would play (C or D)? ___ 8

Your move? ___ 9 Other's move? ___ 10

Outcomes: Your payoff? ___ 11-12 Other's payoff? ___ 13-14

TRIAL 6

What move do you expect the other player to make (C or D)? ___ 15

Your move? ___ 16 Other's move? ___ 17

Outcomes: Your payoff? ___ 18-19 Other's payoff? ___ 20-21

TRIAL 7

What move do you expect the other player to make (C or D)? ___ 22

Your move? ___ 23 Other's move? ___ 24

Outcomes: Your payoff? ___ 25-26 Other's payoff? ___ 27-28

TRIAL 8

What move do you expect the other player to make (C or D)? ___ 29

Your move? ___ 30 Other's move? ___ 31

Outcomes: Your payoff? ___ 32-33 Other's payoff? ___ 34-35

Leave the following area blank:

36 37 38 39 40 41 42 43 44 45 46 47 48 49

50 51 52 53 54 55 56 57 58 59 60 61 62 63 64

ETC for 52 trials

GAME QUESTIONNAIRE

To be filled out upon completion of game play.

Player No.____________ Game No.______________
1 2 3

1. What is your attitude toward playing this game again? (Circle one)

1	2	3	4	5	6	7
Unfavorable			Neutral			Favorable

2. If you were to play the game again, how favorable or unfavorable would you be toward having the same person as the other player? (Circle one)

1	2	3	4	5	6	7
Unfavorable			Neutral			Favorable

3. Do you think the game was fair? (Circle one)

1	2	3	4	5	6	7
unfair						fair

4. Do you think the game was biased in your favor? (Circle one)

1	2	3	4	5	6	7
Against you			Unbiased			in your favor

5. Do you think the game was biased in the other player's favor? (Circle one)

1	2	3	4	5	6	7
Against other			Unbiased			in other's favor

6. Overall, how do you think you did? (Circle one)

1	2	3	4	5	6	7
Poorly			As expected			Very well

7. Overall, how do you thikk the other player did? (Circle one)

1	2	3	4	5	6	7
Poorly			As expected			Very well

8. What reasons do you have for your answers to questions six and seven?

____

____

____

b) Results of an illustrative MIT exercise

i. record of MIT game play, game 1, players 54 versus 83.

The record below (reprinted in computerized form) corresponds to the MIT game exercise record form (5a above). Each line represents player responses on separate trials. The first five lines (trials) are interpreted here; the bracketed numbers (found in the game exercise record) are included to help identify the questions to which the responses correspond.

Trial 1: (cd)

Move of player 1 (row) [15] = C
Move of player 2 (column) [16] = D

Trial 2: (cccc)

Move of player 1 (row) [22] = C
Move of player 2 (column) [23] = C
Row's expectation of column's move [21] = C
Column's expectation of row's move [21] = C

Trial 3: (dccc)

Move of player 1 (row) [29] = D
Move of player 2 (column) [30] = C
Row's expectation of column's move [28] = C
Column's expectation of row's move [28] = C

Trial 4: (cccc)

Move of player 1 (row) [36] = C
Move of player 2 (column) [37] = C
Row's expectation of column's move [35] = C
Column's expectation of row's move [35] = C

Trial 5: (cccccc66)

Move of player 1 (row) [9] = C

Move of player 2 (column) [10] = C

Row's expectation of column's move [6] = C

Column's expectation of row's move [6] = C

Row's anticipation of column's move if in row's situation [8] = C

Column's anticipation of row's move if in column's situation [8] = C

Row's assessment of current situation [5] = 6

Column's assessment of current situation [5] = 6

Trials 6 - 52:

(repeat according to pattern demonstrated above)

```
.GAME  1  PD  54 VS 83  10/11/79
. 52
.cd
.cccc
.dccc
.cccc
.cccccc66
.cccc
.dccc
.cccc
.cccccc76
.cccc
.cccc
.cccc
.cccccc77
.dccc
.cccc
.cccc
.cccccc77
.cccc
.dccc
.cccc
.cc ccc77
.cc c
.dccc
.cccc
.cccccc77
.cccc
.cccc
.cccc
.dcccdc47
.cccc
.cccc
.cccc
.cccccc47
.cccc
.dccd
.cccc
.cccccc47
.cccc
.cccc
.cccc
.dccddc47
.cccc
.cccc
.cccc
.cccccc47
.dccd
.cccc
.cccc
.cccccc57
.cccc
.dccc
.cccc
```

ii) Selected Responses of MIT Player 54 and 83 to open-ended questions about an asymmetric SPD game (game 1)*

At Trial 5

Player 54

[1.] I hope that he has realized that by always playing C, I can control the game by varying my move, to our mutual benefit.

[4.] As I said in 1 above, we can both achieve reasonable point scores if he will let me control the game, and he always play C.

[6.] If I give him a bit of an edge now, he might be more likely to continue playing C even when I start throwing in D's.

Player 83

[1.] I think we're up to trusting each other. He wants me to say C, so he switched from D (in 3) to C (in 4).

[4.] Hopefully we will reach an agreement of me moving C always and him moving 5 C's and 1 D. In that case our scores will equal 11.

[6.] I want to try to force the sequence described in my answer to C because he will want to force to D.

At Trial 9

Player 54

[1.] Evidently, he is willing to let me control things.

[4.] For the same reasons previously stated: we have a good thing going.

[6.] Same reason -- now that our totals are the same, we can go 5 C's, 1 D at a time (me that is). Later in the game, perhaps, I can start pushing my luck and take a lead.

Player 83

[1.] Moves 1 and 3 came out even. As of the last move, we each had 11. Player 53 [sic] switched to D for one move and then switched back.

[4.] Hopefully he/she is attempting to establish a pattern of C's and D's.

[6] So far, the pattern is good, My best move is to play C and see what Player 54 does.

---

*For actual question formats, see Questions 1, 4, and 6 in the trial 5 block of the game exercise record form.

c) Game Record and Players' Commentaries from the Flood Experiment

Table 1

The Plays

Play	Strategies AA	Strategies JW	Payoffs to AA	Payoffs to JW
1	2	2	1	-1
2	2	2	1	-1
3	2	1	0	+
4	2	1	0	+
5	1	1	-1	2
6	2	2	1	-1
7	2	2	1	-1
8	2	1	0	+
9	2	1	0	+
10	2	1	0	+
11	2	2	1	-1
12	1	2	+	1
13	1	2	+	1
14	1	2	+	1
15	1	2	+	1
16	2	2	1	-1
17	1	1	-1	2
18	1	1	-1	2
19	2	1	0	+
20	2	1	0	+
21	2	2	1	-1
22	1	2	+	1
23	1	2	+	1
24	1	2	+	1
25	1	2	+	1
26	2	2	1	-1
27	1	1	-1	2
28	2	1	0	+
29	2	1	0	+
30	2	1	0	+
31	2	2	1	-1
32	1	2	+	1
33	1	2	+	1
34	1	2	+	1
35	1	2	+	1
36	1	2	+	1
37	1	2	+	1
38	2	2	1	-1
39	1	1	-1	2
40	2	1	0	+
41	2	2	1	-1
42	1	2	+	1
43	1	2	+	1
44	1	2	+	1
45	1	2	+	1
46	1	2	+	1
47	1	2	+	1
48	1	2	+	1
49	2	2	1	-1
50	1	1	-1	2

Play	Strategies AA	Strategies JW	Payoffs to AA	Payoffs to JW
51	2	2	1	-1
52	1	2	+	1
53	1	2	+	1
54	1	2	+	1
55	1	2	+	1
56	1	2	+	1
57	1	2	+	1
58	1	2	+	1
59	1	2	+	1
60	2	2	1	-1
61	1	2	+	1
62	1	2	+	1
63	1	2	+	1
64	1	2	+	1
65	1	2	+	1
66	1	2	+	1
67	2	2	1	-1
68	1	1	-1	2
69	2	1	0	+
70	2	1	0	+
71	2	2	1	-1
72	1	2	+	1
73	1	2	+	1
74	1	2	+	1
75	1	2	+	1
76	1	2	+	1
77	1	2	+	1
78	1	2	+	1
79	1	2	+	1
80	1	2	+	1
81	2	2	1	-1
82	1	1	-1	2
83	1	2	+	1
84	1	2	+	1
85	1	2	+	1
86	1	2	+	1
87	1	2	+	1
88	1	2	+	1
89	1	2	+	1
90	1	2	+	1
91	1	2	+	1
92	1	2	+	1
93	1	2	+	1
94	1	2	+	1
95	1	2	+	1
96	1	2	+	1
97	1	2	+	1
98	1	2	+	1
99	2	2	1	-1
100	2	1	0	+

+ denotes 1/2

Table 2

Strategy Frequencies

AA \ JW	1 (D)	2 (C)	Total
(C) 1	8	60	68
(D) 2	14	18	32
Total	22	78	100

Source: Flood, 1952a, pp. 18-19.

Running Comments*

I. Subject AA

Play No.	Comment
1	JW will play 1—sure win. Hence if I play 1—I lose.
2	What is he doing?!!
3	Trying mixed?
4	Has he settled on 1?
5	Perverse!
6	I'm sticking to 2 since he will mix for at least 4 more times.
9	If I mix occasionally, he will switch—but why will he ever switch from 1.
10	Prediction. He will stick with 1 until I change from 2. I feel like DuPont.
19	I'm completely confused. Is he trying to convey information to me?
28	He wants more 1's by me than I'm giving.
31	Some start.
32 - 40	JW is bent on sticking to 1. He will not share at all as a price of getting me to stick to 1.
49	He will not share.
58	He will not share.
59	He does not want to trick me. He is satisfied. I must teach him to share.
67	He won't share.
68	He'll punish for trying!
70	I'll try once more to share—by taking.
91	When will he switch as a last minute grab of (2). Can I beat him to it as late as possible?

---

* The two subjects are friends.

II. Subject JW

Play No.	Comment
1	Hope he's bright.
2	He isn't but maybe he'll wise up.
3	O.K., dope.
4	O.K., dope.
5	It isn't the best of all possible worlds.
6	Oh ho! Guess I'll have to give him another chance.
7	Cagey, ain't he? Well ...
8	In time he could learn, but not in ten moves so:
10	I can guarantee myself a gain of 5, and guarantee that Player AA breaks even (at best). On the other hand, with nominal assistance from AA, I can transfer the guarantee of 5 to Player AA and make 10 for myself too. This means I have control of the game to a large extent, so Player AA had better appreciate this and get on the bandwagon. With small amounts of money at stake, I would (as above) try (by using Col. 2) to coax AA into mutually profitable actions. With large amounts at stake I would play Col. 1 until AA displayed some initiative and a willingness to invest in his own future. One play of row 1 by AA would change me from Col. 1 to Col. 2, where I would remain until bitten. On the last play it would be conservative for me to switch to Col. 1, but I wouldn't do so if the evidence suggested that AA was a nice stable personality and not in critical need of just a little extra cash.
11	Probably learned by now.
12	I'll be damned! But I'll try again.
13	That's better.
14	Ha!
15	(bliss)

Play No.	Comment
17	The stinker
18	He's crazy. I'll teach him the hard way.
19	Let him suffer.
21	Maybe he'll be a good boy now.
22	Always takes time to learn.
23	Time.
27	Same old story.
28	To hell with him.
31	Once again.
32	---, he learns slow!
33	On the beam again.
39	The ---.
41	Always try to be virtuous.
42	Old stuff.
50	He's a shady character and doesn't realize we are playing a 3rd party, not each other.
52	He requires great virtue but doesn't have it himself.
60	A shiftless individual—opportunist, knave.
62	Goodness me! Friendly!
68	He can't stand success.
71	This is like toilet training a child—you have to be very patient.
80	Well.
82	He needs to be taught about that.
92	Good.

Source: Flood, 1952a, pp. 39-42.

6. INSTRUCTIONS FOR ANALYTIC ESSAY

Prisoner's Dilemma Assignment

On the basis of your records of your game play, you are to write an essay of 4-5 pages, double-spaced and typed.

Answer the following questions:

1. Describe generally what happened in the game play to you and the other player.

2. As best you can, explain what happened to you and the other player (what caused you and the other player to move the way you did)?

3. Within the limits of these explanatory factors, were there alternative moves or strategies that you or the other player might have taken?

4. To whom do you attribute responsibility for the series of outcomes generated by sequential game play?

5. How did you feel about yourself, the other player and the people who put you in this situation (or made it possible) during the play? How do you feel now?

6. What, if anything, would you say that you learned about: a) yourself; (b) the other player; (c) people in general, from this exercise?

Please give only your player # when you turn in the assignment. Keep one xerox copy of your paper. You will receive a copy of the other player's paper with his/her perceptions, reactions, and comments. Read this paper, then write a final 1 to 2 page (typed, double-spaced) set of reflections. Attach this to the xerox of your original and turn these in to complete the assignment.

7. INTERVIEW PROCEDURES

Instructions to interviewers.

1. Stick pretty closely to the wording of the questions given here. Repeat questions if necessary. You may elaborate or "follow up" on a question but do not suggest your answer to a question.

2. Make sure that you get some sort of answer from each of the people you interview for each of the questions. This is very important.

3. Watch the time. The interview should take 30 minutes or less. Try to get to question 6 about 10 minutes into the interview and to question 10 about 20 minutes in.

4. Identify yourself on tape at the beginning of the interview by name.

5. Mention the player numbers of the interviewees fairly often during the interview. This will help those listening to a tape later on to identify the speakers.

6. Put the recorder or the microphone in a place which will ensure a good recording.

7. After the interview (a) fast forward your tape to the end of the cassette, (b) label the side of the tape with the player numbers (e.g., 4 vs 17), and (c) turn the tape over and reload it for the next interview if there is one.

8. Please read over the questions before the interview. If you have any problems or questions, ask.

Interviewer: Is the tape recorder on?

Interviewer: Identify yourself or selves if two interviewers.

ESTION (1) What were your player numbers? And what was the number of the game you played (1 or 2 or 3)? And your player role number in that game (1 or 2)?

Interviewer: Check this against index cards you should receive. Revise cards if incorrect. Now say:

We ask you this because we want to be able to put together your game record, essay, etc., with what you say during this interview. It won't be of much use to us to have unidentified comments recorded on tape.

Interviewer: Give each person his index card and ask him/her to hold it in a way that you can see it, or place the card in front of the interviewee. Mention the player number fairly often and encourage people to talk clearly but not both at once.

UESTION (2) Did you think you knew who the other player was at the start of the game?

(If yes) Do you think this made any difference in the way you played? What specific differences?

Did you think you could identify the other player at any point during the game? Or before writing your essay?

(If yes) Did this identification make any difference in the way you played? In what you said in your essay?

UESTION (3) Have either of you ever previously participated in an experiment or exercise or game like this?

(If yes) What was it like?

UESTION (4) When do you think you got the hang of the game or felt you knew what was going on? Right from the start or after a few trials or what?

(If either states that it took him/her a while) Why do you say that?

UESTION (5) Do you think one of the players had more control or influence on the outcome of the game than the other? Player 1? Player 2?

Interviewer: It is very important to get answers from each person for questions (5) and (6). You should not be much more than 10 minutes into the interview when asking question (6).

UESTION (6) In your essays you were supposed to have described what happened in your game as well as why it happened. You've now had a chance to read each other's essays and we want to know what each of you thinks of the other's essay.

Interviewer: Be sure each answers. Follow up for each with (a) and (b). Allow discussion.

(a) Do you agree with the other player's description of what happened and his/her explanation of his/her own behaviour?

(b) Do you agree with his/her explanation of your behaviour?

QUESTION (7) Did you feel that the game was in some way unfair to one of the players?

(If yes) Which player?

(If yes) Does your answer extend to (a) the payoffs? (b) the amount of influence you each had over the outcome or each other? (c) other features of the game itself?

UESTION (8) How well did you think you did? And how well do you think the other did? What was the basis or standard of comparison for making these judgements?

UESTION (9) Did you have a general strategy or plan in playing the game? Or were you just sort of reacting to what the other player was doing?

(If a strategy) What was your objective or aim? How did you think your strategy would help?

(If a strategy) Did you change your strategy at any point or points during the game? How? Why?

Interviewer: You should now be not much more than 20 minutes into the interview.

UESTION (10) Did you think that the other player had a general strategy? Did you think he/she was trying to do what he/she has just said he/she was trying to do?

UESTION (11) Do you think you would have played differently if you had played this game again?

(If yes) How?

UESTION (12) Did you think that the other person should have played differently?

(If yes) How?

(To other person) What's your reaction to his/her answer to this question?

UESTION (13) Do you think the game you played resembled any real life situations?

(If yes) Which? In what respects? What made you think of that?

(If yes) When did you think of that? Why just then?

8. A FORTRAN PROGRAM FOR ANALYZING SEQUENTIAL GAME PLAY (PDST1)

a) PDST1 USER'S GUIDE *

INTRODUCTION

PDST1 is a computer package to do several types of basic analyses of sequential 2-person game experiments. It is an outgrowth of PDSTAT, programed by Sheldon W. Searle, an undergraduate student at MIT, in May 1979. The following is the list of available types of analyses you can do in PDST1:

1. Percentage of Cooperative Moves
2. Conditional Probabilities for Every N Moves
3. Conditional Probabilities for Overall Game
4. Tit for Tat Model Fit
5. First Move Model Fit
6. Last Move Model Fit
7. Players' Prediction Accuracy
8. Choice Matching Model Fit
9. Policy Matching Model Fit
10. Game History Graph
11. Summary statistics
12. Aggregate Game History Graph

The program can remember up to 100 games, each up to 100 moves in length. More detailed explanations of each type of analysis above are given in the following.

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* This section, including the program listing, is principally the work of Akihiko Tanaka.

OPTIONS

Each optional feature has a specific code number.

1. Percentage of Cooperative Moves

This option calculates the percentage of cooperative(C) moves of each player and the average across players of these percentages.

2. Conditional Probabilities for Every N Moves

This option gives what Rapporort and Chammah calls the 'state-conditioned propensities' for every N moves. (You must specify the N.) These are:

Trust: the probability that a player will choose cooperatively following a play on which he defected and received P (i.e., following a play on which both defected). In Chapter III of Resolving Prisonor's Dilemmas, we symbolized A's 'trust' as w = p(C /D D).

Trustworthiness: the probability that a player will choose cooperatively, following a play in which he chose cooperatively and received R (i.e., following a play in which both players chose cooperatively). In Chapter III, we symbolized A's 'trustworthiness' as x = p(C /C C).

Forgiveness: the probability that a player will choose cooperatively following a play in which he chose cooperatively and received the sucker's payoff S (i.e., following a play in which he was the lone cooperator). In Chapter III, we symbolized A's 'forgiveness' as y = p(C /C D).

Responsiveness: the probability that a player will choose cooperatively following a play in which he defected and received T (i.e., following a play in which he was the lone defector). In Chapter III, we called it "repentance" and symbolized A's "responsiveness" as $z = p(C\ /D\ C\ )$.

For more detail, see Rapport and Chammah(1965), pp.67-86. and Chapter III of our module.

3. Conditional Probabilities for the Whole Game

This option calculates the four conditional probabilities described in option 2 this time for the sequential game as a whole.

4. Tit-for-Tat Model Fit

This option gives the fit of what may be called the "lagged tit-for-tat" model, which explains the play of the Prisoner's Dillemma as follows: each player makes the same choice on the next play as his opponent made on the last play.

5. First Move Model Fit

This option gives the fit of the First Move Model, which says that each player makes the same choice throughout the game as his very first move. Higher values in this score indicate the "rigidity" or "consistency" of the player. In other words, players with high scores in this fit are less influenced by the interaction with his opponent.

6. Last Move Model Fit

This option gives the fit of the Last Move Model, which says that the player makes the same choice as he did in the last(previous) move. The score of this fit indicates the player's "inertia". Higher fit of this model also means that the player is less influenced by interaction with his or her opponent.

7. Prediction Accuracy

This option shows how accurately the players predict their opponents' moves. In order to use this and the following two options, you have to include the players' predictions of their opponents in your data set.

8. Choice Matching Model Fit

This option calculates the fit of the Choice Matching Model, which may also be called the "tit-for-tat without lag" model. It assumes that each player makes the same choice on the next move that he believes his opponent will make on that move.

9. Policy Matching Model Fit (Temporary)

This option gives the fit of two temporary versions of the Policy Matching Model: Policy Matching without Lag, and Policy Matching with Lag. Policy Matching means: each player applies the same policy that he believes his opponent is using, to the play that he believes his opponent is going to make. For more detail, see Emshoff and Ackoff(1970) and Chapter IV of our module. (1)

---

(1)

If you actually ask the player what policy he believes that his opponent is using, it is easy to calculate the fit. But to ask such questions may influence the players inference pattern because the question itself might lead the player to think in terms of policy matching.

In this option, assuming that the data set has actual moves and prediction data, two versions of the Policy Matching Model are used to come up with the fit. These two versions were originally worked out by Paul Weiss, an undergraduate at MIT, in the spring of 1979. We consider his versions still inadequate,

10. Game History Graph

---

but since we have not finished programming new versions, we explain Weiss's versions in the following. For simplicity, we assume a male is playing a female. Also we discuss policy matching fit with respect only to the first player(male). The same algorithm is applied to the other player too.

Since we do not have the actual belief of the first player as to his opponent's policy, we have to devise some way to infer what policy he infers that she(the second player) uses. One way is to start from his actual prediction about her next move. Suppose he predicted that she is choosing C. Then, from the four possibilities he must have inferred that she is using either (C/C), (C/D), or (D/C) policy. Since he applies the same policy he believes she uses, given C predicted, either (C/C) or (C/D) tells him to play C, while (D/C) tells his to D. We now have to determine which policy among the three he believes that she is using.

To do this, assuming player's inference is based on his past experience, we look back to the last time when he played C. Then, assuming that he assumes that she predicted his move perfectly, if she played C on the same last move, then we can infer that his inference about her policy is (C/C) or (C/D), and if she played D, then we can infer that his inference about her policy is (D/C). Since we have assumed that his prediction is C, this model tells that his next move will be C if the above procedure inferred that he must have inferred that her policy is (C/C) or (C/D) and that his next move will be D if the above procedure inferred that he must have inferred that her policy is (D/C).

This same algorithm is used if he predicts D. This model is temporarily called the "Policy Matching without Lag."

There is one strong assumption in the above, that is the assumption that the first player assumes that the other player can predict his move perfectly when he played C last. It seems somewhat unlikely that one player thinks that the other player is omniscient. Thus, we want a weaker assumption than this. Weiss's next model, temporarily called the "Policy Matching with Lag," assumes that the first player assumes that she reacts to his previous move. In other words, in this model, we look back to the last time he played C, then see what she played in the following move. If she played C, then we infer that he must have believed that she used (C/C) or (C/D), and if she played D, then (D/C) likewise.

This "Policy Matching with Lag" model has problems too. We assume that the first player assumes his opposite reacts to his previous move (therefore, "with lag") on the one hand; we also assume that he decides his move by applying the same policy that he believes she uses to his current prediction (i.e., "without lag") of her move. In other words, we assume that the player applies the policy "with lag" as if it were the policy "without lag".

Therefore, though we understand that the above two precedent

This option plots the frequency of CC, CD, DC, and DD move pairs for every 10 moves. The "b-option" in the graph is provided to plot Nelson's data set and in usual cases, should be ignored. A small revision is necessary to change the interval length.

11. Record Reset

Invocation of this option begins a new cumulative record with the next set of game data.

12. Summary Statistics

This option provides statistics for all games in a given set. It calculates means, variance, and standard deviation in addition to the whole records.

13. Aggregate Game History Graph

This option plots the percentages of CC,CD, DC, and DD move pairs aggregated over a given set for each 10 moves.

---

logics are doing something close to the policy matching notion described in the text, we believe there might be better algorithms for the interpersonal reflections involved, something closer to Alperson(1975) or Lefebvre(1977).

HOW TO STACK THE DATA

The program package is designed to run easily as a batch job or at a terminal. In either case the format of the data stack is very specific.

The first card contains information as to which options are desired on the particular run. The card consists of a series of 'Y's and 'N's in the first 14 columns of the card. It is very important that they be in the first 14 columns. The 14th column should always be 'N'. A 'Y' in a given column means the option with the same number as the column is desired, an 'N' means it is not desired. A 'Y' or an 'N' must be placed in each of the first 14 columns. For example:

YNYNNNNYYYYYYN

↑ 1st col.

tells the package that options 1,3,8,9,10,11,12,13 are desired.

If you choose option 2 (Conditiona Probabilities for every N Moves), the second card must be the one which tells the length of the interval. The number must be entered in the first three colums of the second card, with the last digit always in the third column.

Example:

␣15

↑ 1st. col. blank ↑ 3rd col.

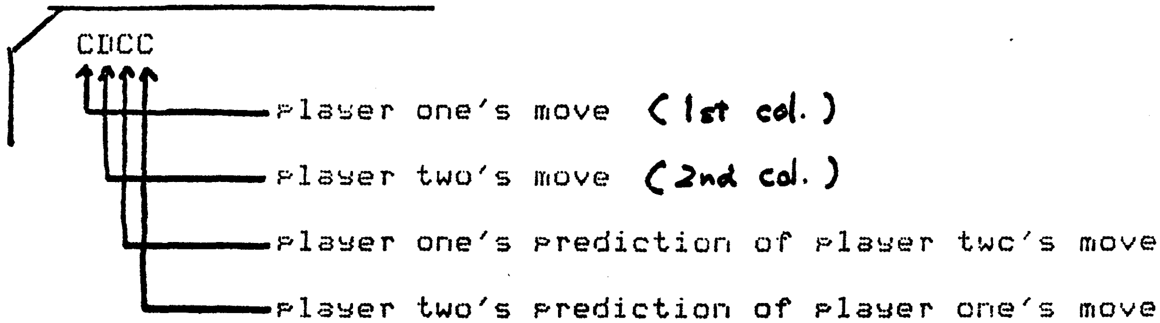
If option 2 is not desired, the second card must be the one which tells the program how many different game records are to follow. The program can accept up to 100 games in the cumulative records. The number of games must be entered in the first three colomns of the second card, with the last digit always in the third column. If option 2 is desired, then this one becomes the third card.

With the third (if option 2 is desired, fourth) card, the individual game records begin. This card contains a written description, up to 72 characters long, of the game which the following move-cards represent. For Example:

GAME 1 PD 21 VS 22, 3/19/79, . . .

The next card tells the program package how many moves there are in the game. There may be from five to one hundred moves. The last digit of the number must fall in the third column on the card, as in the number-of-games card and the length-of-interval card mentioned earlier.

Following the number-of-moves card are the move-cards. Each one contains the record of one move. They must be in order, first move to last move. 'C's and 'D's are placed in the first six columns of the card. The first two columns are the players actual moves. Column three and four are their predictions of the other player's move for that turn, and columns five and six, are yet to be defined. Nothing need be put in columns five and six, eventually other move-by-move data may be entered there, such as predictions of other player's move if she were in your position(Emshoff and Ackoff's "role reversal" -- this more complex format derives from the game record forms illustrated elsewhere in this Appendix.) Example of a move card: card:



After all the move-cards for the first game, the record of the second game begins with a description-card, then a number-of-moves card, and so on.

EXAMPLE DATA LIST 1(HYPOTHETICAL)

```
YYYYNNNNYYYYYN
  5
  3
GAME 1, PD  21  vs 22
 10
DC
DCDD
DDDC
CDCD
DDDD
DCDC
CDDC
DCDC
CDDC
CCCC
GAME 2 PD,  14 VS 16
 10
DC
DCDD
DDDD
CDCD
CDCD
CCCD
CDCD
DCDD
CDCD
CCDD
GAME 3 PD, 12 VS 20
 10
CD
CCCC
CCCC
DCCC
CDDC
CCCC
DDCC
CDCC
DCDD
CCCC
```

b) PDST1 FORTRAN IV code

```
C****  PDST1 MAIN PROGRAM ******* BY AKIHIKO TANAKA AND SHELDON SEARLE
      LOGICAL*1 H1(72)
      DIMENSION GAME(8,100),MOVE(8),OPTION(13), Y(1)
      DATA Y/ 1HY /
      COMMON H1
      WRITE(6,290)
290   FORMAT(///' ***** PDST1 ***** '///' BY AKIHIKO TANAKA AND SHELDON SE
     1ARLE '//)
      READ(5,90) OPTION
      IF(OPTION(2) .NE. Y(1) ) GO TO 100
      READ(5,190) NINT
100   CONTINUE
      READ(5,91) NGAMES
C
C     CHECK FOR RESET
C
      IF( OPTION(11) .NE. Y(1) ) GO TO 05
      CALL DATSTK(9,DUMMY)
      CALL GAMHIS(2,DUMMY)
C
05    CONTINUE
C
C     ENTER GAME BY GAME LOOP
C
      DO 80 I = 1, NGAMES
      READ(5,92) H1
      READ(5,93) NMOVES
      DO 10 J=1,NMOVES
      READ(5,94) MOVE
      DO 10 K = 1,8
      GAME(K,J) = MOVE(K)
10    CONTINUE
      WRITE(6,95) H1,NMOVES
C
C     READ FORMATS
C
90    FORMAT(13A1)
91    FORMAT(I3)
92    FORMAT(72A1)
93    FORMAT(I3)
94    FORMAT(8A1)
95    FORMAT(////' *** RESULTS OF REQUESTED OPTIONS FOR GAME:  '
     2 ,72A1//' THIS GAME HAS  ',I3,'  MOVES.'//)
190   FORMAT(I3)
C
C     *** OPTIONS  ***
C     PD01 -- PERCENTAGE OF COOPERATIVE MOVES
C     PD02 -- CONDITIONAL PROBABILITIES PER N MOVES
C     PD2  -- CONDITIONAL PROBABILITIES FOR THE WHOLE GAME
C     PD1 -- TIT-FOR-TAT MODEL FIT
C     PD3 -- FIRST MOVE MODEL FIT
C     PD4 -- LAST MOVE MODEL FIT
C     PD5 -- PREDICTION ACCURACY
C     PD6 -- CHOICE MATCHING FIT
C     PD7 -- POLICY MATCHING FIT (TEMPORARY)
C     PD8 -- GAME HISTORY GRAPH
C
```

```
      IF( OPTION(1) .EQ. Y(1) )  CALL PD01(GAME, NMOVES)
      IF( OPTION(2) .EQ. Y(1) )  CALL PD02(GAME, NMOVES,NINT)
      IF( OPTION(3) .EQ. Y(1) ) CALL PD2(GAME,NMOVES)
      IF( OPTION(4) .EQ. Y(1) ) CALL PD1(GAME,NMOVES)
      IF( OPTION(5) .EQ. Y(1) ) CALL PD3(GAME,NMOVES)
      IF( OPTION(6) .EQ. Y(1) ) CALL PD4(GAME,NMOVES)
      IF( OPTION(7) .EQ. Y(1) ) CALL PD5(GAME,NMOVES)
      IF( OPTION(8) .EQ. Y(1) ) CALL PD6(GAME,NMOVES)
      IF( OPTION(9) .EQ. Y(1) ) CALL PD7(GAME,NMOVES)
C     IF( OPTION(10) .EQ. Y(1) ) CALL PD8(GAME,NMOVES)
C
80    CONTINUE
C
C
C     CHECK FOR OVERALL STATISTICS
C
      IF( OPTION(12) .EQ. Y(1) ) CALL DATSTK(10, DUMMY)
      IF( OPTION(13) .EQ. Y(1) ) CALL GAMHIS(3,DUMMY)
C
C
999   CONTINUE
C
      STOP
      END
```

```
      SUBROUTINE PD01(GAME, NMOVES)
      LOGICAL*1 H1(72)
C SUBROUTINE PD01 CALCULATES FREQUENCIES OF COOPERATIVE MOVES
      DIMENSION GAME(8,100), COOP(3)
      COMMON H1
      NC1 = 0
      NC2 = 0
      DO 10 N = 1, NMOVES
      IF(GAME(1,N)  EQ  CC(1) ) NC1 = NC1 + 1
      IF(GAME(2,N) .EQ. CC(1) ) NC2 = NC2 + 1
10    CONTINUE
C
      COOP(1) = NC1 / FLOAT(NMOVES)
      COOP(2) = NC2 / FLOAT(NMOVES)
      COOP(3) = (COOP(1) + COOP(2) ) / 2.
C
      CALL DATSTK(11,COOP)
C WRITE OUT RESULTS
      WRITE(6,90) H1,COOP(1),COOP(2),COOP(3)
90    FORMAT(' FREQUENCIES OF COOPERATIVE MOVES FOR GAME:    ',
     172A1//' FRACTION OF COOPERATIVE MOVES:'//' PLAYER ONE: ',
     2F4 2,6X,' PLAYER TWO: ',F4.2,6X,' AVERAGE FOR BOTH: ',F4 2///)
      RETURN
      END
```

```
      SUBROUTINE PD02(GAME, NMOVES,NINT)
C     FOR CONDITIONAL PROBABILITIES FOR EVERY NINT MOVES
      LOGICAL*1 H1(72)
      COMMON H1
      DIMENSION GAME(8,100),MTR1(10),MTR2(10),MTRWR1(10),
     1             MTRWR2(10),MFOR1(10),MFOR2(10),
     2             MRES1(10),MRES2(10),ECCCNT(10),
     3             EDDCNT(10),ECDCNT(10),EDCCNT(10),
     4             TTR1(10),TTR2(10),TTRB(10),
     5             TTRWR1(10),TTRWR2(10),
     6             TTRWRB(10),
     7             TFOR1(10),TFOR2(10),TFORB(10),
     8             TRES1(10),TRES2(10),TRESB(10)
C
      K = 0.
      TR1 = 0
      TR2 = 0.
      TRWR1 = 0.
      TRWR2 = 0.
      FOR1 = 0
      FOR2 = 0
      RES1 = 0.
      RES2 = 0
      CCCNT = 0.
      DDCNT = 0.
      CDCNT = 0.
      DCCNT = 0.
C
C
      DO 100  N=2,NMOVES
      IF(GAME(2,(N-1)) .EQ. CC(3))  GO TO 80
      IF(GAME(1,(N-1))  EQ. GAME(2, (N-1))) GO TO 10
      GO TO 50
10    IF(GAME(1,(N-1)) .EQ. CC(1)) GO TO 20
      GO TO 30
20    IF(GAME(1,N) .EQ. CC(1)) TRWR1 = TRWR1 + 1.
      IF(GAME(2,N)  EQ  CC(1)) TRWR2 = TRWR2 + 1.
      CCCNT = CCCNT + 1.
      GO TO 80
C
30    IF(GAME(1,N) .EQ  CC(1)) TR1 = TR1 + 1.
      IF(GAME(2,N) .EQ. CC(1)) TR2 = TR2 + 1.
      DDCNT = DDCNT + 1.
      GO TO 80
C
50    IF(GAME(1,(N-1))  EQ  CC(1))  GO TO 60
      GO TO 70
60    IF(GAME(1,N)  EQ  CC(1))  FOR1 = FOR1 + 1.
      IF(GAME(2,N) .EQ. CC(1))  RES2 = RES2 + 1.
      CDCNT = CDCNT + 1
      GO TO 80
C
70    IF(GAME(1,N)  EQ  CC(1))  RES1 = RES1 + 1.
      IF(GAME(2,N) .EQ. CC(1)) FOR2 = FOR2 + 1.
      DCCNT = DCCNT + 1.
```

```
C                                                                       PD000560
80    CONTINUE                                                          PD000570
      IF( MOD(N,NINT)  NE  0)   GO TO 100                               PD000580
      K = K + 1                                                         PD000590
      MTR1(K)  = TR1                                                    PD000600
      MTR2(K)  = TR2                                                    PD000610
      MTRWR1(K)  = TRWR1                                                PD000620
      MTRWR2(K)  = TRWR2                                                PD000630
      MFOR1(K)  = FOR1                                                  PD000640
      MFOR2(K)  = FOR2                                                  PD000650
      MRES1(K)  = RES1                                                  PD000660
      MRES2(K)  = RES2                                                  PD000670
      ECCCNT(K) = CCCNT                                                 PD000680
      EDDCNT(K) = DDCNT                                                 PD000690
      ECDCNT(K) = CDCNT                                                 PD000700
      EDCCNT(K) = DCCNT                                                 PD000710
C                                                                       PD000720
      TR1 = 0.                                                          PD000730
      TR2 = 0                                                           PD000740
      TRWR1 = 0.                                                        PD000750
      TRWR2 = 0.                                                        PD000760
      FOR1 = 0                                                          PD000770
      FOR2 = 0.                                                         PD000780
      RES1 = 0.                                                         PD000790
      RES2 = 0.                                                         PD000800
      CCCNT = 0                                                         PD000810
      DDCNT = 0.                                                        PD000820
      CDCNT = 0.                                                        PD000830
      DCCNT = 0.                                                        PD000840
C                                                                       PD000850
100   CONTINUE                                                          PD000860
      DO 140  M = 1, K                                                  PD000870
      IF(ECCCNT(M)   EQ   0 ) ECCCNT(M)  = 1.                           PD000880
      IF(EDDCNT(M)  .EQ.  0.) EDDCNT(M)  = 1.                           PD000890
      IF(ECDCNT(M)   EQ.  0 ) ECDCNT(M)= 1.                             PD000900
      IF(EDCCNT(M)  .EQ.  0.) EDCCNT(M)  = 1.                           PD000910
C                                                                       PD000920
      TTR1(M)  = MTR1(M)/EDDCNT(M)                                      PD000930
      TTR2(M)  = MTR2(M)/EDDCNT(M)                                      PD000940
      TTRB(M)  =  (MTR1(M)  + MTR2(M))/(2*EDDCNT(M))                    PD000950
      TTRWR1(M)  = MTRWR1(M)/ECCCNT(M)                                  PD000960
      TTRWR2(M)  = MTRWR2(M)/ECCCNT(M)                                  PD000970
      TTRWRB(M)  =  (MTRWR1(M)  + MTRWR2(M))/(2*ECCCNT(M))              PD000980
      TFOR1(M)  = MFOR1(M)/ECDCNT(M)                                    PD000990
      TFOR2(M)  = MFOR2(M)/EDCCNT(M)                                    PD001000
      TFORB(M)  =(TFOR1(M)  + TFOR2(M))/2.                              PD001010
      TRES1(M)  = MRES1(M)/EDCCNT(M)                                    PD001020
      TRES2(M)  = MRES2(M)/ECDCNT(M)                                    PD001030
      TRESB(M)  =  (TRES1(M)  + TRES2(M))/2.                            PD001040
140   CONTINUE                                                          PD001050
C                                                                       PD001060
      WRITE(6,90) NINT, H1                                              PD001070
90    FORMAT(///'  CONDITIONAL PROBABILITIES FOR EVERY ',I3,' MOVES FOR PD001080
     1GAME: '//10X,72A1//' TRUST',T31,' TRUSTWORTHINESS',T61,' FORGIVENEPD001090
     2SS',T91,' RESPONSIVENESS'//                                       PD001100
```

```
     34(' PLAYER 1  PLAYER 2  AVERAGE  ')/)
      DO 94  M = 1, K
      WRITE(6,91) TTR1(M),TTR2(M),TTRB(M),
     1            TTRWR1(M),TTRWR2(M),TTRWRB(M),
     2            TFOR1(M),TFOR2(M),TFORB(M),
     3            TRES1(M),TRES2(M),TRESB(M)
      FORMAT(2X,F5 3,11F10 3)
      CONTINUE


      RETURN
      END
```

```
      SUBROUTINE PD1 (GAME, NMOVES )
      LOGICAL*1 H1(72)
C     SUBROUTINE PD1 DOES THE TIT FOR TAT STATISTICS ON THE GAME
C
      DIMENSION GAME(8,NMOVES), TFT(12)
      COMMON H1
C
C     FOR PLAYER ONE:
C
      COUNT1 = 0.
      DO 10 N = 2, NMOVES
      IF( GAME(1, N ) .NE. GAME(2, (N-1) ) ) GO TO 10
      COUNT1 = COUNT1 + 1.
10    CONTINUE
C
C     FOR PLAYER TWO:
C
      COUNT2 = 0.
      DO 20 N =2, NMOVES
      IF( GAME(2, N) .NE. GAME(1, (N-1) ) ) GO TO 20
      COUNT2 = COUNT2 + 1.
20    CONTINUE
C
C     FIGURE PERCENTAGES FOR EACH PLAYER, BOTH TOGETHER
C
      TFT(1) = COUNT1 / FLOAT(NMOVES - 1)
      TFT(2) = COUNT2 / FLOAT(NMOVES - 1)
      TFT(3) = (TFT(1) + TFT(2) ) /2.
C
C     SEND RESULTS TO DATA STACKING SUBROUTINE
C
      CALL DATSTK( 1, TFT)
C
C     WRITE OUT RESULTS
C
      WRITE(6, 90) H1,TFT(1),TFT(2),TFT(3)
90    FORMAT(///' TIT-FOR-TAT STATISTICS FOR GAME:  ',72A1//
     1        ' FRACTION OF MOVES WHICH REPRESENT A TIT-FOR-TAT',
     2        ' POLICY:'//' PLAYER ONE: ',F4.2,6X,' PLAYER TWO: ',
     3        F4.2,6X,' AVERAGE FOR BOTH: ', F4.2///)
C
      RETURN
      END
```

```
      SUBROUTINE PD2(GAME, NMOVES)
C
C     FOR MOVE TRAIT STATISTICS
C
      LOGICAL*1 H1(72)
      COMMON H1
      DIMENSION GAME(8,100),TRAIT(12)
C
      TR1  = 0.
      TRW1 = 0
      FGV1 = 0.
      RES1 = 0.
      TR2  = 0.
      TRW2 = 0.
      FGV2 = 0
      RES2 = 0.
      TRB  =0
      TRWB = 0.
      FGVB = 0
      RESB = 0.
      CCCNT = 0.
      CDCNT = 0
      DCCNT = 0.
      DDCNT = 0.
C
      DO 80 N = 2, NMOVES
      IF(GAME(2,(N-1)) .EQ. CC(3)) GO TO 80
      IF(GAME(1,(N-1)) .EQ  GAME(2,(N-1))) GO TO 10
      IF(GAME(1,(N-1)) .EQ. CC(1))         GO TO 40
      GO TO 50
10    IF(GAME(1,(N-1))  EQ  CC(1))         GO TO 20
      GO TO 30
C
C
C     TRUSTWORTHINESS
C
20    IF(GAME(1,N) .EQ. CC(1))   TRW1 = TRW1 +1.
      IF(GAME(2,N)  EQ  CC(1))   TRW2 = TRW2 + 1.
      CCCNT = CCCNT + 1.
      GO TO 80
C
C     TRUSTINGNESS
C
30    IF(GAME(1,N) .EQ  CC(1))   TR1 = TR1 + 1.
      IF (GAME(2,N) .EQ. CC(1))   TR2 = TR2 + 1.
      DDCNT = DDCNT +1.
      GO TO 80
C
C     FORGIVENESS AND RESPONSIVENESS
C
40    IF(GAME(1,N)  EQ CC(1))   FGV1 = FGV1 +1.
      IF(GAME(2,N) .EQ. CC(1))   RES2 = RES2 +1.
      CDCNT = CDCNT +1
      GO TO 80
50    IF(GAME(1,N) .EQ. CC(1))   RES1 = RES1 + 1.
```

```
      IF(GAME(2,N)  EQ  CC(1))   FGV2 = FGV2 + 1
      DCCNT = DCCNT + 1.
C
80    CONTINUE
C
C    CALCULATE FRACTIONS
C
      IF(DDCNT  EQ  0 ) DDCNT = 1
      IF(CCCNT .EQ. 0.) CCCNT = 1.
      IF(DCCNT  EQ  0 ) DCCNT = 1
      IF(CDCNT .EQ. 0.) CDCNT = 1.
      TRAIT( 1) = TR1  / DDCNT
      TRAIT( 2) = TRW1 /CCCNT
      TRAIT( 3) = FGV1 / CDCNT
      TRAIT( 4) = RES1 /DCCNT
      TRAIT( 5) = TR2 / DDCNT
      TRAIT( 6) = TRW2 / CCCNT
      TRAIT( 7) = FGV2 / DCCNT
      TRAIT( 8) = RES2 / CDCNT
      TRAIT( 9) = ( TR1 + TR2 ) / (2.*DDCNT)
      TRAIT(10) = ( TRW1 + TRW2 ) / (2 *CCCNT)
      TRAIT(11) = ( TRAIT(3) + TRAIT(7)) / 2.
      TRAIT(12) = ( TRAIT(4) + TRAIT(8)) / 2
C
C    SEND RESULTS TO DATSTK
C
      CALL DATSTK(2,TRAIT)
C
      WRITE(6,90) H1
C
90    FORMAT(///' CONDITIONAL PROBABILITIES FOR  GAME:  ',72A1//
     1' FRACTION OF PLAYERS MOVES WHICH INDICATE A GIVEN TRAIT:'///
     2' TRUST',T31,' TRUSTWORTHINESS',T61,' FORGIVENESS',T91,' RESPONSIV
     3ENESS'//
     44(' PLAYER 1  PLAYER 2  AVERAGE  ')/)
      WRITE(6,91) TRAIT( 1),TRAIT( 5),TRAIT( 9),TRAIT(2),TRAIT(6),TRAIT(
     110),
     2             TRAIT(3),TRAIT(7),TRAIT(11),TRAIT(4),TRAIT(8),TRAIT(12)
91    FORMAT(2X,F5.3,11F10.3//)
C
      RETURN
      END
```

```
      SUBROUTINE PD3(GAME, NMOVES)
C     SUBROUTINE PD3 DOES THE 'FIRST MOVE AS INDICATOR' STATISTICS ON THE
C     GAME.  WHAT FRACTION OF EACH PLAYERS MOVES WERE EQUAL TO THAT
C     PLAYERS FIRST MOVE?
C
      LOGICAL*1 H1(72)
      COMMON H1
      DIMENSION GAME(8,100), FSTMV(12)
C
C     WHAT WERE FIRST MOVES?
C
      FST1 = GAME(1,1)
      FST2 = GAME(2,1)
C
C     HOW OFTEN WERE THEY REPEATED?
C
      COUNT1 = 0.
      COUNT2 = 0
      DO 10 N = 2, NMOVES
      IF( GAME(1,N) .EQ. FST1 )  COUNT1 = COUNT1 + 1.
      IF( GAME(2,N) .EQ. FST2 )  COUNT2 = COUNT2 + 1.
10    CONTINUE
C
C     WHAT FRACTION DOES THAT REPRESENT?
C
      FSTMV(1)  = COUNT1 / FLOAT(NMOVES - 1)
      FSTMV(2)  = COUNT2 / FLOAT(NMOVES - 1)
      FSTMV(3)  = ( FSTMV(1) + FSTMV(2) ) / 2.
C
C     CALL DATSTK TO STORE RESULTS AND WRITE THEM
C
      CALL DATSTK(3, FSTMV )
C
      WRITE(6, 90) H1,FSTMV(1),FSTMV(2),FSTMV(3)
90    FORMAT(///' FIRST MOVE AS INDICATOR STATISTICS FOR GAME:  ',72
     1A1//
     2' FRACTION OF MOVES WHICH WERE THE SAME AS PLAYERS FIRST MOVE:'//
     3' PLAYER ONE: ',F4.2,6X,' PLAYER TWO: ',F4.2,6X,' AVERAGE FOR BOTH
     4:',F4.2///)
C
      RETURN
      END
```

```
      SUBROUTINE PD4(GAME, NMOVES )
C
C     PD4 DOES THE 'CONTINUITY' STATISTICS ON THE GAME.
C     WHAT FRACTION OF PLAYERS MOVES WERE EQUAL TO THEIR OWN
C     LAST MOVE?
C
      LOGICAL*1 H1(72)
      COMMON H1
      DIMENSION GAME(8,100), DEP(12)
C
C
      COUNT1 = 0.
      COUNT2 = 0.
      DO 10 N=2, NMOVES
      IF( GAME(1,N) .EQ. GAME(1,(N-1)) ) COUNT1 = COUNT1 + 1.
      IF( GAME(2,N) .EQ  GAME(2,(N-1)) ) COUNT2 = COUNT2 + 1.
10    CONTINUE
C
C     WHAT FRACTION DOES THAT REPRESENT?
C
      DEP(1) = COUNT1 /FLOAT(NMOVES -1)
      DEP(2) = COUNT2 / FLOAT(NMOVES - 1)
      DEP(3) = ( DEP(1) + DEP(2) ) / 2.
C
C     CALL DATSTK TO STORE RESULTS AND WRITE THEM
C
      CALL DATSTK(4,DEP)
C
      WRITE(6,90) H1,DEP(1),DEP(2) ,DEP(3)
90    FORMAT(///' "CONTINUITY"  STATISTICS FOR GAME:  ',72A1//
     1' FRACTION OF MOVES WHICH WERE THE SAME AS PLAYERS LAST MOVE:'//
     2' PLAYER ONE: ',F4 2,6X,'PLAYER TWO: ',F4.2,6X,' AVERAGE FOR BOTH:
     3   ',F4.2///)
C
      RETURN
      END
```

```
      SUBROUTINE PD5( GAME, NMOVES)
C     PD5 DOES THE 'PREDICTION ACCURACY' STATISTICS ON THE GAME.
      LOGICAL*1 H1(72)
      COMMON H1
      DIMENSION GAME(8,100), PRED(12)
      COUNT1 = 0.
      COUNT2 = 0.
      DO 10 N = 2, NMOVES
      IF( GAME(2,N) .EQ. GAME(3,N) ) COUNT1 = COUNT1 + 1.
      IF( GAME(1,N)  EQ  GAME(4,N) ) COUNT2 = COUNT2 + 1.
10    CONTINUE
C
C ***WHAT FRACTION DOES THAT REPRESENT?
      PRED(1) = COUNT1 / FLOAT(NMOVES - 1)
      PRED(2) = COUNT2 / FLOAT(NMOVES - 1)
      PRED(3) = ( PRED(1) + PRED(2) ) / 2.
C
C     CALL DATSTK TO STORE RESULTS .
C
      CALL DATSTK(5,PRED)
      WRITE(6,90) H1,PRED(1),PRED(2),PRED(3)
90    FORMAT(///' "PREDICTION ACCURACY" STATISTICS FOR  GAME:  ',72A1
     1//' FRACTION OF PREDICTIONS WHICH WERE ACCURATE: '//
     2' PLAYER ONE: ',F4.2,6X,' PLAYER TWO: ',F4.2,6X,
     3'     AVERAGE FOR BOTH: ',F4.2///)
C
      RETURN
      END
```

```
      SUBROUTINE PD6(GAME,NMOVES)
C
C     PD6 DOES THE 'CHOICE MATCHING' STATISTICS ON THE GAME
C     WHAT FRACTION OF EACH PLAYERS MOVES WERE EQUAL TO HIS
C     PREDICTION OF HIS OPPONENTS MOVES?
C
      LOGICAL*1 H1(72)
      COMMON H1
      DIMENSION GAME(8,100), CHM(12)
      COUNT1 = 0.
      COUNT2 = 0.
      DO 10 N = 2, NMOVES
      IF( GAME(1,N) .EQ  GAME(3,N) ) COUNT1 = COUNT1 + 1.
      IF( GAME(2,N) .EQ. GAME(4,N) ) COUNT2 = COUNT2 + 1.
10    CONTINUE
C
C     WHAT FRACTION DOES THAT REPRESENT?
C
      CHM(1) = COUNT1 / FLOAT(NMOVES - 1)
      CHM(2) = COUNT2 / FLOAT(NMOVES - 1)
      CHM(3) = ( CHM(1) + CHM(2) ) / 2.
C
C     CALL DATSTK TO STORE RESULTS AND WRITE THEM
C
      CALL DATSTK(6, CHM)
C
      WRITE(6, 90) H1,CHM(1), CHM(2), CHM(3)
90    FORMAT(///' "CHOICE MATCHING" STATISTICS FOR  GAME:  ',72A1
     1//' FRACTION OF MOVES WHICH WERE THE SAME AS PLAYERS PREDICTION OF
     2 OPPONENTS MOVES: '//' PLAYER ONE: ',F4.2,6X,
     3'     PLAYER TWO: ',F4.2,6X,' AVERAGE FOR BOTH: ',F4.2///)
C
      RETURN
      END
```

```
      SUBROUTINE PD7(GAME, NMOVES)                                     PD700010
C     PD 7 DOES THE 'POLICY MATCHING' STATISTICS                       PD700020
      LOGICAL*1 H1(72)                                                 PD700030
      COMMON H1                                                        PD700040
      DIMENSION GAME(8,100), POLM(6)                                   PD700050
C     'POLICY MATCHING WITHOUT LAG'                                    PD700060
      MMOVES = NMOVES - 1                                              PD700070
      COUNT1 = 0.                                                      PD700080
      COUNT2 = 0.                                                      PD700090
      DO 10 N = 2, NMOVES                                              PD700100
      DO 20 M = 1, MMOVES                                              PD700110
      IF( M  GE  N ) GO TO 40                                          PD700120
      IF( GAME(3, N) .EQ. GAME(1, N-M )) GO TO 30                      PD700130
20    CONTINUE                                                         PD700140
30    IF ( GAME(2, N-M ) .EQ. GAME(1, N)) COUNT1 = COUNT1 + 1.         PD700150
40    CONTINUE                                                         PD700160
      DO 50 L = 1, MMOVES                                              PD700170
      IF ( L  GE  N ) GO TO 10                                         PD700180
      IF( GAME(4, N) .EQ. GAME(2, N-L )) GO TO 60                      PD700190
50    CONTINUE                                                         PD700200
60    IF( GAME(1, N-L )  EQ  GAME(2,N) ) COUNT2 = COUNT2 +1.           PD700210
10    CONTINUE                                                         PD700220
C     WHAT FRACTION DOES THAT REPRESENT?                               PD700230
      POLM(1) = COUNT1 / FLOAT(MMOVES)                                 PD700240
      POLM(2) = COUNT2 / FLOAT(MMOVES)                                 PD700250
      POLM(3) = ( POLM(1) + POLM(2) ) / 2.                             PD700260
C     'POLICY MATCHING WITH LAG'                                       PD700270
      COUNT3 = 0.                                                      PD700280
      COUNT4 = 0                                                       PD700290
      DO 110 N = 3,NMOVES                                              PD700300
      DO 120 M = 2,MMOVES                                              PD700310
      IF(M .GE. N ) GO TO 140                                          PD700320
      IF( GAME(3, N)  EQ  GAME(1, N-M) ) GO TO 130                     PD700330
120   CONTINUE                                                         PD700340
130   IF( GAME(2, N-M+1) .EQ. GAME(1,N) ) COUNT3 = COUNT3 + 1.         PD700350
140   CONTINUE                                                         PD700360
      DO 150 L = 2, MMOVES                                             PD700370
      IF( L  GE  N ) GO TO 110                                         PD700380
      IF( GAME(4, N) .EQ. GAME(2, N-L) ) GO TO 160                     PD700390
150   CONTINUE                                                         PD700400
160   IF( GAME( 1, N-L+1) .EQ. GAME(2, N) ) COUNT4 = COUNT4 + 1.       PD700410
110   CONTINUE                                                         PD700420
C     WHAT FRACTION DOES THAT REPRESENT?                               PD700430
      POLM(4) = COUNT3 / FLOAT(NMOVES-2)                               PD700440
      POLM(5) = COUNT4 / FLOAT( NMOVES - 2 )                           PD700450
      POLM(6) = ( POLM(3) + POLM(4) ) / 2.                             PD700460
C     CALL DATSTK TO STORE RESULTS AND WRITE THEM                      PD700470
      CALL DATSTK(7,POLM)                                              PD700480
      WRITE(6,90) H1, POLM(1),POLM(4),POLM(2),POLM(5),POLM(3),POLM(6)  PD700490
90    FORMAT(///' "POLICY MATCHING" STATISTICS FOR THIS GAME:  ',72A1/ PD700500
     1//17X,'WITHOUT LAG        WITH LAG'//                            PD700510
     2'     PLAYER ONE:',T22,F4 2,T38,F4.2//                           PD700520
     3'     PLAYER TWO:',T22,F4.2,T38,F4.2//                           PD700530
     4'     AVG FOR BOTH:',T22,F4.2,T38,F4.2////)                      PD700540
      RETURN                                                           PD700550
```

```
      END                                                               PD7005
```

```
      SUBROUTINE PD8(GAME,NMOVES)                                       PD800010
     GENERATES GAME HISTORY GRAPH                                       PD800020
                                                                        PD800030
      LOGICAL*1 H1(72)                                                  PD800040
      COMMON H1                                                         PD800050
      DIMENSION GAME(8,100)                                             PD800060
      DIMENSION ROW1(80),ROW2(80),ROW3(80),ROW4(80),ROW5(80),           PD800070
     1ROW6(80),ROW7(80),ROW8(80),ROW9(80),ROW10(80),ROW11(80)           PD800080
      DIMENSION NT(5,10)                                                PD800090
      DIMENSION GRAPH(80,11), CHAR(6)                                   PD800100
      DATA GRAPH/880*1H /, CHAR/1H#,1H$,1H%,1H*,1HB,1H /                PD800110
      DO 100 I = 1,80                                                   PD800120
      ROW1(I) = CHAR(6)                                                 PD800130
      ROW2(I) = CHAR(6)                                                 PD800140
      ROW3(I) = CHAR(6)                                                 PD800150
      ROW4(I) =  CHAR(6)                                                PD800160
      ROW5(I) = CHAR(6)                                                 PD800170
      ROW6(I) = CHAR(6)                                                 PD800180
      ROW7(I) = CHAR(6)                                                 PD800190
      ROW8(I) = CHAR(6)                                                 PD800200
      ROW9(I) = CHAR(6)                                                 PD800210
      ROW10(I) = CHAR(6)                                                PD800220
      ROW11(I) = CHAR(6)                                                PD800230
      DO 100 J = 1, 11                                                  PD800240
      GRAPH(I,J) = CHAR(6)                                              PD800250
00    CONTINUE                                                          PD800260
      K = 0                                                             PD800270
      NCC = 0                                                           PD800280
      NCD = 0                                                           PD800290
      NDC = 0                                                           PD800300
      NDD = 0                                                           PD800310
      NXB = 0                                                           PD800320
C                                                                       PD800330
      DO 20 N = 1,NMOVES                                                PD800340
      IF(GAME(1,N)  .EQ. GAME(2,N)) GO TO 11                            PD800350
      IF(GAME(1,N)  EQ. CC(1) ) GO TO 13                                PD800360
      IF(GAME(1,N) .EQ. CC(2) ) GO TO 14                                PD800370
      GO TO 15                                                          PD800380
11    IF(GAME(1,N) .EQ. CC(1) ) GO TO 12                                PD800390
      NDD = NDD + 1                                                     PD800400
      GO TO 16                                                          PD800410
2     NCC = NCC + 1                                                     PD800420
      GO TO 16                                                          PD800430
3     NCD = NCD + 1                                                     PD800440
      GO TO 16                                                          PD800450
14    NDC = NDC + 1                                                     PD800460
      GO TO 16                                                          PD800470
15    NXB = NXB + 1                                                     PD800480
16    CONTINUE                                                          PD800490
      IF(MOD(N,10)  NE. 0 ) GO TO 20                                    PD800500
      K = K + 1                                                         PD800510
      NT(1,K) = NCC                                                     PD800520
      NT(2,K) = NCD                                                     PD800530
      NT(3,K) = NDC                                                     PD800540
      NT(4,K) = NDD                                                     PD800550
```

```
      NT(5,K) = NXB
      NCC = 0
      NCD = 0
      NDC = 0
      NDD = 0
      NXB = 0
20    CONTINUE
C
C
      DO 10 M2 = 1, 11
      M = M2 - 1
      DO 10 N = 1, K
      DO 10 J = 1, 5
      IG1 = ((N-1)*8)+J
      IG2 = 1 + M
      IF(NT(J,N) .EQ. (10-M)) GRAPH(IG1,IG2) = CHAR(J)
10    CONTINUE
C
C
      DO 30 I = 1, 80
      ROW1(I) = GRAPH(I,1)
      ROW2(I) = GRAPH(I,2)
      ROW3(I) = GRAPH(I,3)
      ROW4(I) = GRAPH(I,4)
      ROW5(I) = GRAPH(I,5)
      ROW6(I) = GRAPH(I,6)
      ROW7(I) = GRAPH(I,7)
      ROW8(I) = GRAPH(I,8)
      ROW9(I) = GRAPH(I,9)
      ROW10(I) = GRAPH(I,10)
      ROW11(I) = GRAPH(I,11)
30    CONTINUE
      WRITE(6,90)H1,ROW1,ROW2,ROW3,ROW4,ROW5,ROW6,ROW7,ROW8,ROW9,ROW10,R
     1OW11
90    FORMAT(///' GAME HISTORY GRAPH FOR  GAME:  ',72A1//
     1' LEGEND: # = CC, $ = CD, % = DC, * = DD, B = B-OPTION'///
     212X,'10 .',80A1/15X,'.'/13X,'9 .',80A1/15X,'.'/13X,'8 .',80A1/
     315X,' '/13X,'7  ',80A1/15X,' '/13X,'6  ',80A1/15X,'.'/13X,'5 .',
     480A1/' OCCURENCES    .'/'  PER TEN-   4 .',80A1/'  MOVE SET     .'
     5/13X,'3  ',80A1/15X,' '/13X,'2 .',80A1/15X,' '/13X,'1 .',
     680A1/15X,'.'/13X,'0 .',80A1/15X,39('. ')/
     7T20,'10',T28,'20',T36,'30',T44,'40',T52,'50',T60,'60',
     8T68,'70',T76,'80',T84,'90',T91,'100'/T53,'MOVES'///)
C
      CALL GAMHIS(1,NT)
C
      RETURN
      END
```

```
      SUBROUTINE DATSTK(ICODE,GAMSTA)
C     THIS SUBROUTINE RECORDS THE RESULTS FOR ALL THE GAMES FROM ALL
C     THE STATISTIC SUBROUTINES, AND GENERATES OVERALL STATISTICS.
      LOGICAL*1 H1(72)
      COMMON H1
      COMMON N1,N2,N3,N4,N5,N6,N7,N8,N9,N10,NTT
      COMMON COOP1,COOP2,COOP3
      COMMON TFT1,TFT2,TFT3
      COMMON TRT1,TRT2,TRT3,TRT4,TRT5,TRT6,
     1      TRT7,TRT8,TRT9,TRT10,TRT11,TRT12
      COMMON DEP1,DEP2,DEP3,FSTMV1,FSTMV2,FSTMV3
      COMMON PRED1,PRED2,PRED3,CHM1,CHM2,CHM3
      COMMON POLM1,POLM2,POLM3,POLM4,POLM5,POLM6
C     LIST ICODES HERE:
      DIMENSION GAMSTA(12)
      DIMENSION NTT(5,10)
      DIMENSION COOP1(100),COOP2(100),COOP3(100)
      DIMENSION DEP1(100),DEP2(100),DEP3(100)
      DIMENSION TFT1(100),TFT2(100),TFT3(100)
      DIMENSION TRT1(100),TRT2(100),TRT3(100),TRT4(100),TRT5(100),
     1         TRT6(100),TRT7(100),TRT8(100),TRT9(100),TRT10(100),
     2         TRT11(100),TRT12(100)
      DIMENSION FSTMV1(100),FSTMV2(100),FSTMV3(100)
      DIMENSION PRED1(100),PRED2(100),PRED3(100)
      DIMENSION CHM1(100),CHM2(100),CHM3(100)
      DIMENSION POLM1(100),POLM2(100),POLM3(100),POLM4(100),POLM5(100),
     1POLM6(100)
C     ADD OTHER DIMENSIONS AS CALLED FOR
C     SORT ACCORDING TO ICODE
C
      IF(ICODE.EQ.11) GO TO 01
      IF(ICODE.EQ.12) GO TO 02
      IF(ICODE.EQ.1) GO TO 10
      IF(ICODE.EQ.2) GO TO 20
      IF(ICODE.EQ.3) GO TO 30
      IF(ICODE.EQ.4) GO TO 40
      IF(ICODE.EQ.5) GO TO 50
      IF(ICODE.EQ.6) GO TO 60
      IF(ICODE.EQ.7) GO TO 70
      IF(ICODE.EQ.8) GO TO 80
      IF(ICODE.EQ.9) GO TO 90
      IF(ICODE.EQ.10) GO TO 100
C     STACKING ROUTINES FOR EACH STATISTIC SUBROUTINE
C      STACKER FOR PD01(FREQUENCIES OF COOPERATIVE MOVES)
01    CONTINUE
      N1 = N1 + 1
      COOP1(N1) = GAMSTA(1)
      COOP2(N1) = GAMSTA(2)
      COOP3(N1) = GAMSTA(3)
      GO TO 999
02    CONTINUE
C     STACKER FOR PD1 (TIT-FOR-TAT)
10    CONTINUE
      N3 = N3 + 1
      TFT1(N3) = GAMSTA(1)
```

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      TFT2(N3)  = GAMSTA(2)
      TFT3(N3)  = GAMSTA(3)
      GO TO 999
C     STACKER FOR PD2 (CONDITIONAL PROBABILITIES )
20    CONTINUE
      N4 = N4 +1
      TRT1(N4)  = GAMSTA(1)
      TRT2(N4)  = GAMSTA(2)
      TRT3(N4)  = GAMSTA(3)
      TRT4(N4)  = GAMSTA(4)
      TRT5(N4)  = GAMSTA(5)
      TRT6(N4)  = GAMSTA(6)
      TRT7(N4)  = GAMSTA(7)
      TRT8(N4)  = GAMSTA(8)
      TRT9(N4)  = GAMSTA(9)
      TRT10(N4)  = GAMSTA(10)
      TRT11(N4)  = GAMSTA(11)
      TRT12(N4)  = GAMSTA(12)
      GO TO 999
C     STACKER FOR PD3 ( FIRST MOVE AS INDICATOR )
30    CONTINUE
      N5 = N5 + 1
      FSTMV1(N5)  = GAMSTA(1)
      FSTMV2(N5)  = GAMSTA(2)
      FSTMV3(N5)  = GAMSTA(3)
      GO TO 999
C     STACKER FOR PD4 ( CONTINUITY )
40    CONTINUE
      N6 = N6 + 1
      DEP1(N6)  = GAMSTA(1)
      DEP2(N6)  = GAMSTA(2)
      DEP3(N6)  = GAMSTA(3)
      GO TO 999
C     STACKER FOR PD5( PREDICTION ACCURACY )
50    CONTINUE
      N7 = N7 + 1
      PRED1(N7)  = GAMSTA(1)
      PRED2(N7)  = GAMSTA(2)
      PRED3(N7)  = GAMSTA(3)
      GO TO 999
C     STACKER FOR PD6 (CHOICE MATCHING )
60    CONTINUE
      N8 = N8 + 1
      CHM1(N8)  = GAMSTA(1)
      CHM2(N8)  = GAMSTA(2)
      CHM3(N8)  = GAMSTA(3)
      GO TO 999
C     STACKER FOR PD7 ( POLICY MATCHING )
70    CONTINUE
      N9 = N9 + 1
      POLM1(N9)  = GAMSTA(1)
      POLM2(N9)  = GAMSTA(2)
      POLM3(N9)  = GAMSTA(3)
      POLM4(N9)  = GAMSTA(4)
      POLM5(N9)  = GAMSTA(5)
```

```
      POLM6(N9) = GAMSTA(6)
      GO TO 999
80    CONTINUE
89    GO TO 999
C
90    CONTINUE
C     RESET ROUTINE, TO INITIALIZE A NEW SET OF GAMES
      N1 = 0
      N2 = 0
      N3 = 0
      N4 = 0
      N5 = 0
      N6 = 0
      N7 = 0
      N8 = 0
      N9 = 0
      N10 = 0
      WRITE(6,990)
990   FORMAT(//' * CUMULATIVE DATA ARRAYS HAVE BEEN RESET *'//)
      GO TO 999
100   CONTINUE
C ** STATISTICS SECTION, CALUCULATES MEAN AND STANDARD DEVIATION
C ** FOR ALL STATISTICS GENERATED FOR THIS SET OF GAMES
      WRITE(6,1090)
1090  FORMAT(1X,'*  SUMMARY STATISTICS FOR ALL GAMES SINCE LAST RESET:
     1*'/// )
C     FOR PD01 (FREQUENCIES OF COOPERATIVE MOVES)
C
      IF(N1 EQ.0) GO TO 1000
      CALL MOMNT(COOP1,N1,COOP1M, COOP1V, COOP1S)
      CALL MOMNT(COOP2,N1, COOP2M, COOP2V, COOP2S)
      CALL MOMNT(COOP3,N1, COOP3M, COOP3V, COOP3S)
C
C     WRITE OUT ARRAYS AND RESULTS
C
      WRITE(6,1011)
      DO 1001 I = 1, N1
      WRITE(6,1012) COOP1(I),COOP2(I),COOP3(I)
1001  CONTINUE
      WRITE(6,1013) COOP1M,COOP1V,COOP1S,COOP2M,COOP2V,COOP2S,
     1              COOP3M,COOP3V,COOP3S
1011  FORMAT(' FREQUENCIES OF COOPERATIVE MOVES:'/' (LISTED BY GAME)'
     1//'  PLAYER ONE:',8X,'PLAYER TWO:',8X,'AVG FOR BOTH:'//)
1012  FORMAT(T14,F4.2,T33,F4.2,T55,F4.2)
1013  FORMAT(///' OVER ALL GAMES      MEAN    VARIANCE    STD DEV '//
     1' PLAYER ONE:',8X,F4.2,6X,F4.2,6X,F4.2//
     2' PLAYER TWO:',8X,F4 2,6X,F4 2,6X,F4 2//
     3' AVG. FOR BOTH:',5X,F4.2,6X,F4.2,6X,F4.2////)
C
1000  CONTINUE
      GO TO 120
C     FOR PD1 (TIT-FOR-TAT)
110   CONTINUE
      IF(N3 EQ 0) GO TO 130
      CALL MOMNT(TFT1, N3, TFT1M, TFT1V, TFT1S)
```

```
      CALL MOMNT(TFT2, N3, TFT2M, TFT2V, TFT2S)
      CALL MOMNT(TFT3, N3, TFT3M, TFT3V, TFT3S)
C     WRITE OUT ARRAYS AND RESULTS
      WRITE(6,1091)
      DO 101 I = 1, N3
      WRITE(6,1092) TFT1(I),TFT2(I),TFT3(I)
101   CONTINUE
      WRITE(6,1093) TFT1M,TFT1V,TFT1S,TFT2M,TFT2V,TFT2S,
     1              TFT3M,TFT3V,TFT3S
1091  FORMAT(' TIT-FOR-TAT:  WHAT FRACTION OF PLAYERS MOVES WERE SAME AS
     1LAST MOVE OF OTHER PLAYER? '/' (LISTED BY GAME)'//' PLAYER ONE:',
     28X,'PLAYER TWO:',8X,'AVG  FOR BOTH:'//)
1092  FORMAT(T14,F4.2,T33,F4.2,T55,F4.2)
1093  FORMAT(///' OVER ALL GAMES:    MEAN   VARIANCE  STD.DEV.'//
     1' PLAYER ONE:',8X,F4.2,6X,F4.2,6X,F4.2//
     2' PLAYER TWO:',8X,F4.2,6X,F4.2,6X,F4 2//
     3' AVG. FOR BOTH:',5X,F4.2,6X,F4.2,6X,F4.2////)
C
      GO TO 130
C     FOR PD2 ( CONDITIONAL PROBABILITIES )
120   CONTINUE
      IF( N4 .EQ. 0 ) GO TO 110
      CALL MOMNT(TRT1,N4,TRT1M,TRT1V,TRT1S)
      CALL MOMNT(TRT2,N4,TRT2M,TRT2V,TRT2S)
      CALL MOMNT(TRT3,N4,TRT3M,TRT3V,TRT3S)
      CALL MOMNT(TRT4,N4,TRT4M,TRT4V,TRT4S)
      CALL MOMNT(TRT5,N4,TRT5M,TRT5V,TRT5S)
      CALL MOMNT(TRT6,N4,TRT6M,TRT6V,TRT6S)
      CALL MOMNT(TRT7,N4,TRT7M,TRT7V,TRT7S)
      CALL MOMNT(TRT8,N4,TRT8M,TRT8V,TRT8S)
      CALL MOMNT(TRT9,N4,TRT9M,TRT9V,TRT9S)
      CALL MOMNT(TRT10,N4,TRT10M,TRT10V,TRT10S)
      CALL MOMNT(TRT11,N4,TRT11M,TRT11V,TRT11S)
      CALL MOMNT(TRT12,N4,TRT12M,TRT12V,TRT12S)
C     WRITE OUT ARRAYS AND RESULTS
      WRITE(6,1291)
      DO 121 I = 1, N4
      WRITE(6,1292) TRT1(I),TRT5(I),TRT9(I),TRT2(I),TRT6(I),TRT10(I),
     1           TRT3(I),TRT7(I),TRT11(I),TRT4(I),TRT8(I),TRT12(I)
121   CONTINUE
      WRITE(6,1293) TRT1M,TRT1V,TRT1S,TRT5M,TRT5V,TRT5S,TRT9M,TRT9V,
     1              TRT9S,TRT2M,TRT2V,TRT2S,TRT6M,TRT6V,TRT6S,
     2               TRT10M,TRT10V,TRT10S,TRT3M,TRT3V,TRT3S,TRT7M,
     3               TRT7V,TRT7S,TRT11M,TRT11V,TRT11S,TRT4M,TRT4V,
     4               TRT4S,TRT8M,TRT8V,TRT8S,TRT12M,TRT12V,TRT12S
C
1291  FORMAT(' CONDITIONAL PROBABILITIES:'/' WHAT FRACTION OF PLAYERS
     XMOVES REPRESENT A GIVEN "TRAIT"?'/
     1/' (LISTED BY GAME)'//
     2' TRUST',T31,' TRUSTWORTHINESS',T61,' FORGIVENESS',T91,'RESPONSIVE
     3NESS'//
     44(' PLAYER 1 PLAYER 2 AVERAGE  ')/)
1292  FORMAT(2X,F5.3,11F10.3)
1293  FORMAT(///' OVER ALL GAMES:'//32X,' MEAN    VARIANCE   STD DEV.'//
     1'     TRUSTINGNESS:   PLAYER ONE:      ',F4.2,6X,F4.2,6X,F4.2//
```

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     216X,'     PLAYER TWO:      ',F4 2,6X,F4 2,6X,F4 2//                    DAT0221
     316X,'     AVG.FOR BOTH:  ',F4.2,6X,F4.2,6X,F4.2//                      DAT0222
     4'    TRUSTWORTHINESS:PLAYER ONE:     ',F4 2,6X,F4 2,6X,F4 2//          DAT0223
     516X,'     PLAYER TWO:     ',F4.2,6X,F4.2,6X,F4.2//                     DAT0224
     616X,'     AVG FOR BOTH:  ',F4.2,6X,F4 2,6X,F4 2//                      DAT0225
     7'    FORGIVENESS:     PLAYER ONE:     ',F4.2,6X,F4.2,6X,F4.2//         DAT0226
     816X,'     PLAYER TWO:     ',F4 2,6X,F4 2,6X,F4 2//                     DAT0227
     916X,'     AVG.FOR BOTH:  ',F4.2,6X,F4.2,6X,F4.2//                      DAT0228
     X'    RESPONSIVENESS: PLAYER ONE:     ',F4 2,6X,F4 2,6X,F4 2//          DAT0229
     X16X,'     PLAYER TWO:     ',F4.2,6X,F4.2,6X,F4.2//                     DAT0230
     X16X,'     AVG FOR BOTH:  ',F4 2,6X,F4 2,6X,F4 2////)                   DAT0231
      GO TO 110                                                              DAT0232
C     FOR PD3 ( FIRST MOVE AS INDICATOR )                                    DAT0233
 130  CONTINUE                                                               DAT0234
      IF (N5  EQ  0 ) GO TO 140                                              DAT0235
      CALL MOMNT(FSTMV1,N5,FSTM1M,FSTM1V,FSTM1S)                             DAT0236
      CALL MOMNT(FSTMV2,N5,FSTM2M,FSTM2V,FSTM2S)                             DAT0237
      CALL MOMNT(FSTMV3,N5,FSTM3M,FSTM3V,FSTM3S)                             DAT0238
C     WRITE OUT ARRAYS AND RESULTS                                           DAT0239
      WRITE(6,1391)                                                          DAT0240
      DO 131 I = 1, N5                                                       DAT0241
      WRITE(6,1392) FSTMV1(I),FSTMV2(I),FSTMV3(I)                            DAT0242
 131  CONTINUE                                                               DAT0243
      WRITE(6,1393) FSTM1M,FSTM1V,FSTM1S,FSTM2M,FSTM2V,FSTM2S,               DAT0244
     1              FSTM3M,FSTM3V,FSTM3S                                     DAT0245
 1391 FORMAT(' FIRST MOVE AS INDICATOR:  WHAT FRACTION OF PLAYERS MOVES DAT0246
     1SAME AS PLAYERS FIRST MOVE?'/' (LISTED BY GAME)'//' PLAYER ONE:', DAT0247
     28X,' PLAYER TWO:',8X,' AVG  FOR BOTH:'//)                              DAT0248
 1392 FORMAT(T14,F4.2,T33,F4.2,T55,F4.2)                                     DAT0249
 1393 FORMAT(///' OVER ALL GAMES:     MEAN    VARIANCE  STD.DEV.'//          DAT0250
     1' PLAYER ONE:',8X,F4.2,6X,F4.2,6X,F4.2//                               DAT0251
     2' PLAYER TWO:',8X,F4 2,6X,F4 2,6X,F4 2//                               DAT0252
     3' AVG. FOR BOTH:',5X,F4.2,6X,F4.2,6X,F4.2////)                         DAT0253
C     FOR PD4 ( CONTINUITY )                                                 DAT0254
C                                                                            DAT0255
 140  CONTINUE                                                               DAT0256
      IF (N6 .EQ. 0 ) GO TO 150                                              DAT0257
      CALL MOMNT(DEP1,N6,DEP1M,DEP1V,DEP1S)                                  DAT0258
      CALL MOMNT(DEP2,N6,DEP2M,DEP2V,DEP2S)                                  DAT0259
      CALL MOMNT(DEP3,N6,DEP3M,DEP3V,DEP3S)                                  DAT0260
C     WRITE OUT ARRAYS AND RESULTS                                           DAT0261
      WRITE(6,1491)                                                          DAT0262
      DO 141 I = 1, N6                                                       DAT0263
      WRITE(6,1492) DEP1(I),DEP2(I),DEP3(I)                                  DAT0264
 141  CONTINUE                                                               DAT0265
      WRITE(6,1493) DEP1M,DEP1V,DEP1S,DEP2M,DEP2V,DEP2S,                     DAT0266
     1                   DEP3M,DEP3V,DEP3S                                   DAT0267
 1491 FORMAT( ' CONDITUITY:  WHAT FRACTION OF PLAYERS MOVES SAME AS HIS DAT0268
     1 LAST MOVE?'/' (LISTED BY GAME)'//' PLAYER ONE:',8X,' PLAYER TWO: DAT0269
     2',    8X,'AVG  FOR BOTH:'//)                                           DAT0270
 1492 FORMAT(T14,F4.2,T33,F4.2,T55,F4.2)                                     DAT0271
 1493 FORMAT(///' OVER ALL GAMES:     MEAN    VARIANCE  STD.DEV.'//          DAT0272
     1' PLAYER ONE:',8X,F4.2,6X,F4.2,6X,F4.2//                               DAT0273
     2' PLAYER TWO:',8X,F4.2,6X,F4 2,6X,F4 2//                               DAT0274
     3' AVG.FOR BOTH:',6X,F4.2,6X,F4.2,6X,F4.2////)                          DAT0275
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```
C     FOR PD5 ( PREDICTION ACCURACY )
150    CONTINUE
       IF(N7 .EQ. 0) GO TO 160
       CALL MOMNT(PRED1,N7,PRED1M,PRED1V,PRED1S)
       CALL MOMNT(PRED2,N7,PRED2M,PRED2V,PRED2S)
       CALL MOMNT(PRED3,N7,PRED3M,PRED3V,PRED3S)
C     WRITE OUT ARRAYS AND RESULTS
       WRITE(6,1591)
       DO 151 I = 1, N7
       WRITE(6,1592) PRED1(I), PRED2(I), PRED3(I)
151    CONTINUE
       WRITE(6,1593) PRED1M,PRED1V,PRED1S, PRED2M,PRED2V,PRED2S,
      1              PRED3M,PRED3V,PRED3S
1591   FORMAT( ' PREDICTION ACCURACY:  WHAT FRACTION OF PLAYERS
      1PREDICTIONS WERE ACCURATE?'/' (LISTED BY GAME)'//
      2' PLAYER ONE:',8X,' PLAYER TWO:',8X,' AVG.FOR BOTH:'//)
1592   FORMAT(T14,F4.2,T33,F4.2,T55,F4.2)
1593   FORMAT(///' OVER ALL GAMES:     MEAN   VARIANCE  STD.DEV.'//
      1' PLAYER ONE:',8X,F4.2,6X,F4.2,6X,F4.2//
      2' PLAYER TWO:',8X,F4.2,6X,F4.2,6X,F4.2//
      3' AVG.FOR BOTH:',6X,F4.2,6X,F4.2,6X,F4.2////)
C     FOR PD6 (CHOICE MATCHING )
160    CONTINUE
       IF(N8 .EQ. 0) GO TO 170
       CALL MOMNT(CHM1,N8,CHM1M,CHM1V,CHM1S)
       CALL MOMNT(CHM2,N8,CHM2M,CHM2V,CHM2S)
       CALL MOMNT(CHM3,N8,CHM3M,CHM3V,CHM3S)
C     WRITE OUT ARRAYS AND RESULTS
       WRITE(6,1691)
       DO 161 I = 1, N8
       WRITE(6,1692) CHM1(I),CHM2(I),CHM3(I)
161    CONTINUE
       WRITE(6,1693) CHM1M,CHM1V,CHM1S,CHM2M,CHM2V,CHM2S,
      1              CHM3M,CHM3V,CHM3S
1691   FORMAT( ' CHOICE MATCHING:'/' (LISTED BY GAME)'//
      1' PLAYER ONE:',8X,' PLAYER TWO:',8X,' AVG.FOR BOTH:'//)
1692   FORMAT(T14,F4.2,T33,F4.2,T55,F4.2)
1693   FORMAT(///' OVER ALL GAMES:     MEAN   VARIANCE  STD.DEV.'//
      1' PLAYER ONE:',8X,F4.2,6X,F4.2,6X,F4.2//
      2' PLAYER TWO:',8X,F4.2,6X,F4.2,6X,F4.2//
      3' AVG.FOR BOTH:',6X,F4.2,6X,F4.2,6X,F4.2////)
C     FOR PD7 ( POLICY MATCHING )
170    CONTINUE
       IF (N9 .EQ. 0) GO TO 180
       CALL MOMNT(POLM1,N9,POLM1M,POLM1V,POLM1S)
       CALL MOMNT(POLM2,N9,POLM2M,POLM2V,POLM2S)
       CALL MOMNT(POLM3,N9,POLM3M,POLM3V,POLM3S)
       CALL MOMNT(POLM4,N9,POLM4M,POLM4V,POLM4S)
       CALL MOMNT(POLM5,N9,POLM5M,POLM5V,POLM5S)
       CALL MOMNT(POLM6,N9,POLM6M,POLM6V,POLM6S)
C     WRITE OUT ARRAYS AND RESULTS
       WRITE(6,1791)
       DO 171 I = 1, N9
       WRITE(6,1792) POLM1(I),POLM2(I),POLM3(I),POLM4(I),POLM5(I),POLM6(I
      1)
```

```
171   CONTINUE
      WRITE(6,1793) POLM1M,POLM1V,POLM1S,POLM2M,POLM2V,POLM2S,
     1              POLM3M,POLM3V,POLM3S,POLM4M,POLM4V,POLM4S,
     2              POLM5M,POLM5V,POLM5S,POLM6M,POLM6V,POLM6S
1791  FORMAT( ' POLICY MATCHING:'//' (LISTED BY GAME)'//
     1' POLICY MATCHING WITHOUT LAG:        POLICY MATCHING WITH LAG'/
     2/
     3' PLAYER_1  PLAYER_2  AVERAGE        PLAYER_1  PLAYER_2  AVERAGE'
     4//)
1792  FORMAT(T4,F4.2,T14,F4.2,T24,F4.2,T39,F4.2,T49,F4.2,T59,F4.2)
1793  FORMAT(///' OVER ALL GAMES:'//32X,' MEAN   VARIANCE  STD DEV.'//
     1'     WITHOUT LAG: PLAYER ONE:     ',F4.2,6X,F4.2,6X,F4.2//
     216X,' PLAYER TWO:      ',F4.2,6X,F4.2,6X,F4.2//
     316X,' AVG.FOR BOTH:   ',F4.2,6X,F4.2,6X,F4.2//
     4'     WITH LAG:    PLAYER ONE:     ',F4.2,6X,F4.2,6X,F4.2//
     516X,' PLAYER TWO:      ',F4.2,6X,F4.2,6X,F4.2//
     616X,' AVG FOR BOTH:   ',F4.2,6X,F4.2,6X,F4.2////)
C
180   CONTINUE
C
999   CONTINUE
      RETURN
      END
```

```
      SUBROUTINE GAMHIS(ICODE,NT)
C THIS SUBROUTINE GENERATES AGGREGATE GAME HISTORY GRAPH
      LOGICAL*1 H1(72)
      COMMON H1
      COMMON N1,N2,N3,N4,N5,N6,N7,N8,N9,N10,NTT
      DIMENSION NT(5,10),NTT(5,10),NPT(5,10)
      DIMENSION ROW1(80),ROW2(80),ROW3(80),ROW4(80),ROW5(80),
     1          ROW6(80),ROW7(80),ROW8(80),ROW9(80),ROW10(80),
     2          ROW11(80),ROW12(80),ROW13(80),ROW14(80),ROW15(80),
     3          ROW16(80),ROW17(80),ROW18(80),ROW19(80),ROW20(80),
     4          ROW21(80)
      DIMENSION GRAPH(80,21),CHAR(5)
      DATA GRAPH/1680*1H /, CHAR/1H#,1H$,1H%,1H*,1HB/
C
      IF(ICODE .EQ. 1) GO TO 10
      IF(ICODE .EQ. 2) GO TO 20
      IF(ICODE .EQ. 3) GO TO 30
C
10    CONTINUE
      N10 = N10 + 1
      DO 110 N = 1, 10
      NTT(1,N) = NTT(1,N) + NT(1,N)
      NTT(2,N) = NTT(2,N) + NT(2,N)
      NTT(3,N) = NTT(3,N) + NT(3,N)
      NTT(4,N) = NTT(4,N) + NT(4,N)
      NTT(5,N) = NTT(5,N) + NT(5,N)
110   CONTINUE
      GO TO 999
C
C RESET ROUTINE
C
20    CONTINUE
      N10 = 0
      DO 210 I = 1,5
      DO 210 J = 1,10
      NTT(I,J) = 0
210   CONTINUE
      WRITE(6,990)
990   FORMAT(//' *CUMULATIVE HISTORY GRAPH DATA HAVE BEEN RESET *
     X'///)
      GO TO 999
C
30    CONTINUE
      IF(N10 .EQ. 0) GO TO 999
      DO 310 M2 = 1,21
      M = M2 -1
      DO 310 N = 1, 10
      DO 310 J = 1, 5
      IG1 = ((N-1)*8) + J
      IG2 = 1 + M
      NPT(J,N) = ( NTT(J,N)*2 ) / N10
      IF(NPT(J,N) .EQ. (20-M)) GRAPH(IG1,IG2) = CHAR(J)
310   CONTINUE
C
C
```

```
171   CONTINUE
      WRITE(6,1793) POLM1M,POLM1V,POLM1S,POLM2M,POLM2V,POLM2S,
     1              POLM3M,POLM3V,POLM3S,POLM4M,POLM4V,POLM4S,
     2              POLM5M,POLM5V,POLM5S,POLM6M,POLM6V,POLM6S
1791  FORMAT( ' POLICY MATCHING:'//' (LISTED BY GAME)'//
     1' POLICY MATCHING WITHOUT LAG:        POLICY MATCHING WITH LAG'/
     2/
     3' PLAYER_1  PLAYER_2  AVERAGE         PLAYER_1  PLAYER_2  AVERAGE'
     4//)
1792  FORMAT(T4,F4.2,T14,F4.2,T24,F4.2,T39,F4.2,T49,F4.2,T59,F4.2)
1793  FORMAT(///' OVER ALL GAMES:'//32X,' MEAN   VARIANCE  STD DEV.'//
     1'     WITHOUT LAG: PLAYER ONE:     ',F4.2,6X,F4.2,6X,F4.2//
     216X,' PLAYER TWO:     ',F4.2,6X,F4.2,6X,F4.2//
     316X,' AVG.FOR BOTH:   ',F4.2,6X,F4.2,6X,F4.2//
     4'     WITH LAG:    PLAYER ONE:     ',F4.2,6X,F4.2,6X,F4.2//
     516X,' PLAYER TWO:     ',F4.2,6X,F4.2,6X,F4.2//
     616X,' AVG FOR BOTH:   ',F4.2,6X,F4.2,6X,F4.2////)
C
180   CONTINUE
C
999   CONTINUE
      RETURN
      END
```

```
      SUBROUTINE GAMHIS(ICODE,NT)
C THIS SUBROUTINE GENERATES AGGREGATE GAME HISTORY GRAPH
      LOGICAL*1 H1(72)
      COMMON H1
      COMMON N1,N2,N3,N4,N5,N6,N7,N8,N9,N10,NTT
      DIMENSION NT(5,10),NTT(5,10),NPT(5,10)
      DIMENSION ROW1(80),ROW2(80),ROW3(80),ROW4(80),ROW5(80),
     1          ROW6(80),ROW7(80),ROW8(80),ROW9(80),ROW10(80),
     2          ROW11(80),ROW12(80),ROW13(80),ROW14(80),ROW15(80),
     3          ROW16(80),ROW17(80),ROW18(80),ROW19(80),ROW20(80),
     4          ROW21(80)
      DIMENSION GRAPH(80,21),CHAR(5)
      DATA GRAPH/1680*1H /, CHAR/1H#,1H$,1H%,1H*,1HB/
C
      IF(ICODE .EQ. 1) GO TO 10
      IF(ICODE .EQ. 2) GO TO 20
      IF(ICODE .EQ. 3) GO TO 30
C
10    CONTINUE
      N10 = N10 + 1
      DO 110 N = 1, 10
      NTT(1,N) = NTT(1,N) + NT(1,N)
      NTT(2,N) = NTT(2,N) + NT(2,N)
      NTT(3,N) = NTT(3,N) + NT(3,N)
      NTT(4,N) = NTT(4,N) + NT(4,N)
      NTT(5,N) = NTT(5,N) + NT(5,N)
110   CONTINUE
      GO TO 999
C
C RESET ROUTINE
C
20    CONTINUE
      N10 = 0
      DO 210 I = 1,5
      DO 210 J = 1,10
      NTT(I,J) = 0
210   CONTINUE
      WRITE(6,990)
990   FORMAT(//' *CUMULATIVE HISTORY GRAPH DATA HAVE BEEN RESET *
     X'///)
      GO TO 999
C
30    CONTINUE
      IF(N10 .EQ. 0) GO TO 999
      DO 310 M2 = 1,21
      M = M2 -1
      DO 310 N = 1, 10
      DO 310 J = 1, 5
      IG1 = ((N-1)*8) + J
      IG2 = 1 + M
      NPT(J,N) = ( NTT(J,N)*2 ) / N10
      IF (NPT(J,N) .EQ. (20-M)) GRAPH(IG1,IG2) = CHAR(J)
310   CONTINUE
C
C
```

```
      DO 320 I = 1, 80
      ROW1(I)  = GRAPH(I,1)
      ROW2(I)  = GRAPH(I,2)
      ROW3(I)  = GRAPH(I,3)
      ROW4(I)  = GRAPH(I,4)
      ROW5(I)  = GRAPH(I,5)
      ROW6(I)  = GRAPH(I,6)
      ROW7(I)  = GRAPH(I,7)
      ROW8(I)  = GRAPH(I,8)
      ROW9(I)  = GRAPH(I,9)
      ROW10(I)  = GRAPH(I,10)
      ROW11(I)  = GRAPH(I,11)
      ROW12(I)  = GRAPH(I,12)
      ROW13(I)  = GRAPH(I,13)
      ROW14(I)  = GRAPH(I,14)
      ROW15(I)  = GRAPH(I,15)
      ROW16(I)  = GRAPH(I,16)
      ROW17(I)  = GRAPH(I,17)
      ROW18(I)  = GRAPH(I,18)
      ROW19(I)  = GRAPH(I,19)
      ROW20(I)  = GRAPH(I,20)
      ROW21(I)  = GRAPH(I,21)
320   CONTINUE
C
      WRITE(6,390) ROW1,ROW2,ROW3,ROW4,ROW5,ROW6,ROW7,ROW8,ROW9,ROW10,
     1             ROW11,ROW12,ROW13,ROW14,ROW15,ROW16,ROW17,ROW18,
     2             ROW19,ROW20,ROW21
390   FORMAT(///' CUMULATIVE GAME HISTORY GRAPH: '//
     1'     LEGEND: # = CC, $ = CD, % = DC, * = DD, B = B-OPTION'///
     211X,'100 .',80A1/15X,'.',80A1/12X,'90 .',80A1/15X,'.',80A1/
     312X,'80  ',80A1/15X,' ',80A1/12X,'70  ',80A1/15X,' ',80A1/
     412X,'60 .',80A1/15X,'.',80A1/12X,'50 .',80A1/' OCCURENCES    .',
     580A1/'  PER TEN-  40  ',80A1/'  MOVE SET       ',80A1/
     612X,'30 .',80A1/15X,'.',80A1/12X,'20 .',80A1/15X,'.',80A1/
     712X,'10  ',80A1/15X,' ',80A1/13X,'0  ',80A1/15X,39('  ')/
     8T20,'10',T28,'20',T36,'30',T44,'40',T52,'50',T60,'60',
     9T68,'70',T76,'80',T84,'90',T91,'100'/T53,'MOVES'///)
C
999   CONTINUE
      RETURN
      END
```

```
      SUBROUTINE MOMNT(X, NPTS, XMEAN, XVAR, XSTD )
      COMMON N1,N2,N3,N4,N5,N6,N7,N8,N9,N10
      DIMENSION X(100)
C
C    THIS SUBROUTINE CALCULATE MEAN, VARIANCE AND STATNDARD DEVIATION
      IF(NPTS .EQ. 1 ) GO TO 150
C
      SUMX = 0.
      SUMXX = 0
      DO 10 I = 1, NPTS
      SUMX = SUMX + X(I)
      SUMXX = SUMXX + X(I)**2
10    CONTINUE
      SUM = NPTS
      XMEAN = SUMX / SUM
      XVAR = ( SUMXX - SUMX*XMEAN ) / (SUM - 1.0)
      XSTD = SQRT ( XVAR )
      GO TO 20
150   CONTINUE
      XMEAN = X(1)
      XVAR = 0.
      XSTD = 0.
20    RETURN
      END
```

```
      FUNCTION CC(I1)
      DIMENSION LET(3)
      DATA LET/1HC,1HD,1HB/
      IF (I1.EQ.1) CC = LET(1)
      IF (I1 EQ 2) CC = LET(2)
      IF (I1.EQ.3) CC = LET(3)
      RETURN
      END
```

9. ILLUSTRATIVE ANALYSES OF MIT STUDENT PLAY

a) Data input for PD game 1: 54 versus 83

```
.start main
.yyyyyyyyyynnn
. 15
.  1
.GAME  1  PD  54 VS 83  10/11/79
. 52
.cd
.cccc
.dccc
.cccc
.cccccc66
.cccc
.dccc
.cccc
.cccccc76
.cccc
.cccc
.cccc
.cccccc77
.dccc
.cccc
.cccc
.cccccc77
.cccc
.dccc
.cccc
.cc ccc77
.cc c
.dccc
.cccc
.cccccc77
.cccc
.cccc
.cccc
.dcccdc47
.cccc
.cccc
.cccc
.cccccc47
.cccc
.dccd
.cccc
.cccccc47
.cccc
.cccc
.cccc
.dccddc47
.cccc
.cccc
.cccc
.cccccc47
```

(cont)

```
.dccd
.cccc
.cccc
.cccccc57
.cccc
.dccc
```

CMS Sample Run of PDST1

Everything after periods is user inputs. in CMS.

`.start main` is to start a fortran program. The above differs from computer system to another.

`.yyyyyyyyyynnn` is to select options. Here, we choose option 1 thru 10.

`.␣15`. Since we chose option 2, we have to specify the length of interval.

`.␣␣1` is to show how many games to be input. In this case, we have only one game.

`.GAME ....`. You can write anything up to 72 characters. It is usually used to describe the game.

`.␣52` is the length of the game. In this case we have 52 moves.

```
.cd
.cccc
 : : : :
```

game record. The 5th to 8th columns are unspecified for this program.

b) RESULTS OF REQUESTED OPTIONS FOR GAME: GAME 1 PD 54 VS 83 10/11/79

THIS GAME HAS 52 MOVES.

FREQUENCIES OF COOPERATIVE MOVES FOR GAME: GAME 1 PD 54 VS 83 10/11/79

FRACTION OF COOPERATIVE MOVES:

PLAYER ONE: 0.81 PLAYER TWO: 0.98 AVERAGE FOR BOTH: 0.89

CONDITIONAL PROBABILITIES FOR EVERY 15 MOVES FOR GAME:

GAME 1 PD 54 VS 83 10/11/79

TRUST			TRUSTWORTHINESS			FORGIVENESS			RESPONSIVENESS		
PLAYER 1	PLAYER 2	AVERAGE	PLAYER 1	PLAYER 2	AVERAGE	PLAYER 1	PLAYER 2	AVERAGE	PLAYER 1	PLAYER 2	AVERAGE
0.0	0.0	0.0	0.700	1.000	0.850	1.000	1.000	1.000	1.000	1.000	1.000
0.0	0.0	0.0	0.750	1.000	0.875	0.0	1.000	0.500	1.000	0.0	0.500
0.0	0.0	0.0	0.846	1.000	0.923	0.0	1.000	0.500	1.000	0.0	0.500

CONDITIONAL PROBABILITIES FOR GAME: GAME 1 PD 54 VS 83 10/11/79

FRACTION OF PLAYERS MOVES WHICH INDICATE A GIVEN TRAIT:

TRUST			TRUSTWORTHINESS			FORGIVENESS			RESPONSIVENESS		
PLAYER 1	PLAYER 2	AVERAGE	PLAYER 1	PLAYER 2	AVERAGE	PLAYER 1	PLAYER 2	AVERAGE	PLAYER 1	PLAYER 2	AVERAGE
0.0	0.0	0.0	0.750	1.000	0.875	1.000	1.000	1.000	1.000	1.000	1.000

TIT-FOR-TAT STATISTICS FOR GAME: GAME 1 PD 54 VS 83 10/11/79

FRACTION OF MOVES WHICH REPRESENT A TIT-FOR-TAT POLICY:

PLAYER ONE: 0.78 PLAYER TWO: 0.80 AVERAGE FOR BOTH: 0.79

FIRST MOVE AS INDICATOR STATISTICS FOR GAME: GAME 1 PD 54 VS 83 10/11/79

FRACTION OF MOVES WHICH WERE THE SAME AS PLAYERS FIRST MOVE:

PLAYER ONE: 0.80 PLAYER TWO: 0.0 AVERAGE FOR BOTH:0.40

'CONTINUITY' STATISTICS FOR GAME: GAME 1 PD 54 VS 83 10/11/79

FRACTION OF MOVES WHICH WERE THE SAME AS PLAYERS LAST MOVE:

PLAYER ONE: 0.61 PLAYER TWO: 0.98 AVERAGE FOR BOTH: 0.79

'PREDICTION ACCURACY' STATISTICS FOR GAME: GAME 1 PD 54 VS 83 10/11/79

FRACTION OF PREDICTIONS WHICH WERE ACCURATE:

PLAYER ONE: 0.96 PLAYER TWO: 0.86 AVERAGE FOR BOTH: 0.91

'CHOICE MATCHING' STATISTICS FOR GAME: GAME 1 PD 54 VS 83 10/11/79

FRACTION OF MOVES WHICH WERE THE SAME AS PLAYERS PREDICTION OF OPPONENTS MOVES:

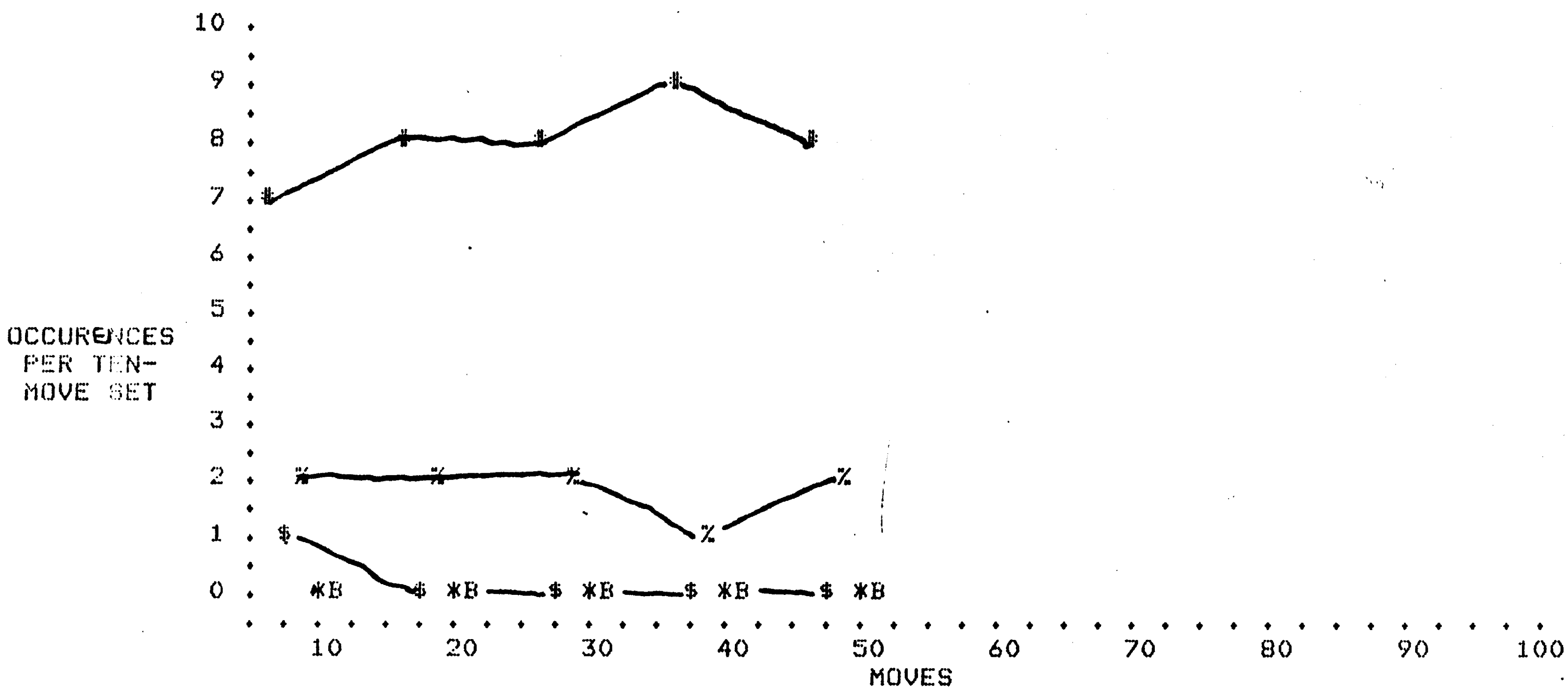
PLAYER ONE: 0.76 PLAYER TWO: 0.94 AVERAGE FOR BOTH: 0.85

'POLICY MATCHING' STATISTICS FOR THIS GAME: GAME 1 PD 54 VS 83 10/11/79

	WITHOUT LAG	WITH LAG
PLAYER ONE:	0.75	0.76
PLAYER TWO:	0.78	0.78
AVG.FOR BOTH:	0.76	0.76

GAME HISTORY GRAPH FOR GAME: GAME 1 PD 54 VS 83 10/11/79

LEGEND: # = CC, $ = CD, % = DC, * = DD, B = B-OPTION



R;

c) Some Summary Results Derived from MIT Student Play (game #1, an asymmetric SPD) N = 19 pairs; most games have 50+ moves.

1. Frequencies of Cooperative Moves

OVER ALL GAMES	MEAN
PLAYER ONE:	0.53
PLAYER TWO:	0.62
AVG. FOR BOTH:	0.58

2. Conditional Probabilities

OVER ALL GAMES:

		MEAN
TRUSTINGNESS:	PLAYER ONE:	0.16
	PLAYER TWO:	0.34
	AVG.FOR BOTH:	0.25
TRUSTWORTHINESS:	PLAYER ONE:	0.65
	PLAYER TWO:	0.76
	AVG.FOR BOTH:	0.70
FORGIVENESS:	PLAYER ONE:	0.41
	PLAYER TWO:	0.56
	AVG.FOR BOTH:	0.49
RESPONSIVENESS:	PLAYER ONE:	0.51
	PLAYER TWO:	0.50
	AVG.FOR BOTH:	0.50

3. Tit-for-Tat Model Fit

OVER ALL GAMES:	MEAN
PLAYER ONE:	0.73
PLAYER TWO:	0.74
AVG. FOR BOTH:	0.74

4. First Move Model Fit

OVER ALL GAMES:	MEAN
PLAYER ONE:	0.65
PLAYER TWO:	0.45
AVG. FOR BOTH:	0.55

5. Continuity Model Fit

OVER ALL GAMES:	MEAN
PLAYER ONE:	0.77
PLAYER TWO:	0.81
AVG.FOR BOTH:	0.79

6. Prediction Accuracy of the Players

OVER ALL GAMES:	MEAN
PLAYER ONE:	0.77
PLAYER TWO:	0.72
AVG.FOR BOTH:	0.74

7. <u>Choice Matching Model Fit</u>

OVER ALL GAMES:	MEAN
PLAYER ONE:	0.76
PLAYER TWO:	0.77
AVG.FOR BOTH:	0.76

8. <u>Policy Matching Fit</u> (Temporary)

OVER ALL GAMES:

		MEAN
WITHOUT LAG:	PLAYER ONE:	0.70
	PLAYER TWO:	0.70
	AVG.FOR BOTH:	0.70
WITH LAG:	PLAYER ONE:	0.71
	PLAYER TWO:	0.70
	AVG.FOR BOTH:	0.70

9. Aggregate Game History

LEGEND: # = CC, $ = CD, % = DC, * = DD, b = B-OPTION