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ABSTRACT

THE STRUCTURE OF INTERNATIONAL CONFLICT: GAME THEORETIC PERSPECTIVES

By

Terence Dungworth

This analysis of dyadic international conflict employs the game theoretic model of strategic choice and merges this with a behaviorally grounded theory of preferences for outcomes of conflict. A parsimonious taxonomy of dyadic conflict situations is generated by this approach and it thereby becomes possible to develop general principles concerning the necessary and sufficient conditions for the occurrence of any given outcome. These offer a basis for predicting outcomes of dyadic conflict when the latter is formulated in terms of the game model even when very limited information about preference structures of the two players is available.

Further theoretical development takes place when the question of dynamic transformation of preference orderings is considered. Though game theory in its present form is commonly acknowledged to be a static mode of analysis, it is possible to introduce dynamic elements into an application by the construction of axioms of transformation for both players after a given conflict situation leads

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to advantage for one of the players. The impact of that outcome on future preference structure can be stated in terms of three models of transition, identified as Fearful Loser, Greedy Winner, and Satisfied Winner. The principles of transition incorporated into these models offers a means of constructing the viable transformations of a given game. It is demonstrated that both the timing and the nature of the changes in preferences affect the kind of game which can develop, and that, in the absence of perfect information about the intentions of the other player, specification of the particular game which ensues is rarely possible. Thus the dynamic transformations do not lead to deterministic outcomes, but rather to a set of outcomes, one of which will be the actual consequence.

Finally, the question of deception is examined. It is shown that in some situations, given certain limiting assumptions, it is possible for players to transmit to each other signals concerning their preference structures which do not coincide with true preferences. As a consequence, when these are believed, a strategic choice may be induced which differs from the choice which would be made if the true preferences of the opponent were known. In some conflict situations such deception is profitable for the deceiver in the sense that the induced strategy of the opponent permits a strategic choice which leads to a more preferred outcome than the natural choice would provide. In other situations, deception can backfire by engendering a less preferred outcome. It is further shown that in

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shown that in the Game of Chicken deception can take place without detection since the deceiver's strategic choice after deception is identical to the choice that the deceived player expects. In all other games where deception is both possible and profitable the deceiver must reveal the deception in order to take advantage of it.

In conclusion, the utility of this approach for inquiry into international conflict is considered. While there are clear difficulties involved in the operationalization of the relevant variables (due mainly to the fact that preferences of real world actors are obscure), it is nevertheless argued that the parsimony of the taxonomy, coupled with the dynamic and deceptive elements of the essay, offer a clear, logical structure with considerable heuristic value for research into dyadic conflict.

THE STRUCTURE OF INTERNATIONAL CONFLICT:

GAME THEORETIC PERSPECTIVES

By

Terence Dungworth

A DISSERTATION

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Michigan State University
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

Department of Political Science

1975

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ACKNOWLEDGEMENTS

This work would not have been possible without the assistance, support and tolerance of my wife. These, however, are not my only reasons for dedicating this dissertation to her.

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CHAPTER I

THE STUDY OF INTERNATIONAL CONFLICT

In this essay, I shall state a theory of inter-nation conflict behavior and, through the use of a game theoretic mode of analysis, will investigate the implications of that theory for ideas about the structure of such conflict. Of course, game theory is not the only viable approach to such investigation, and in order to put this inquiry into perspective, it will be useful to consider, briefly, some of the general techniques that have been employed in conflict analysis. Three primary categories of research will be reviewed--empirical investigation; experimental inquiry, including simulations; and more formally derived models, of which game theoretic systems are an instance. Each of these three modes will be evaluated from the point of view of their value for increased understanding of international conflict and theory construction. The game theoretic mode will then be considered in somewhat more detail.

EMPIRICAL INVESTIGATION

Empiricism in international relations has received heavy emphasis during the last two decades.[1] It has been claimed that this has been a characteristic response by the members of the field to their doubts concerning the value of "speculation and impression" as "a satisfactory route to knowledge." (Singer, 1965). The consequence has been a desire to improve observational techniques, and to accumulate not merely masses of facts, but data and descriptions, in the sense used by Singer (ibid). These data, which might concern attributes, transactions, perceptions, and events, will--it is hoped--provide the basis for premises and hypotheses which might lead to models and theories, as well as offering some grounds for their verification. In addition, a rigorous empirical focus can provide answers to non-theoretical questions of a substantive character. Policy considerations, for instance, involve matters of fact about past actions of other nations as well as currently prevailing conditions.[2] Theory is not a prerequisite for action in cases like this. Further, it should be noted that many simulations also depend on data, not hazy notions about empirical referents, for their correspondence with the 'real world'.

Wright (1942) and Lasswell (1949) were among early empiricists (though it should be emphasized that both were also theorists of considerable import). Richardson (1960b) may be similarly classified. More recently, Singer has been a major advocate of the approach, particularly with respect to the accumulation of data concerning war (1968).

Two types of empirical inquiry deserve particular mention--events data analysis, and content analysis employing a stimulus-response formulation.

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Events Data Analysis

If science is considered as an effort to pick out and explain patterns in the phenomena under consideration, then events data analysis may be considered to be subsumed under the picking out category. They are distinguished from transactional, attribute, or perceptual data by their concern with the "overt behavior of international political actors toward each other and/or their environments." (Azar, 1970, p. 1). The collection of the data tends to be highly systematized, involving fairly complex techniques for coding, scaling and organization. The contribution made by events data gatherers to the understanding of the technical problems associated with data collection has been substantial. In general, there are two approaches. One is the categorization approach, which attempts to set up a classificatory scheme for events; the other is the measurement approach which seeks to quantify properties of an event (e.g. in terms of conflict, co-operations, hostility, violence, etc.). The most prominent example of the former is the World Event/Interaction System (WEIS) developed by Charles McClelland (1970). The latter is difficult to distinguish in principle from the perceptual analyses conducted by researchers such as Holsti, North, and Brody (discussed below under Content Analysis). However, it has led to such developments as the 13-point interval scale formed by Azar and others, and Corson's ratio scale (1969). Evaluation of these scales tends to be a ju

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Perhaps the most ambitious and most interesting claim of events data practitioners concerns the role to be played by events data as a link between foreign policy analysis and analysis of the international system as a whole. McClelland argues that the external actions of international actors constitute a dependent variable for foreign policy analysis, and that they provide the initial input of the international system. The point is echoed, somewhat more emphatically by Azar (1971). While the argument that events data constitute this real world link seems reasonable, I am not clear about its clarifying or explanatory potential. It seems to me that such an emphasis would lead to efforts to develop a general theory of foreign policy and international systems analysis. I cannot see how events data provide any additional theoretical impetus. Furthermore, given the relatively impoverished state of theory in international relations, it does not seem profitable to attempt over-arching explanations when the smaller units are beyond our comprehension.[3]

Content Analysis and the Mediated Stimulus-Response Model

Though this formulation exists independently of the substance of international conflict, it is included as empirical investigation since it relies upon content analysis for its operalization.

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The mediated stimulus-response model as used by Holsti, North and Brody to examine the pre-WW I crisis (1968) and the Cuban missile crisis (1969) is a refined version of the simpler S-R model used by Zinnes (1968), though the model is not specified by the latter. The basic hypothesis is that some nation, X, perceiving itself to be the target of hostile expressions from some other nation, Y, will be moved to express its own hostility to Y. Y, now a target itself, will be stimulated to return X's expression as and when that expression is perceived. The mediated model introduces the qualification that X, upon perceiving Y's expression, makes a statement of plans and intentions toward Y; it is not necessary that this expression be hostile in the same manner and to the same extent as the initial Y expression. It may be more or less extreme. Similarly, Y's reaction to X need not be totally consistent with the expression made by X. Thus, the mediated model allows for the consideration of such tactics as bluff, concealment, stalling, etc., and takes into account disinterest and misunderstanding. In both versions of the model, hypotheses are tested by way of data collected through content analysis. Perceptions and expressions of hostility made by the nations are coded according to intensity, and - in the mediated model - are combined with scaled action data (hard indices of certain economic and military conditions) to form the S-r:s-R structure.

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What distinguishes this approach from events data is of course the inclusion of perceptual and affective data based on content analysis. This is appealing in at least two ways. First, it seems reasonable to consider that national decision-makers act on the basis of their perceptions of the situation, such perceptions being to some extent dependent upon idiosyncratic and unobservable affective elements. Second, observers of international crises are handicapped by the large number of variables involved and the relative invisibility of much of the information that would be useful in acquiring understanding. Thus it behooves us to focus on those elements of the situation that are accessible--namely, public inter-state communications and certain hard variables. A theory which attempts to explain crisis in such terms has at least the potential for making verifiable predictions, and should accordingly be encouraged.

However, the formulation is not devoid of problems, some technical, some logical. Perhaps the most troubling technical difficulty, inherent in all content analysis and all measurement of non-observable characteristics, concerns the coding of expressions. It is possible to employ a number of coders, and then to evaluate inter-coder reliability, but even when such reliability is high, it is difficult to evaluate the validity of the coding. We can assume that coders are trained according to some scheme, and that reliability between them indicates sound training. But this does not tell us whether their i

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whether their interpretations are consistent with the intentions of the actor whose expressions they are coding. It is rarely possible to come to a satisfactory conclusion on this matter; the researchers simply have to be trusted.

The primary logical problem, which I believe is built into the statement of the stimulus-response model, mediated or otherwise, can best be illustrated by considering the model as a simple dyadic interaction system, and expressing the relationship between the variables in differential equation form. Given two nations, X and Y, let x = the expressed attitude of X towards Y, and let y = the expressed attitude of Y towards X. Then, by the logic of the S-R model, the change over time in x is some function of y, and vice versa. Let (x, y) be the value of the attitudes of (X, Y) respectively to the other. Then we may write the system: $dx/dt = y$, and $dy/dt = x$, which simply states that the change over time in the attitude of one nation to the other is equal to the expression made by the other. That is, it is the stimulus response model, where the stimulus and the response are of equal value. Clearly, the model goes to plus or minus infinity over time.[4] When mediation is introduced, the system simply becomes $dx/dt = ay$, $dy/dt = bx$, where a and b are parameters that tap the factors which are considered to mediate the basic model. (Obviously, in an operational form of the model, these would have to be specified. This is not necessary however for the point I wish to make). The system still goes to plus or minus infinity over time. It begins moving as soon as (x, y) and (a, b) assume values that are non-zero, and it never stops moving. It may move slowly or quickly, depending on the size of the parameters. This kind of system is not isomorphic to the real world, in which crises do come to an end without war.

Stated in this form, the relationship between the stimulus-response approach to crisis, and the Richardson approach to arms races is striking. The symbolic statement of the two models is virtually identical, as is their logic. Both are deterministic, though the S-R model is usually treated as a type of empirical investigation. I do not believe it will become fruitful until this deterministic aspect is more fully explored.

Experimental Investigation and Simulations

In the physical sciences researchers are frequently able to isolate the elements in which they are interested, and subject them to controlled analysis. International relations researchers who would like to do the same kind of thing are handicapped by the nature of the subject matter. The actors in international events, and the settings in which events take place are not amenable to manipulation. Consequently, those who wish to experiment must simulate actors and their environments; then it becomes possible to control for particular variables, to run a process a number of different times and so forth.

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This has been attempted in three ways: gaming, involving human actors with virtually no programming of their interactions; man-machine simulations, in which the interaction is to some extent controlled by computer; and simulations, in which all interaction takes place according to pre-programmed instruction.

Gaming is conducted in two ways that are relevant for international relations. The least important of these is the game theory experiment, commonly involving the Prisoner's Dilemma, and seeking to determine whether or not the rational choices dictated by the theory are to be found in the experimental situation (Rapaport and Chammah, 1965). This aspect is relevant only to the extent that it can be argued that the experimental situation involving contrived conflict between individuals over a relatively trivial issue is analagous to spontaneous conflict between nations over non-trivial issues. In other words, is the experimental model isomorphic to the real world? The other gaming alternative is to establish in the experiment structural relationships between participants that match real world relationships, and then to have the participants interact in terms of their perceived roles. War games are included in this category. So are Political Military Exercises (PME) developed by Bloomfield and others (1959 and 1965).

Gaming differs from nan-machine and all machine simulations in an important respect. The former contains structural parameters

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but virtually no process parameters. There is no theory built into the experiment concerning expectations about interaction. Participants are left to their own devices. Simulations which are partly or completely programmed, however, have incorporated into them both structure and process, the latter being the reflection of an explicit or implicit theoretical orientation on the part of the experimenter. Normally, this is acknowledged. Guetzkow, whose Inter Nation Simulation (INS) is the most prominent example of a man-machine simulation in the field, is most explicit on this point (1959 and 1968). Similarly, a totally computerized simulation such as the Technological, Economic, Military, Political Evaluation Routine (TEMPER, Abt et al, 1965) is completely theoretical since nothing is left to chance in its operation. In this sense, it is a deterministic system of the same character (in principle) as Richardson's model of arms races. All states of both systems are completely determined by the initial statement of the model, though the simulation is of course a great deal more complex than the Richardson equations, and furthermore may not be known to be internally consistent before it is run.

Since simulations are models of theories, it is clear that they can be no more valid than the theory behind them, and this theory can be valid only to the extent that it is isomorphic with the relevant variables in the real world. How then is a simulation to be evaluated with respect to its validity? Guetzkow has attempted to validate the

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INS, and has concluded that it is impossible to do so at the present time. Fedder (1969) has argued that experimental models can never be validated in terms of real world situations, but can only be internally tested (in terms of their theories), and that this tells us little about the applicability of the simulation outside the experimental context. Nevertheless, the simulation may have value to the extent that it shows logical contradictions, counter-factual or non-obvious consequences which are otherwise obscured. For examinations of the validity problem in general see Hermann (1967), and for a particular analysis of PME, INS and TEMPER see Alker and Brunner (1969).

FORMALLY DERIVED MODELS

In one sense at least, to speak of formally derived models in international relations is to imply a notion of 'model' or 'formal derivation' or both, that is somewhat at odds with the prevailing philosophy of science literature. Kaplan, for instance, argues that a model, while not co-extensive with theory, nevertheless is dependent upon the existence of a theory. A model is an abstraction of a theory, and should be more or less isomorphic with the world which the theory attempts to organize and explain. If there is no theory, explicit or otherwise, there can be no model (1964, p. 263-5). The same kind of point is made by Rudner (1966) and Popper (1968). Furthermore, the formal model is, by definition of 'formal', devoid of empirical content and needs no empirical referents for the validity of its derivations or r

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derivations or relationships. Thus, a number of interpretations are possible for any given formal model. In this strict sense, formal models are non-existent in the field of international relations (and rarely occur elsewhere in the behavioral sciences--Kaplan, p. 262). I shall therefore adopt a looser interpretation and assume that formal modelling is a way of theorizing in symbolic style without necessary reference to a systematic data-base (though empirical referents, however hazy, form the foundation of the model), and without the insistence that the resulting formulation be operational and hence testable. Thus, models so formed would not necessarily purport to be explanations in the scientific sense, and might be loosely characterized as analytic rather than synthetic (or descriptive). Included in this characterization of modelling would be the mathematical systems created by Lanchester (1916), who developed a differential equation model of the rate of loss of military forces when in action, and Richardson (1960) who developed a much better known dyadic interaction arms race system which has been shown to possess some empirical relevance. For reviews, see Rapoport,(1957 and 1960). Extensions and adaptations of Richardson's basic approach may be found in Caspary (1967), who seeks to qualify the economic factor in Richardson's argument; Smoker (1969), who considers the impact on the model of fear due to nuclear weaponry; and Harvath and Foster (1970) who apply the approach to war alliance formation and maintenance. Saaty (1968) has considered

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has considered the application of mathematical models to arms control and disarmament in general, and has advanced a number of important suggestions for further applications of formal approaches. Perhaps the most important of these concern game theory.

It seems proper to include in the category of modelling, as specified above, the mathematical theory of games, though, as was noted earlier, games have also been the focus of a good deal of experimental work. Since Von Neuman and Morgenstern originated the theory (1947), it has drawn the interest of numerous commentators: (Schelling, 1960; Rapoport, 1960; Boulding, 1962; Shubik, 1964; Kaplan, 1968; Brams, 1975; and, of course, the plentiful articles in the Journal of Conflict Resolution). To some extent all of them have noted the potential contribution that game theory might, at some time, make to the study of international conflict and the strategy and bargaining that is an adjunct to conflict. However, most writers also point out that formal game theoretic models that apply to international relations have not been developed, and that due to the difficulties involved in assumptions about the notion of rationality, and in the quantification of the kind of parameters that are necessarily incorporated into games, such developments do not appear to be forthcoming (e.g. Saaty, 1968, p. 61; Kaplan, 1968, p. 485). The problems connected with simplifying through assumptions are of course characteristic of all models. By their nature models are abstractions either of a real world situation or of a theoretical notion, and consequently are rarely completely isomorphic wit

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isomorphic with that which they model. The critical question is whether or not that which is missing operates in the system in such a way that its absence renders the model valueless. This is a rather subjective judgment, and may depend upon the researcher's purposes. It is clearly a dilemma that can never be completely resolved, since the simplification that is the model's weakness is also its strength. That is, the normal objective in modelling is to reduce complexity, and induce clarification, which is difficult to do unless something is left out. When the model is completely isomorphic with another system then it may be considered a symbolic representation of that system, with the purpose of explication.

Before proceeding to further explication of the game model and the manner in which it will be employed in this essay, I want to first of all consider the question of the theoretical utility of the approaches that have been discussed. Some notion of the process of scientific inquiry is necessary if the contribution of the three strategies to theorizing is to be adequately estimated. However, I would like to avoid the complex and generally unresolved (Kaplan, 1964, p. 29) philosophical issues concerning the precise nature of the scientific method. I shall make the general assumption that science is an essentially cyclical process, involving the interaction of empirical referents, of some degree of specificity, with tentative explanations and predictions, which in turn depend upon further empirical referents for th

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First of all, I would like to comment that in principle such differences seem highly appropriate. One does not have to accept Kuhn's argument (1970) about paradigms and normal science in its entirety in order to appreciate the value of ongoing debate about methods and approaches. However, I believe that the form the debate has taken is sterile, since it has been based upon a misconception about the way in which theory is developed.

Advocates of the formal modelling approach (such as Young), and of simulation, which is a more complex and partially non-symbolic type of modelling, argue that theory will be developed only through the synthesis of complex factors into simpler representations of them. In other words, theories will be derived or deduced from their models. But the models themselves are dependent on already existing theories, whether this is realized or not. A set of differential equations describing a system embodies a theory; so does a programmed simulation. It makes no sense to me to then talk of these constructs

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as progenitors of theory. Obviously, they are valuable approaches in the sense that they offer the possibility of clarification, explication and testing of the theories they represent. These activities may then lead to refinements and modifications of the theoretical constructs. But it is not accurate, in my opinion, to say that these approaches will lead to theory construction.

Empiricists similarly claim that their systematic organization of data provide a basis for the assumptions and premises which form the foundation of theory. I take this as more than an observation that all theory which seeks to explain the 'real world' must have its roots in the real world. I believe the claim is that empirical investigation will 'lead to' theory. In a Bayesian sense, induction may lead to probabilistic generalizations and hence to predictions, but this is not the same as theory. Philosophical objections to the notion of puristic induction are well argued by writers such as Hempel (1968) and Popper (1968). Furthermore, there are a number of strong arguments (Churchman, 1961) for the point of view that facts and their systematic collection possess strong theoretical content. Singer acknowledges this (1968, p. 1), but immediately argues that data-less theorizing is sterile (Ibid., p. 2). To me, this is a contradiction. On the one hand, Singer implies that the selection and organization of facts is dependent upon theory (perhaps vague); on the other, he argues that theory is dependent upon data. I don't think we can have it both ways, unless we are simply s

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we are simply saying that there is cyclical interaction between data and theory throughout scientific inquiry, with which nobody argues.

In conclusion then, what I have attempted to show is that all three strategies are valuable for the potential development of the discipline of international relations, but that none of them, and no combination of them, can be considered to be a method for the construction of theory. No such method exists. The orgins of theory lie in the creative imagination of the researcher, not in facts about the world he seeks to explain or in the methods/strategies he uses. Whether the imagination is stimulated more by ignoring the data or assimilating it (or a combination) appears to me to be an individual matter. For the balance of this essay, I will take the formal approach represented by game theory, but will attempt to anchor it to the empirical world through the development of a specific behavioral theory. This does not mean that empirical applications will be conducted. What follows will stand or fall on the basis of its internal logical structure, and the implications this has for general theoretical principles of international conflict. Before proceeding with a more comprehensive statement of the method and scope of the inquiry, it is necessary to expand upon the rather brief comments that have so far been made about the theory of games.

Game Theory in the Analysis of International Conflict

Game theory is a formal system of rational strategic choice in situations of conflict of interest.[5] As a branch of mathematics it is devoid of empirical content. All theorems follow deductively from axioms, and validation is therefore a matter of internal consistency only. As Rapoport has pointed out:

> The principle according to which game theory classifies games is best understood if game theory is viewed as the branch of mathematics concerned with the formal aspect of rational decision. The emphasis is on the word "formal" which in this context means "devoid of content."...Similarly a mathematical theory of rational decision is concerned not with the problem of making wise decisions but with the logical structure of problems which arise in connection with the necessity of making decisions (1966, p. 16).

A number of assumptions are necessary prerequisites to a game theoretic analysis of any conflict problem. First of all, the problem of decision arises because the decision maker is dependent to some extent upon the actions and decisions of the party or parties with whom the conflict exists. That is, the consequence of choice is not unilaterally determined by the nature of that choice. This separates game theory from other approaches to rational decision.

> What distinguishes game-theoretic models from other models of rational choice is that the outcome is assumed to be contingent on the choices of more than one player. Thus, the preferences of other players, and choices consistent with these preferences, must be explicitly taken into account when one chooses an optimal course of action (e.g. how to vote, what coalition to join, and so on) (Brams, 1975, p. xv).

Thus in order for a conflict problem to be amenable to game theoretic investigation there must be at least two players, each of whom has available at least two courses of action. Furthermore, the consequences of each pair of choices must be capable of specification and the specification must be known by all players. In this fashion, players can consider the outcomes and assign preference rankings to them. It does not make sense to consider choice rational if decision makers lack a conception of what the choice will lead to. Once consequences are known, however, there exists a basis for judging the merits of one particular strategy as opposed to another.

This basis - for deciding between alternative strategies - is formalized as the concept of rationality, which, of course, is not a unique property of game theoretic analysis. Anthony Downs has offered a simple yet thorough definition:

> A rational man is one who behaves as follows: (1) he can always make a decision when confronted with a range of alternatives; (2) he ranks all the alternatives facing him in his order of preference in such a way that each is either preferred to, indifferent to, or inferior to each other; (3) his preference ranking is transitive; (4) he always chooses from among the possible alternatives that which ranks highest in his preference ordering; and (5) he always makes the same decision each time he is confronted with the same alternatives (1957, p. 6).

The question of whether or not such an assumption of rationality is isomorphic with the situation for which a game is a model obviously arises. Speaking primarily of the international conflict arena, Harsanyi has argued that such an approach is justifiable, though not literally true:

> This assumption of rational behavior of course, if taken quite literally, is certainly unrealistic in many situations. Policy makers are human and therefore

> occasionally do make mistakes. Moreover, their policy objectives are seldom quite consistent. For one thing, when people have to choose between two or more very unpleasant policy alternatives, they often find it very hard to make up their minds and follow any of these policies in a consistent manner. For another thing, every policy maker is subject to conflicting pressures from his own constituents, and these may make it very difficult for him to adopt any unambiguous policy line...
>
> However, in spite of such occasional inconsistencies and mistakes, if we observe a given country's foreign policy over long periods, we can usually discern some fairly stable and consistent basic policy goals pursued by that country, subject only to minor deviations... Thus in many cases the assumption of rational behavior in the game-theoretical analysis of international politics can be regarded as a legitimate simplifying assumption, at least for the purposes of first approximation.
>
> Indeed, apart from economic life, there are probably few areas of social behavior where rational calculation plays a more important part than it does in international politics. According to common observation, most foreign policy decisions are strongly influenced by weighing the advantages and the disadvantages likely to result from alternative policies; and this fact makes these decisions eminently susceptible to game-theoretical analysis (1966, p. 370-371).

This, of course is a claim that decision makers act more or less as if they are rational. In other words, actual foreign policy decisions are comparable to those that would be made by a rational man. Strategic choice in conflict is viewed in a similar fashion. This way of looking at international relations is so common that it has come to be referred to as the "Classical Model" (Allison, 1971, Chapter 1). Recently however, some doubts about its general utility have been raised. Schell

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raised. Schelling has questioned in a general way whether or not theory and research can progress very far if investigators continue to view the state as isomorphic with an individual (1975). Earlier, in a comprehensive and challenging consideration of a specific crisis, Allison similarly suggested that determinants of national actions in international conflicts are much more complex than the rational actor formulation can model:

> Difficulties arise when the thing to be explained is not the behavior of an individual but rather the behavior of a large organization or even a government. Nations can be reified, but at considerable cost in understanding. By personifying nations, one glides over critical characteristics of behavior where an organization is the main mover--for example, the fact that organizational action requires the coordination of large numbers of individuals, thus necessitating programs and SOPs. Thinking about a nation as if it were a person neglects considerable differences among individual leaders of a government whose positions and power lead them to quite different perceptions and preferences. Thus where the actor is a national government, a conception of action for objectives must be modified. (Perhaps the organizational and political factors could be formulated as "constraints" within which the government actually chooses...) (1971, p. 253-54).

Of course, Allison is not making the claim that the rational man concept has nothing to contribute to the understanding of international conflict. He is asserting however, that the organizational and political factors, represented by Models II and III in the work cited, are much more significant than generally believed, while the rational choice model, on the other hand, has relatively little explanatory power.

In the face of this analysis, it seems important to restate the element in international conflict which has provided the primary impetus for the application of rational choice models. Individuals do make decisions during crisis. They establish goals, consider alternative means of achieving those goals, and estimate the consequences of implementing these means. Such estimates take into account, in principle at least, the goals and means of the other party or parties in the dispute. These deliberations may of course be skilled or inept; they may be well or mis-informed; they may be wise or foolish. But they do take place. Since models of rational choice incorporate assumptions about these elements in conflict-- since, in fact such processes are the essence of ideas about rational decision -- there still appears to be a place for analysis using such techniques. I do not wish to argue that organizational and political aspects are unimportant. Allison's discussion soundly demonstrates their relevance. However, I believe that there are grounds for conceptually relating them to rational decision as limitations upon the scope of the options from which decision makers must choose. This is suggested by Allison himself in the last sentence of the above quotation. Considering them to be constraints in this fashion does not eliminate them from any analysis, nor does it diminish their potential impact on the decisions that are made. However, they can be looked upon as contextual variables which can be held constant in order to facilitate exposition of ideas about the rational structure of conflict.

Specification of The Game Model

There are four basic categories of games, as represented in Figure 1.1 (Lieber, 1971, p. 21).

	Zero Sum	Variable Sum
2 Person	2 Person Zero Sum (e.g. Chess, 2 Hand Poker)	2 Person Variable Sum (e.g. US-USSR Arms Race
N Person	N Person Zero Sum (e.g. Multi-Hand Poker, 3 Person Duel)	N Person Variable Sum (e.g. US-USSR-China Arms Race

Figure 1.1 Four Different Categories of Games

In principle, any one of these categories could be employed in the analysis of international conflict. In practice, there are serious limitations associated with three of them. With respect to the zero sum game, whether 2 person or n person, I shall follow Morton Kaplan:

> It is clear that the zero-sum game--although this is the only completely solved game--is virtually useless for most statecraft problems. The limited character of the zero-sum game is best demonstrated by the fact that the classic models of the zero-sum game, such as poker or bridge or even coin tossing, become non-zero-sum games as soon as utilities are substituted for dollars in the payoff boxes (1964, p. 207-08).

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The n-person games will also be excluded since game theory does not offer very satisfactory ways of dealing with n-person problems,[6] and also because the focus of this paper is upon dyadic interaction processes. Therefore, we are left with the 2 person variable sum game, the main distinguishing characteristic of which is that one player's loss is not necessarily the other's gain. Both may lose. Alternatively, both may gain. Naturally, it is still the case that both seek, on an individual basis, to maximize their individual payoff. This formulation has in fact been most common in game theoretic analyses of international conflict (Lieber, 1972, Chapter 2; Brams, 1975, Chapter 1; Glenn Snyder, 1971). Further restrictions are customarily established on the number of available strategies per player. While in principle two person non-zero sum games could involve any number of strategies, it is usual for two strategies only to exist in the model. There are consequently four possible outcomes in the game model, and the matrix representing the situation will look like Figure 1.2:

		B	
		b_1	b_2
A	a_1	$a_1 b_1$	$a_1 b_2$
	a_2	$a_2 b_1$	$a_2 b_2$

Figure 1.2 Strategies and Outcomes in The Two Person 2x2 Game

The two players are A and B, each with strategies (a_1, a_2) and (b_1, b_2) respectively. Each of the entries in the cells represents a unique consequence of a pair of strategies. As it stands, this matrix is without much meaning. In order for it to be relevant to the analysis of international conflict, the following has to be done:

1. The nature of the strategies must be specified.
2. The character of the consequences of pairs of strategies must be stated.
3. Some means of determining the preferences of the players must be established.

The first two steps are relatively straightforward, and may be illustrated by reference to the U.S. vs U.S.S.R. conflict that took place in terms of the missiles placed in Cuba in the early 1960's. In that conflict, the USSR had established missile sites in Cuba, but had not completed installation or operationalization of the missiles when they were detected by U.S. overflights. The U.S. then brought pressure to bear upon the Soviet Union to remove the missiles. This idea was resisted by the Soviets who argued that, among other things, American missiles should be withdrawn from Turkey as a quid pro quo. Tension mounted, and for a period of 13 days, the ultimate outcome of this conflict was highly uncertain. Brams has modelled this conflict in the following manner:

		Soviet Union	
		Withdraw	Maintain
U.S.	Blockade	Compromise	Soviet Victory
	Air Strike	U.S. Victory	Nucler War

Figure 1.3 Brams Version of The Cuban Missile Crisis (Utilities excluded)

This formulation specifies both the strategies available to the players, and the consequences to be expected from each strategic pair. Thus, if the Soviets had maintained the missiles in Cuba in the face of U.S. demands for removal, and if the U.S. had conducted an air strike to destroy the missiles, the outcome would very likely have been nuclear war. Each of the other cells represents a similarly specific outcome. It is not necessary to accept this particular version of the crisis in order to see the manner in which tasks (1) and (2) can be accomplished.

A more general way of looking at international conflict, in terms of the basic matrix shown in Figure 2, is as follows:

		B: Conciliation	B: Aggression
A	Conciliation	Compromise	Advantage for B
A	Aggression	Advantage for A	War

Figure 1.4 The Basic Model of International Conflict

The argument here is quite simple: If nations behave in a conciliatory manner during conflict, there is a strong likelihood of a peaceful compromise outcome; if both behave aggressively, a violent, warlike outcome will probably result; if one is aggressive while the other is not, the aggressor will gain some advantage.

This is the basic model which will be investigated in this essay. At the moment, in Figure 1.4, it is obviously incomplete. Though the strategies and the consequences are specified, there is no way of knowing how the players will act because their preferences for the outcomes are unknown. The possible range of these preferences is easy to state. Since there are four outcomes, each player has 4! ways in which to rank them so that there are no ties between outcomes. That is, if we think of these outcomes as being most preferred, next most, and so on down to least preferred on a monotone scale, but make no statement as to which will be most preferred, and which

least preferred, and so on, then any ranking is possible. Thus, as stated there are $4! = 24$ ways for each player to arrange them. We have already observed that the decision problem in game theory is an interdependent one. A cannot make a rational choice without taking into account the preferences held by B, and vice versa. Therefore, each player has to consider the way in which his preferences interlock with the preferences of the other. Since each has 24 individual rankings, the total possible interlocking rankings are $24^2 = 576$. This means that, given the matrix in Figure 1.4, there are 576 different ways in which the two players' preferences can be assigned to the outcomes. In other words, there are 576 possible conflict situations that can be modelled by this simple matrix. The possibilities of movement towards a greater understanding of international conflict would be enhanced if it were possible to make a comprehensive statement about these situations. If each of them is, in principle, possible, then analyses which incorporate only a subset of them may be considered ideographically interesting case studies, but they cannot be thought of as nomothetic in any way. In fact, game theoretic studies have considered only two of the 576 situations to any degree. Versions of Chicken and Prisoner's Dilemma[7] have been employed on several occasions, but there has been no attempt to assess the total set. Brams has argued that such an assessment is more or less impossible:

> Obviously, we cannot possibly consider the potential relevance of all of these different games to international relations. Although it would probably be possible to conjure up hypothetical situations that mirror the different rankings of payoffs by the players in many of these very simple games, they would tell us little about their occurrence in reality, how numerical payoffs might be assigned to the different ranks, relationships among the games, and so forth (1975, p. 26).

This statement is probably sound in the absence of any method of organizing the games into meaningful subsets. Brams has observed that Rapoport and Guyer (1966) have developed a classification scheme for reducing the total number of games to 78, but still feels that this is too large a number to be grasped in toto. In fact, it will be shown in Chapter II that the development of behaviorally grounded axioms of preferences with respect to the outcomes in the matrix offer a method of synthesizing the essential elements in the total set of 576 situations, so that comprehensive statements about them can realistically be made. This will be the first major task of this essay. It will be demonstrated in Chapter III that there are a total of only 36 viable situations in inter nation dyadic conflict and that only 21 are unique in all senses. These will constitute a basic taxonomy upon which subsequent analysis will be based. Further synthesis will take place in terms of common properties among the 36 games, and necessary and sufficient conditions for the occurrence of any given outcome will be stated.

The impact of a given outcome on the preferences for outcomes in subsequent conflicts will be considered in Chapter IV. An axiomatic theory of preference transitions will be stated, and each game in the basic taxonomy will be subject to dynamic analysis in terms of this theory. In Chapter V I shall investigate the extent to which deception and misrepresentation of preferences can influence such consequences, and will also consider the impact of such misrepresentation on future conflicts. Chapter VI will be a summary chapter in which the main ideas of the essay will be drawn together.

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ENDNOTES

[1]See for instance, Singer (1968; Rosenau (1969); McClelland; (1970). For an argument that inquiry has focused too much on theory, and too little on research see: *A Design For International Relations Research; Scope, Theory, Methods, and Relevance*. Monograph 10, The American Academy of Political and Social Science.

[2]Tanter and Ullmann (1972), have put together an interesting reader on policy issues.

[3]The lack of theoretical coherence is a common theme in international relations texts. See Brams (1975), p. 6.

[4]The General Solution for this model is as follows:

$$x = \frac{x_o + y_o{}^{et}}{2} + \frac{x_o - y_o{}^{e-t}}{2}$$

$$y = \frac{y_o + x_o{}^{et}}{2} + \frac{y_o - x_o{}^{e-t}}{2}$$

[5]The Seminal work is, of course, Von Neuman and Morgenstern (1947).

[6]See Rapoport (1970) for a comprehensive presentation of n-person theory.

[7]For a discussion of these games and their applications see the following: Rapoport (1966); Snyder (1971); Lieber (1972, Chapter 2); Brams (1975, Chapter 1). Also see Chapter II below.

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CHAPTER II

A STRATEGY FOR TAXONOMIC DEVELOPMENT

In this chapter I wish to examine the way in which the theoretically undifferentiated set of dyadic interaction situations may be reduced from the total of 576 to a smaller, more manageable number. In considering this problem it is important to distinguish at the outset between reductions based solely on properties of the mode of analysis and those based on theoretical and substantive considerations. The former approach focuses on the game representation of the situation and seeks purely game theoretic principles which might identify common elements between otherwise distinct games. In this sense, it is devoid of substantive content. Therefore, in principle, such an approach might be applicable to all substantive situations. It might, for instance, lead to a subset of games which could be considered representative of all situations which can be modelled by games. This would obviously be valuable, since it would mean that all applied analysis could begin with the subset rather than the total. I shall argue in this chapter that, unfortunately, such an approach will not work, and that a method must be sought which takes into account from the beginning the content of the situation being investigated. This implies that initial reduction can take place only in terms of theoretically justifiable interpretations of the substance of the interaction situation. It does not mean, of course, that game theoretic principles derived from the content free analysis of games will never be useful. It will in fact be shown at a later point that elements of such work are directly relevant to the game theoretic stage of this inquiry.

In order to develop this argument in greater depth I shall examine the advantages and disadvantages of the purely game theoretic approach to reduction and will contrast them with the behaviorally based alternative which will be employed in this essay. This requires putting aside for the moment the identification of the conflict situation as international. The set of situations that is being considered may then be represented by the following matrix:

		Player B	
		b_1	b_2
Player A	a_1	a_1b_1	a_1b_2
	a_2	a_2b_1	a_2b_2

Figure 2. 1 The 2x2 Matrix

A and B are the two players; a_1 and a_2 are the two options open to A, while b_1 and b_2 are correspondingly open to B. The outcomes are represented by the combinations of the two sets of options, and each outcome will possess a value to one player which may or may not be identical

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identical to that held by the other. If cardinal utilities were employed to represent these values, then for each player an infinity of such utilities could exist for each outcome, and efforts to classify the infinite set of games which would result would be futile. Consequently, it is necessary to establish at the outset that ordinal preferences will be employed.[1] In addition, I shall assume that preference orderings are strict.[2] This means, of course, that there are no ties in the rankings of either player. Each player can rank the four outcomes in $4! = 24$ ways, and set of games represented by the above matrix therefore totals $24^2 = 576$.

The objective of any taxonomy is of course to reduce this number to subsets which contain the essential features of the whole, or which merit investigation in their own right. A review of the literature reveals one main effort to do this. Rapoport and Guyer (1966) argue that two games may be considered strategically and analytically equivalent if one can be derived from the other by the interchange of (a) columns, (b) rows, (c) players' roles, or (d) any combination of these. Applying this rule to the 576 games, the authors develop a taxonomy comprised of only 78. An example will illustrate their procedure.

Given the matrix in Game 1, Rapoport and Guyer observe that the games shown in Games 2, 3, and 4 are the same game with a switch of rows, columns and both, respectively, and that in each case the solution to the game yields the same payoff to the players. That is, (4, 4) is the payoff throughout (here and subsequently 4 is the highest payoff, 3 the next highest, and so on). Strategically, then it is possible to generalize that B will always play the dominant strategy which pays either (4) or (2), and that consequently A will always play the strategy which yields (4) or (1) knowing that (4) will result.

4, 4	1, 3
3, 2	2, 1

Game 1

3, 2	2, 1
4, 4	1, 3

Game 2

1, 3	4, 4
2, 1	3, 2

Game 3

2, 1	3, 2
1, 3	4, 4

Game 4

Figure 2. 2 A Set of Strategically Equivalent Games

In addition, the authors observe, the roles of the two players in each of these games can be reversed, so that, for instance the matrices in Games la - 4a result. In each case, the outcome is again (4, 4), the only difference being that A is now faced with the strategy choices previously open to B, and vice versa. Thus, the matrix in Game 1 is equivalent to seven additional games (making a total of eight games in this particular subset).

4, 4	2, 3
3, 1	1, 2

Game 1a

3, 1	2, 3
4, 4	1, 2

Game 2a

2, 3	4, 4
1, 2	3, 1

Game 3a

1, 2	3, 1
2, 3	4, 4

Game 4a

Figure 2. 3 The Effects of Role Reversal

Rapoport and Guyer demonstrate that there are 66 games in the total of 576 which, like Game 1, represent a subset of 8 games, and that there are 12 games which represent a subset of 4 (all of these 12 being symmetric). Thus, $(66 \times 8) + (12 \times 4) = 576$, and analytically, it is claimed, the taxonomy thus consists of 78 games. Further analysis can then take place in terms of this subset without loss of significant cases. This argument is sound provided attention is focused upon game theoretic considerations only-- that is, if the preference orderings and the resulting strategic properties of the matrix are the domain of the inquiry. In the eight games set out above for instance, there is no question that the nature of the strategic choices and the consequences (i.e. payoffs) to which they lead are the same in each matrix. However it is important to keep in mind that in any applied work there are substantive and theoretical concerns which exist independent of the analytic technique being employed. Obviously, since these are the objective of the investigation, they are of paramount importance, and must be protected. This is particularly true whenever the analytic technique involves reduction of the universe of inquiry to some subset on the basis of criteria which are themselves part of the technique, but not part of the substance. The danger of course is that substantively or theoretically important information may be irretrievably lost or indefinitely ignored. For instance, each time a game is eliminated from a taxonomy on grounds of analytic redundancy, the substantive situation it represents is also eliminated. The latter however may not be redundant for it is quite possible for two strategically equivalent games to be radically different in a substantive and theoretical sense.

The following discussion is an elaboration of this point. Using Prisoner's Dilemma[3] as the context I shall first of all consider the circumstances under which the idea of strategic equivalence can be employed without theoretical or substantive loss, and will then look at the more general conditions under which it cannot.

The matrix in Game 5 will be recognized as a case of Prisoner's Dilemma. This is a symmetric game, and therefore, in the Rapoport/ Guyer sense, there are three other games that are equivalent(Games 6, 7, 8).

Figure 2.4 contains the four strategically equivalent games. It should be remembered that each of these games corresponds in terms of format to the basic 2x2 game matrix depicted in Figures 1.2 and 2.1.

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3, 3	1, 4
4, 1	2, 2

Game 5

4, 1	2, 2
3, 3	1, 4

Game 6

1, 4	3, 3
2, 2	4, 1

Game 7

2, 2	4, 1
1, 4	3, 3

Game 8

Figure 2.4 Four Strategically Equivalent Versions of Prisoner's Dilemma

Without question, strategic consideration of the preference orderings leads to a predicted payoff of (2, 2) in each case. However, these preferences represent a theory about behavior in a real world situation. Prisoner's Dilemma characterizes the situation in which two suspects have been detained on suspicion of a major crime. There is insufficient evidence for conviction on this major charge but there is adequate evidence of a minor offense. The suspects are separated and each of them is offered a deal. If one confesses while the other does not, the one who confesses will receive a light sentence while the one who does not will receive a very heavy sentence. If both confess, they will each receive a heavy sentence. If neither confesses, they will each receive a moderate sentence for the minor offense. The substance of the game matrix which represents this situation is thus as follows:

		B: No Confession	B: Confession
A	No Confession	Moderate, Moderate	Very Heavy, Light
A	Confession	Light, Very Heavy	Heavy, Heavy

Figure 2.5 The Substance of Prisoner's Dilemma

The association of each outcome in this matrix with a unique pair of strategies represents ideas about the kind of constraints faced by a prosecutor's office and the way the legal system works. As far as the suspects are concerned, the matrix is a given. They cannot influence it, they can only react to it, and their reaction takes the form of assignation of preference orderings to the outcomes. Since each suspect is presumed to have the same set of preferences the matrix is symmetric and looks as follows:

3, 3	1, 4
4, 1	2, 2

Game 9

Though it is rarely stated, the numbers within this matrix embody a theory of preferences with respect to incarceration. The main postulate of this theory is that being out of jail is preferable to being in it. Consequently suspects prefer light sentences to very heavy ones on a monotone scale, and they rank the outcomes accordingly. This leads to the Prisoner's Dilemma, in which both get heavy sentences (2, 2) while being rational, and moderate sentences (3, 3) while being irrational.

Game 9 is identical to Game 5, and so is strategically equivalent to Games 6, 7, and 8. The question to ask now is whether or not Game 9 can serve as an adequate emissary for 6, 7 and 8 in a taxonomy which represents not just a set of games but also the situations which they model. In other words, can Game 9 be considered generally (theoretically, substantively and strategically) equivalent to the others? If not, then it does not make much sense to eliminate them on strategic equivalence grounds only. The answer to the question depends of course on the nature of the situation being modelled by 6, 7 and 8. If it is the same as the situation being modelled by 9, then they can all be considered equivalent, and only one of them need be retained. Let us consider, in the case of Game 6, when this might occur. What would the situation have to be if 6 were to be considered generally equivalent to 9? Clearly it would have to be a case of Prisoner's Dilemma with the same set of constraints (leading to the stated outcomes) and the same theory of preferences (leading to the stated rankings). A simple notational rearrangement can be used to show how Game 6 can fit this requirement:

		B	
		Doesn't Confess	Confess
A	Confess	Light, Very Heavy	Heavy, Heavy
	Doesn't Confess	Moderate, Moderate	Very Heavy, Light

Figure 2.6 A Notational Rearrangement of Prisoner's Dilemma

The only difference between Figure 2.6 and Figure 2.5 is that A's strategies have been switched. In all other respects they are identical. The outcomes associated with any given pair of strategies is the same in both. For instance, (Confess, Doesn't Confess) leads to (Light, Very Heavy). Similarly, in the numerical matrix representing Figure 2.6 (see Game 6) outcomes are ranked identically to those in Game 9. Consequently, everything is preserved. Theory, substance and strategy are all the same in the two games. Putting it another way, the two games represent one situation.

Obviously, this relabelling procedure could be conducted in two additional ways, which would lead to Games 7 and 8. They also would be differently organized representations of the same situation.

Speaking generally then, it is possible to say that when modelling any given situation with a 2x2 two person game, there will be four ways of constructing the matrix if the relevant theory of preferences posits symmetrical rankings (as in Prisoner's Dilemma), and eight ways of constructing it if rankings are asymmetrical (because the reversal of roles leads to four additional notational re-arrangements). Under these circumstances, it is correct, but not very helpful, to observe that only one of the various arrangements of each situation need be kept in a taxonomy.

The critical aspect of the issue can now be addressed. It is or is it not appropriate and useful to argue that Game 9 adequately represents Games 6, 7 and 8 when they are derived from substantively and/or theoretically different situations? An examination of the Prisoner's Dilemma formulation with a different set of preferences for the outcome (i.e. with a different theoretical orientation) will be instructive. Assume, for purposes of illustration, that suspects prefer long sentences to short ones. They like being in prison. Their preference orderings will then be the reverse of those discussed above. Very Heavy sentences, being most desired, will be ranked 4, Heavy will be ranked 3, and so on. These new rankings will of course have no effect upon the consequences of any given action by the suspects. That is, if both confess, both will still receive 'heavy' sentences: if one confesses while the other does not, the confessor will receive a 'light' sentence while the other will receive a 'very heavy' sentence. However, as will now be shown, the restructuring of preference orderings will affect the choice of strategy, and will thereby alter the outcome.

The matrix that represents the new situation is as follows:

		B: Doesn't Confess	B: Confess
A	Doesn't Confess	Moderate, Moderate	Very Heavy, Light
A	Confess	Light, Very Heavy	Heavy, Heavy

Figure 2.7 Prisoner's Dilemma

Nothing has changed here; Figure 2.7 is substantively identical to Figures 2.6 and 2.5. When the new theory of preferences is built in, we get Game 10.

2,2	4,1
1,4	3,3

Game 10

It will immediately be seen that Game 10 is identical numerically to Game 8, and is equivalent strategically to 6, 7 and 9. However since 8 represents the idea that short sentences are preferable to long ones while 10 represents the opposite the rational strategies and the substantive outcome are different. Both confess in 8; neither confesses in 10; both are given heavy sentences in 8; both are given moderate sintences in 10. There is still a dilemma but it focuses on the question of how to avoid short sentences not long ones. Thus, 8 and 10, though strategically equivalent games, are models of substantively and theoretically different situations.

Therefore, the question of whether or not 8 can adequately represent 10, or vice versa, depends on the purposes of the inquiry. If the objective is to investigate and categorize the purely game theoretic elements of the matrices,[4] then strategic equivalence with a game already in the taxonomy will serve as a perfectly satisfactory criterion for rejection of any game. There will be no loss when analysis is conducted. However, if the focus of the inquiry is upon the substantive and theoretical properties of the situation being modelled, rather than upon the technique being used to model it, then it is clear that the elimination of 10 because of the inclusion of 8 will also entail the exclusion of the substantive and theoretical information contained in 10.[5] This is a loss which cannot be tolerated since 10, as well as 8 represents a theoretically viable set of preference orderings for the specified outcomes. In fact, all four strategically equivalent games under consideration (5, 6, 7 and 8) are representations of substantively unique situations, and each of these situations is viable in the absence of theoretical demonstration of non-viability.

Based on the above arguments then, I shall proceed as follows in the development of the taxonomy and the analysis of the findings:

1. A set of substantively and theoretically based constraints upon preference orderings of outcomes will be generated. These will reduce the set of viable international conflict situations quite drastically.

2. This viable subset will then be represented by game matrices which will be analyzed in the customary game theoretic fashion.

3. Further reduction of the subset will take place on the basis of common properties of the game matrices. Some of these properties will be similar to those developed by Rapoport and Guyer while others will be quite different.

4. The implications of the above analysis for dyadic international conflict will then be considered.

ENDNOTES

[1]This can, and at a later point will, be justified on grounds other than expediency. See below, p. 49.

[2]Rapoport and Guyer (1966) make the same assumption. For a comment on the effect of relaxing permitting indifference between outcomes see Guyer and Hamburger (1968).

[3]For extended analysis of Prisoner's Dilemma, see Rapoport and Chammah (1965).

[4]It should be stressed that this is precisely the case in the article by Rapoport and Guyer. Their analysis is purely game theoretic and is without substantive content. Thus, the question of whether or not the 78 game taxonomy can serve as a beginning point for applied analysis is not specifically considered by them.

[5]Obviously it would be possible to retain this information if, for instance, two taxonomies were maintained side by side. One could represent the strategically unique set of games defined by Rapoport and Guyer while the other could represent the situations that were theoretically and substantively relevant. The point of the present argument of course is that in applied analysis the latter procedure is necessary while the former is not.

CHAPTER III

A TAXONOMY OF DYADIC INTERNATIONAL CONFLICT SITUATIONS

My objective in this chapter is to develop a taxonomy of two person, two strategy games which will realistically approach a systematized paradigm of conflict interaction between two nations. There will be four sections:

1. Axioms of Preference

It will be argued here that general principles about the way in which nations rank outcomes can be developed, and that any preference set out of the total of 24 which is inconsistent with them can be eliminated from consideration.

2. Admissible Preference Orderings

Based on the axioms developed in Section 1, it will be possible to specify the set of viable preference orderings for the four outcomes. Each nation will be considered to operate under the same set of axiomatic constraints, and therefore the set of preference orderings for one nation will be the mirror image of the set attributed to the other.

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3. Statement of the Taxonomy

When each admissible ranking of outcomes by one nation is associated with each ranking by the other in game matrix form, the set of games which results will comprise the basic taxonomy. This will be presented in full.

4. Analysis of the Taxonomy

The primary emphasis here will be on the nature of the outcome that can be expected rather than on the elements of strategic choice that are present in the various games. Naturally, determinants of choice will be established in order that outcomes can be specified.

Axioms of Preference

In Chapter I the model of conflict being employed in this essay was specified as follows:

		Nation B	
		Conciliation	Aggression
Nation A	Conciliation	Compromise (C)	Advantage to B (B*)
	Aggression	Advantage to A (A*)	War (W)

Figure 3.1 The Substance of The Conflict Situation

In the notation that will be used hereafter, these strategies and outcomes may be characterized by the following matrix:

		B	
		b_1	b_2
A	a_1	$a_1 b_1$	$a_1 b_2$
	a_2	$a_2 b_1$	$a_2 b_2$

Figure 3.2 Strategies and Outcomes

In order to transform these characterizations into games, payoff utilities must be assigned to the various outcomes. As stated earlier, ordinal rather than cardinal preferences will be employed throughout. This facilitates analysis without loss of generality,[1] and is in addition a more realistic representation of the substantive situation being modelled. It is difficult for example to see any basis for the development of interval utilities with respect to any of the four outcomes depicted in Figure 3.1, but it is easy to see how one of them could be clearly preferable by some unspecified amount to another. In a confrontation with the United States, for instance, Cuba might very well prefer Compromise to War by a clear margin, and yet be unable to state the size of that preference in anything but ordinal terms. I would argue that this is the norm in international conflict.

Following the usual procedure the most desired outcome will be assigned the highest payoff, the next most desired will be assigned the second highest, etc.. With four outcomes, the preferences will be 4, 3, 2, 1, respectively.

It will also be assumed that preference orderings are strict - neither A nor B is indifferent to any two outcomes.[2]

It should be noted at this point that Figure 3.2 corresponds directly to the conflict matrix in Figure 3.1. A's strategies a_1 and a_2 represent conciliation and aggression respectively. For B, b_1 and b_2 are similar representations. Therefore, $a_1 b_1$ corresponds to the compromise outcome, abbreviated as C; $a_2 b_1$ corresponds to Advantage to A, abbreviated as A*; and so on.

It should also be noted that all matrices and games will be organized this way. The first strategy will always be conciliation, the second strategy will always be aggression. The outcomes will always be compromise if $a_1 b_1$ are the strategies, war if $a_2 b_2$ are the strategies, and so on. This means that the substantive matrix (Figure 3.1) will be constant and that all games will correspond directly to it. Thus if a game is shown in which A and B rank outcome $a_1 b_2$ as (1, 4) respectively it can be assumed, even if it is not explicitly stated, that A ranks B* as least preferable (1) while B ranks B* as most preferable (2).

As was observed earlier each nation has 4! = 24 ways in which to rank order the four outcomes. In principle, therefore, it is possible to have $24^2 = 576$ unique conflict situations. This is quite a large number--too large in fact to comprise a useful taxonomy. However, it is clear that all of them must be accounted for if the taxono

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taxonomy is to be useful. Fortunately, reduction is possible through the imposition of constraints derived from the situation being modelled. If there exist certain preference rankings of the four outcomes which can be argued to be inadmissible in an international conflict, then clearly those games which incorporate such rankings can be eliminated from consideration. The following three axioms provide a basis for such elimination.[3]

> Axiom 1: For A, A* will be preferred at all times to B*. For B, the reverse will be true.

This is simply saying that no rational nation will prefer defeat to victory, no matter what the conflict situation. Thus, when the United States and the Soviet Union are in conflict each ranks its own advantage higher than it ranks the advantage of the other, when those are two distinct outcomes, as they are in the model being employed in this discussion.

> Axiom 2: If A ranks W higher than A* then A will rank W and A* higher than C. Similarly, for B, when W is preferable to B*, then W and B* are preferable to C.

In many situations, immediate gain will be preferable to War. War is a risky undertaking, the consequences of which are difficult to predict, particularly if antagonists are approximately equal in strength. Thus there are no guarantees that war will lead to ultimate gain. For these reasons, it is tempting to argue that, for A, A* will always be preferable to W, while for B, B* will be preferable to W.

However, this would be inappropriate as a general principle for the following reasons. First, it may be argued that under some circumstances decision-makers would rather seek total dominance with some risk than more moderate gain with certainty. Second, it is possible that either party may wish to appear committed to war in order to intimidate the other. Thus, the idea that war is preferable to advantage is a plausible construction, and should be incorporated into the taxonomy.

Moreover, if this is the situation for either nation, then it makes sense to argue that both the potential gain from W and the more moderate gain from Advantage will be preferred to Compromise. The motive for war is, presumably, gain, and so gain of any kind must outrank compromise, which offers no gain at all.

> Axiom 3: For A, C is preferred to B*. For B, C is preferred to A*.

The compromise outcome to any conflict is better than a defeat, since the compromise at least maintains relative position. A defeat on the other hand involves relative loss.

These three axioms comprise the theory of preferences in inter-nation conflict which will be used as the basis for developing the taxonomy of games.

Admissible Preference Orderings

Based on the behavioral principles just developed, it will now be possible to specify the admissible set of preference orderings for nations in conflict. The precise number of orderings in this set will determine the total number of games in the resulting taxonomy. For instance, if each nation had ten admissible preference orderings, the total number of possible games would be 100. If there were five admissible orderings, the total number of games would be 25.

At this stage of the inquiry, it is possible to introduce one element of the notion of strategic equivalence used by Rapoport and Guyer. It is apparent that the set of preference orderings which is admissible for one nation is the same as that which is admissible for the other except that the positions of the two nations will be reversed. For instance, if it is admissible for nation A to rank the outcomes (C, A*, B*, W) as (4, 3, 2, 1) respectively, then there will exist in the set of rankings by B an ordering of (C, B*, A*, W) as (4, 3, 2, 1) respectively. The two rankings are of course the same except that the roles of the two players are reversed. This situation will exist for every ordering in the two sets, and one set will be the mirror image of the other.

When rankings from one set are combined with rankings from the other to form game matrices, it will be found that there are symmetric and non-symmetric games. Symmetric games will be

formed when a ranking is combined with its mirror image. The example just used for instance will form the following game:

4,4	2,3
3,2	1,1

Game 11

There will be as many symmetric games in the taxonomy as there are admissible preference orderings in a single set. These games will be unique in the sense that no other game that is derived from the two sets will be equivalent in the Rapoport sense. However, when a game is formed by combining a preference ordering from one set with a non-mirror image ordering from the other, a non-symmetric game will result. For instance, consider the game in which A ranks (C, A*, B*, W) as (4, 3, 2, 1), while B ranks (C, B*, A*, W) as (4, 3, 1, 2). In other words, in this case, B would rather go to war than yield an advantage to A. The matrix is:

4,4	2,3
3,1	1,2

Game 12

This is non-symmetric. In addition, it is not unique since there is a game in the taxonomy which is equivalent strategically except that the roles of the players are reversed. The equivalent game is the one in which the preference ordering by A is the mirror image of B's ordering in the game just mentioned, and vice-versa. The resulting matrix for the new but equivalent game is therefore:

4, 4	1, 3
3, 2	2, 1

Game 13

Analysis of game 12 is straightforward. A has a dominant strategy (a_1), and so plays it. B, knowing this, in turn plays b_1, and the payoff is (4, 4). Analysis of Game 13 is identical except that A is not in B's position and vice versa, so that B has the dominant strategy, while A chooses on the basis of B's predicted play. The two games are equivalent except for the reversal of roles.

On the basis of the preceeding discussion, it may be observed that each non-symmetric game in the taxonomy will be strategically equivalent to one other non-symmetric game also in the taxonomy, and that an analysis of one is tantamount to an analysis of the other. In addition, it should be noted, the two games are substantively and

theoretically equivalent. The outcome in both is the same except that roles are reversed, and of course the theory of preferences upon which they are based is identical. Therefore the criteria of general equivalence are satisfied, and there is no loss if the total number of non-symmetric games is halved in this fashion.

The following general rule may now be stated: the total number of games in the taxonomy will equal the number of symmetric games plus one half the number of non-symmetric games. If, for instance, there are ten admissible preference orderings for each nation, resulting in a grand total of 100 games, then 10 of these will be symmetric and unique, while 90 will be non-symmetric. From the point of view of analytic parsimony, the taxonomy may thus be considered to consist of 55 games.

From the nature of the constraints established by the axioms, it is clear that for any given nation, let us say A, each outcome in the matrix can be assigned some but not all preference rankings. The admissible permutations for A and B may be specified as follows:

	For Nation A						For Nation B					
	P1	P2	P3	P4	P5	P6	P1	P2	P3	P4	P5	P6
4	C	C	A*	A*	A*	W	C	C	B*	B*	B*	W
3	A*	A*	C	C	W	A*	B*	B*	C	C	W	B*
2	B*	W	B*	W	C	C	A*	W	A*	W	C	C
1	W	B*	W	B*	B*	B*	W	A*	W	A*	A*	A*

Figure 3.3 Admissible Preference Orderings

In other words, of the 24 possible arrangements of preferences of the four outcomes, only six (for each nation) satisfy the axioms stated above. Since each ranking by one nation can be coupled with each ranking by the other there are therefore $6^2 = 36$ possible interaction situations. Further reduction is now possible on the basis of the role reversal concept discussed at the beginning of this section. It may be observed that the table for B is the same as the table for A execpt that the positions of A* and B* are switched. For notational convenience, the first column of Table A will be identified as P1(A), and the second as P2(A), and so on. Similarly, Table B will be referred to by P1(B), P2(B), etc.. Obviously, when P1(A) is matched with P1(B) the resulting situation will be symmetric. In terms of these preference rankings it will also be unique in game theoretic terms - that is, there will be no other equivalent game, even if the positions of A and B are allowed to switch (each assumes the preference ordering of the other). Such a reversal of positions yields exactly the same game when the matrix is symmetric. There are six symmetric games which can be derived from the tables. These consist of the preference orderings of the two first columns P1(A), P1(B), the two second columns P2(A), P2(B), and so on down to the two sixth columns. The remaining 30 games are of course non-symmetrical, and from the general rule stated above these contain two sets of fifteen, each set being the mirror image of the other. One of the sets can be eliminated since they are generally not just strategically, equivalent. The taxonomy may now be stated.

Statement of The Taxonomy

GAME 1

P1(A), P1(B)

4, 4	2, 3
3, 2	1, 1

Symmetric. Therefore no equivalent game exists

GAME 2

P1(A), P2(B)

4, 4	2, 3
3, 1	1, 2

Equivalent to P2(A), P1(B)

GAME 3

P1(A), P4(B)

4, 3	2, 4
3, 2	1, 1

Equivalent to P3(A), P1(B)

GAME 4

P1(A), P4(B)

4, 3	2, 4
3, 1	1, 2

Equivalent to P4(A), P1(B)

Figure 3.4 The Basic Taxonomy

GAME 5

P1(A), P5(B)

4, 2	2, 4
3, 1	1, 3

Equivalent to P5(A), P1(B)

GAME 6

P2(A), P2(B)

4, 4	1, 3
3, 1	2, 2

Symmetric

GAME 7

P2(A), P3(B)

4, 3	1, 4
3, 2	2, 1

Equivalent to P3(A), P2(B)

GAME 8

P2(A), P4(B)

4, 3	1, 4
3, 1	2, 2

Equivalent to P4(A), P2(B)

GAME 9

P2(A), P5(B)

4, 2	1, 4
3, 1	2, 3

Equivalent to P5(A), P2(B)

Figure 3.4 (continued)

GAME 10

P3(A), P3(B)

3, 3	2, 4
4, 2	1, 1

Symmetric

GAME 11

P3(A), P4(B)

3, 3	2, 4
4, 1	1, 2

Equivalent to P4(A), P3(B)

GAME 12

P3(A), P5(B)

3, 2	2, 4
4, 1	1, 3

Equivalent to P5(A), P3(B)

GAME 13

P4(A), P4(B)

3, 3	1, 4
4, 1	2, 2

Symmetric

GAME 14

P4(A), P5(B)

3, 2	1, 4
4, 1	2, 3

Equivalent to P5(A), P4(B)

Figure 3.4 (continued)

GAME 15

P5(A), P5(B)

2, 2	1, 4
4, 1	3, 3

Symmetric

GAME 16

2, 2	1, 3
3, 1	4, 4

Symmetric

GAME 17

3, 2	2, 3
4, 1	1, 4

Equivalent to P6(A), P 3(B)

GAME 18

3, 2	1, 3
4, 1	2, 4

Equivalent to P6(A), P4(B)

GAME 19

2, 2	1, 3
4, 1	3, 4

Equivalent to P6(A), P5(B)

Figure 3.4 (continued)

GAME 20

4, 2	2, 3
3, 1	1, 4

Equivalent to P6(A), P1(B)

GAME 21

4, 2	1, 3
3, 1	2, 4

Equivalent to P6(A), P2(B)

Figure 3.4 (continued)

Note: In subsequent discussions, games will be referenced by their number in this taxonomy, e.g. Game 1, or Game 2, etc.. The equivalent game will be referenced by the number plus an E, e.g. 2E, 3E, etc..

Preliminary Analysis of the Taxonomy

The next step is to undertake a classification of games within the taxonomy. This might be done on the basis of whether or not games had solutions, involved paradoxes, had no solutions at all, and so forth. However, since the taxonomy is associated directly with international conflict, greater light might be shed on the nature of that conflict if the classifications grouped those games which led to a particular outcome. This would permit an examination of each group for common characteristics, and might suggest some general statements about the logic of conflict. This is the course that will be followed here.

In order to classify the games in terms of the outcomes to which they lead, it is first necessary to specify decision rules for strategic choice. The only assumption needed at this stage is that a dominating strategy will be chosen if it exists. This is defined as that strategy which yields a more preferred outcome than the other strategy, no matter what the other player does. If both players have such strategies, the outcome will be clearly specified. If only one has a dominating strategy, the effect is to reduce the game to a 1x2 matrix, in which the player without a dominating strategy can choose a higher or lower payoff. He will obviously choose the higher of the two, and this will lead to an equilibrium position where neither player can improve unilaterally. These games will be considered stable. If neither player has a dominating strategy, the game will be considered unstable. Additional comments will be made about unstable games at a later point.

Since there are four outcomes, it is at least in principle possible that there will be four groups of games, each group leading to one of the outcomes. In practice, as will be shown, there are no symmetric games which lead to an advantage for one player or the other. This means that for every game which leads to an advantage for A, there is a generally equivalent game which leads to an advantage for B. Since it would be redundant to analyze both groups, only those which lead to an advantage for B will be enumerated.

Therefore there will be three groups of games leading to determinate outcomes, and one group of unstable games.

Games That Lead to War

4, 3	1, 4
3, 1	2, 2

8

4, 2	1, 4
3, 1	2, 3

9

3, 3	1, 4
4, 1	2, 2

13

3, 2	1, 4
4, 1	2, 3

14

2, 2	1, 4
4, 1	3, 3

15

2, 2	1, 3
3, 1	4, 4

16

3, 2	1, 3
4, 1	2, 4

18

2, 2	1, 3
4, 1	3, 4

19

4, 2	1, 3
3, 1	2, 4

21

Figure 3.5 Classification of Games by Outcome

Games That Lead to Advantage For One of The Players (B)

4, 3	2, 4
3, 2	1, 1

3

4, 3	2, 4
3, 1	1, 2

4

4, 2	2, 4
3, 1	1, 3

5

3, 3	2, 4
4, 1	1, 2

11

3, 2	2, 4
4, 1	1, 3

12

3, 2	2, 3
4, 1	1, 4

17

4, 2	2, 3
3, 1	1, 4

20

Games That Lead to Compromise

4, 4	2, 3
3, 2	1, 1

1

4, 4	3, 2
3, 1	1, 2

2

4, 4	1, 3
3, 1	2, 2

6

Figure 3.5 (continued)

Unstabel Games With Cyclical Tendencies

4, 3	1, 4
3, 2	2, 1

7

3, 3	2, 4
4, 2	1, 1

10

Figure 3. 5 (continued)

General Principles Summarizing the Taxonomy

During international crisis it is common for information about the respective positions of the adversaries to be scarce. Frequently, only limited pieces of evidence about attitudes and preferences are available. Under these circumstances it would be helpful if inferences about outcomes could be made on the basis of these limited data. The problem of course is that such inferences are difficult to generate in the absence of general principles of conflict and crisis interaction. While there do not appear to be any satisfactory theories which would supply such principles, it is possible when examining a taxonomy such as the one just presented to search inductively for patterns within those games that lead to a particular outcome. This will not generate theory, but it may provide some basis for predictions of outcomes even if preferences for all outcomes are not known. I have therefore derived from the taxonomy necessary and/or sufficient conditions for the occurrence of each outcome. The preferences that are excluded from the following matrices are irrelevant to the outcome.

Conditions Under Which War Occurs

War is inevitable if securing an advantage is most desired by one player while yielding an advantage is least desired for both players. In matrix form then the sufficient conditions for war are as follows:

-, -	1, 4
-, 1	-, -

or

-, -	1, -
4, 1	-, -

Figure 3.6 Sufficient Conditions For The Occurrence of War

In order for war to be the outcome, yielding an advantage to the other must be the least preferred outcome for both players. The necessary conditions for war are therefore as follows:

Either

-, -	1, -
1, -	-, -

or

-, -	1, -
-, 1	-, -

Figure 3.7 Necessary Conditions For War

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It may be noted that the necessary conditions is also sufficient in all situations except Game 6, which is unstable.

Conditions For Avoiding War

In stable games, war is always avoided if it is the least preferred outcome for at least one player; however, it cannot be avoided if it is least preferred by neither.

Either

-, -	-, -
-, -	1, -

or

-, -	-, -
-, -	-, 1

Figure 3.8 Necessary And Sufficient Conditions For The Avoidance of War in Stable Games

Games 7 and 10, which are both unstable, cannot be included in this generalization because war is possible as part of the cyclical pattern of outcomes that is typical of such games, even though it is least preferred by one or both of the players. This violates the sufficiency condition for avoidance. Game 6 violates the necessary condition in that neither player ranks war as least preferred, and yet war does not occur because of the prominence of the compromise outcome.

Conditions Under Which Compromise Will Result

Compromise will occur whenever it is the most preferred outcome for both players. It never occurs if this condition is violated.

4, 4	-, -
-, -	-, -

Figure 3.9 Necessary And Sufficient Conditions For Compromise

As noted earlier, three games lead to compromise. Games 1 and 2 lead to a stable compromise in which both players achieve their most desired outcome, and therefore this outcome is in equilibrium as long as the preferences do not change. This situation is probably characterized by the kind of interaction that takes place between allies (England and the United States for instance), where disputes may arise, but where the idea of going to war to resolve them is relatively distasteful to both. Game 6 differs from 1 and 2 in the sense that it is unstable. That is, neither player has a dominating strategy. It is included in the "compromise" category because compromise is a pareto-optimal outcome which is in equilibrium. This means that there is no other outcome which yields better payoffs for both players (Rapoport and Guyer, 1966, p. 205), and that neither has any unilateral incentive to be aggressive.

It has been strongly argued by more than one analyst that the "prominent" nature of this outcome makes it an overwhelmingly probable occurrence (Deutsch, 1966, Chapter 4; Rapoport, 1966, p. 128; Schelling, Chapter 4 and Appendix C).

These three are the only games in the taxonomy in which both players value compromise most highly. It might be argued of course that they are not significant games of conflict. Their inclusion is, however, required by the formal constraints of the taxonomy, and because it is worth knowing the preference structures which must exist if compromise is to be a prossible outcome of dyadic interaction.

Conditions Which Yield an Advantage to One Player (B)

In order for any player (let us say, B) to obtain an advantage, the other player (A) must rank war as the least important outcome. Advantage to B is inevitable, given this condition, whenever B ranks advantage higher than compromise.

-, -	-, -
-, -	1, -

Figure 3.10 Necessary Conditions For a Player to Obtain an Advantage

Let X and Y be B's preferences for C and B* respectively. Then the conditions sufficient to yield B an advantage are as follows:

-, X	-, Y
-, -	1, -

Where X is smaller than Y

Figure 3. 11 Sufficient Conditions For a Player to Obtain an Advantage

Naturally there is a mirror image situation which leads to an advantage for A.

<u>Conditions For Unstable Games</u>

These are distinguished from all other games in the taxonomy by the fact that both players have a pure strategy at their disposal which contains their most and least preferred outcomes. Game 10 is of course recognizable as a version of Chicken. I shall not go into the specifics of the analysis of this game here, except to say that without co-operation and trust, it is difficult to see how any single outcome can be predicted.[4] This is particularly true if the possibility of an iterated game is ruled out, as it may be in many international conflict situations. The same kind of observation may be made about Game 7, which contains much of the character of Chicken, but in somewhat less virulent form. It should be noted that in both of these games, Compromise is a Pareto-optimal outcome (since there is no other outcome which is more preferred by both), as it was in Game 6. However, this does not help since Compromise is not in equilibrium.

One of the players (Game 7) or both (Game 10) have a strong incentive to think in terms of an aggressive strategy in the hope that the other will be conciliatory. If iterated, these games are likely to be cyclical.

So far I have said nothing about the notion of security level, and the effect this might have on these unstable games. In the sense that this concept is dependent upon the calculation of mixed strategies, it is not applicable when preferences are ordinal (Rapoport and Guyer, 1966, p. 205). However, it is plausible to think of nations minimizing their maximum loss. Strategically, this simply means avoiding the least desirable outcome. If this decision rule is applied when no dominating strategy exists, then Game 7 will lead to an advantage for A (a_2b_1), and 10 will lead to compromise (a_1b_1). There is of course a game, 7E which leads to an advantage for B. This is not a very satisfactory way of dismissing the complexities that exist in these games, since the dilemma posed by the threat of unilateral defection by one or the other is still present in all but 6. In 7 for instance, avoiding the worst outcome leads to an advantage for A. Curiously, both players are better off if A relinquishes his advantage by choosing the strategy which contains the status quo. However, if A is going to choose that strategy, B may as well choose his second strategy which contains his most preferred outcome, etc., etc.. Thus, the idea of minimizing loss does not eliminate complexity. As in Chicken, players in this game tend to oscillate from one outcome to another if the game is iterated. If they are involved in a single play, it is once again difficult to predict any outcome.

The clear value of the necessary and sufficient conditions which have just been established lies in the reduction of a somewhat large set of information to a much smaller statement of principles. This specifies the parameters which must be known for predictions of outcomes to be confident, and also permits some interesting observations about the general structure of international conflict.

For, instance, given that the Axioms of Preference are reasonably isomorphic with decision-maker's options, it is easy to see why the peaceful resolution of conflict is so difficult to achieve. Compromise is never a consequence of rational choice unless it is the most desired outcome for both players. This suggests that the hard line position with respect to unilateral conciliatory moves may be correct. They do not lead to a peaceful status quo unless the other party is already committed to conciliation. To expand upon this, let us assume that communication is possible and that A, preferring compromise to all other outcomes, wishes to induce conciliation in B. Even if A can give ironclad guarantees, or can effectively pre-commit (which amounts to the same thing), there are <u>no</u> situations in which it is rational for B to make a conciliatory move, unless B is already predisposed to conciliation on the basis of a most preferred ranking for compromise. This is so, even if A moves first and is unilaterally conciliatory. Therefore, such efforts by A are a waste of time. Furthermore, the nation which prefers compromise above all other outcomes is at a disadvantage in the vast preponderance of conflict situations. In every instance, either an advantage must be yielded to the other or war must break out. There are no alternatives.

This is a bit disheartening if one is committed to the philosophical position that peaceful solutions are on the whole superior to violent ones in terms of the impact they each have on our daily lives. Consolation may be drawn from the observation that, even if peace is difficult to achieve, war is relatively easy to avoid, since it never occurs when it is the least preferred outcome for either player. Of course, the nation for which it is least preferred frequently ends up on the wrong end of a relative power shift. This implies that power loss tends to occur for nations which are unwilling or reluctant to fight to avoid it. Thus, the cost of avoiding war may be subordination when the opponent is in an aggressive frame of mind.

One final point can be made. In this model, war appears to be a product of the fear that is built into the preference axioms. A sufficient condition for war (in all cases except Game 6, which is unstable) is the desire to prevent the other from getting ahead. This is manifested by the least preferred ranking assigned by each nation to the advantage of the other in every instance where war is the

outcome. It is not necessarily the case that each nation ranks its own advantage highly, and that this 'traps' the two nations into war, though this situation does arise in many games. In some cases compromise is preferred to advantage by at least one of the nations (see Games 8, 9, and 21 for instance), and even more frequently both compromise and advantage are ranked higher than war (see the games just cited, plus 13, 14, and 18). However, these are not critical determinants. What is critical is the attitude toward the position of the other. This kind of consequence of the model is probably consistent with the Balance of Power idea, which suggests that nations are willing, in a multi-polar world, to go to war in order to prevent a shift in the balance. In the present model, an assumption of equi-potency (i.e. bi-polar balance) has been made, and Axioms of Preference have been developed accordingly. This can be viewed as a special case of the multi-polar situation, and the distaste with which each pole views the relative progress of the other may be seen as reluctance to tolerate an imbalanced condition.

Empirically, of course, international conflict is much more complex than the simplifying assumptions of this model, and there are some quite obvious shortcomings which it would be desirable to correct. One of these involves the notion of change. The above discussions have proceeded as if international conflict is conducted by single simultaneous declarations of either conciliation or aggression, accompanied by appropriate actions. Clearly, this is not the case.

Conflict does not end in this fashion, except perhaps when war breaks out. Therefore, it would be useful to consider what happens over time. One way in which this can be approached is to investigate logically the impact of a given outcome in a given game on the future relations of the two opponents. This will be undertaken in Chapter 4. A second problem with the present formulation is that it assumes perfect information. I have shown that one part of this perfection - complete information - is not necessary for understanding the structure of conflict, but it is still the case that information is assumed to be correct. Obviously, this is heroic. The source of most information about preference positions relative to the conflict is the nation itself, and it is obviously a simple matter for nations to misrepresent their position if it seems in their interest to do so. Consequently, I shall explore this issue in Chapter 5.

ENDNOTES

[1]Consider, for example, a Prisoner's Dilemma matrix expressed in ordinal preference terms:

3, 3	1, 4
4, 1	2, 2

Obviously there is an infinite number of interval scale utilities that can be assigned to each outcome for each player without disturbing the relative position of the rankings. Yet it is precisely the relative position that determines the character of the game.

[2]These assumptions are consistent with those made by Rapoport and Guyer, op. cit.. For an examination of their basic approach under conditions of weak preference orderings see Melvin Guyer and Henry Hamburger (1968, pp. 205-208).

[3]Some comparisons can be drawn between these axioms and Morton Kaplau's "rules" of behavior for actors in the international system. Rule 1 of the 'Balance of Power' System, for instance, states that actors will "act to increase capabilities but negotiate rather than fight" (1964, p. 23). Similarly, Rule 3 of the 'loose bipolar' system states that "all bloc actors are to increase their capabilities in relation to those of the opposing bloc" (1964, p. 38). These rules are comparable in spirit to Axiom 1. However, the Axioms of Preference do not directly correspond to Kaplan's rules. The latter are considerably more restrictive and numerous than the former, and, of course, approach the issue from a systems rather than a game theoretic viewpoint.

[4]For an extended discussion of chicken, see Rapoport (1966, pp. 138-144).

CHAPTER IV

THE INTRODUCTION OF DYNAMIC PROCESSES

It is difficult for game theory to deal with the elements of time and change. From its inception it has been considered a technique of analysis for static situations. Von Neumann and Morgenstern have themselves made this clear:

> We repeat most emphatically that out theory is thoroughly static...a static theory deals with equilibria. The essential characteristic of an equilibrium is that it has no tendency to change... (1947, p. 23).

In spite of this, it must be acknowledged that the social conflict problems upon which game theory is focused are themselves imbued with dynamic properties. Von Neumann and Morgenstern were of course aware of this and did not consider their 'static' theory to be any more than the forerunner of a dynamic theory which would incorporate much more of the intricacy of the substantive conflict situation. To date, the dynamic theory has not appeared. Nevertheless, some work has been done on the question of whether or not changes from one confrontation to the next can be meaningfully represented by the game model. Karl Deutsch has observed:

> An interesting development of game theory toward the analysis of dynamic processes is being carried forward by developing sequences of games,

> such that the outcome of the first game might determine the nature of the next game to be played. A change of rules following a certain outcome of the first play of a game would have the same effect, since any significant rule change similarly could be considered to turn the subsequent play into a new game. Certain learning processes could thus be pictured as sequences of games in which one or several players would learn to change their utility functions, that is, the values they put on each of the various possible outcomes of the game, and they thus would change the corresponding portions of the payoff matrix where the values of all outcomes for all players are recorded. Alternatively, certain moves in a game might be taken as leading to changes in those rules of the game that limit the capabilities of the players; thus by the transition to successor games in which one or more of the players were less closely limited in their range of choices, the acquisition of new resources or the learning of new skills could be simulated (1966, pp. 58-59).

Efforts to implement the kind of ideas which Deutsch mentions have for the most part focused upon the impact which a given payoff might have on future strategy choices in an iterated situation. Luce and Raiffa for instance, have analyzed in some depth the logical problems faced by players under sequentially compounded--that is, temporally repeated--games, dividing such games into four distinct classes:

> The central ideas are these: In one class of games (recursive and stochastic) a normalized game is played at each stage, and the player's strategies control not only the (monetary) payoff but also the transition probabilities which govern the game to be played at the next stage. In another class (survival and attrition games) there is but one component game and it is repeated. The players have limited initial resources, and these fluctuate in time according to the outcomes of repeated plays of the given game. In still another class (compounded decision problems) a given game is repeated, and each player attempts to control the

> average payoff by exploiting the statistical records of his adversary's previous choices. The final class (economic ruin games)...is typified by the problem of corporated dividend policy: The more generous the dividend policy of the corporation, the less secure it is against future exigencies; however, in opposition to this platitude is the truth, imposed by interest rates, that a dollar today is worth more than the present value of a dollar to be delivered in the future (1957, pp. 457-458).

Intuitively, the survival and attrition category is perhaps closest to the international conflict situation that is being modelled in this essay. The notion that a given outcome alters the available resources of the players seems to match the idea that nations compete for gain (not necessarily economic) and that a victory adjusts power relations favorably for one, unfavorably for the other. It is more difficult, however, to feel comfortable with the requirement that there be but one component game. This is not because there are many possible situations in international conflict, for this is not denied by the idea of a single game if the simplifying assumption is made that nations are involved in only one conflict with a given opponent at any one time. It is because this one situation is not likely to be constant over time. In other words the idea of the iterated game seems to have limited applicability in international relations. It would appear to be inevitable that whenever one of the four basic consequences occurs, this in itself will influence the characteristics of the ensuing situation. For instance, let us assume the Nation A attempts to achieve a compromise in a conflict which maintains the status quo with Nation B but that B behaves aggressively and consequently seizes an advantage. Is it not probable that this will affect A's preferences for the outcomes in subsequent conflicts? If so, then the game will have changed. This, of course, is precisely the point raised by Deutsch, and, substantively, is more challenging and interesting than the application of an iterated game construction.

An approach which is analagous to the Luce and Raiffa discussion of compounded decision games, is taken by Rapoport (1966, Chapter 10), who develops the concept of conditional propensity with respect to strategic choice during iterated plays. Rapoport's primary concern here is with the paradoxical nature of Prisoner's Dilemma. As observed previously, rational players in this game do not fare as well as those who are jointly irrational. By applying conditional rather than absolute choice criteria, Rapoport seeks to demonstrate that the jointly undominated outcome can be achieved by more or less rational means. Conditional criteria are based upon previous outcomes. Thus, the second time a game is played, a given strategy will be repeated if it led to a 'good' outcome. Consider, for instance, the following special version of Prisoner's Dilemma, in which players are considered to be automata, and initial strategies are chosen at random.

A 'good' outcome is defined by Rapoport as a positive payoff, while a 'bad' outcome is defined as a negative payoff. Consequently, if a_1, b_1 were the strategies for A, B respectively in the first game,

5, 5	-10, 10
10, -10	-5, -5

Figure 4.1 Rapoport's Special Instance of Prisoner's Dilemma

the payoff would be (5, 5). Since this is positive for both, the same strategies would be chosen indefinitely. If a_2, b_2 were chosen, the payoff would be negative, and on the second play both would switch to first strategies, and would continue them since a positive payoff would occur. If initial strategies were a_1, b_2 or a_2, b_1, then the player employing the first strategy would get a negative payoff and would switch for the second game. Each wo uld then get a negative payoff, and both would switch for the third game, thus obtaining a positive payoff. At that point, first strategies would be consistently employed since there would be no incentive to switch.

Thus, on the basis of this analysis, it is Rapoport's claim that, given iterated plays, and conditional criteria of strategic choice, the (5, 5) outcome can be rationally reached even in the situation where absolute criteria of unilateral decision would lead to (-5, -5). He then demonstrated that the (5, 5) outcome is not a stable equilibrium when players select strategies based upon the problem of independently maximizing individual payoffs, even when conditional propensities are employed.

> Roughly, this model...leads to a conclusion that if initially the tendency of the players to 'stick' with the (a_1, b_1) outcome is sufficiently large, it will become still larger until (a_1, b_1) outcomes occur exclusively. But if the initial tendency to stick with (a_1, b_1) is not sufficiently large, it will become still smaller. Interpreted psychologically, this can be stated so: trust begets trust; distrust begets distrust (p. 157).

There is a good deal of appeal in this approach. The problem of trust has received much attention in the analysis of international relations, particularly in arms race and deterrence literature,[1] and appears to be a critical issue in the general investigation of inter-nation conflict. However, there are serious problems when application of the conditional propensity idea is attempted. First of all, the iteration problem discussed earlier still exists here. The conditional criteria notion only works if the same game is being played on repeated occasions. It does not work if the game is different from time to time, and it does not work if there is only a single play of the game. The international conflict situations that are iterated are few, if any.[2] It is true of course that nations have continuing relations which may be conflictual, but it is not often that they continue in precisely the same form. Second, even if iteration is assumed, the substantive nature of the international conflict outcomes does not lend itself to the conditional propensity concept. When one nation obtains an advantage by being aggressive while the other is being conciliatory, the conditional propensity idea suggests that when the next conflict occurs, the conciliator will switch to aggression. In the formulation being employed, this will lead to war. Iteration must stop at this point until the war is over. When it is over, entirely new preferences are likely to exist for both nations for all outcomes of conflict situations. Thus, unless it happens that both nations behave in a conciliatory fashion at the same point in time (i.e. the first conflict situation), war will result from the employment of conditional criteria of strategic choice just as surely as it results from the absolute criteria which Rapoport seeks to replace. But, if war is going to break out whenever one of the nations behaves aggressively, there is no point in either nation behaving in a conciliatory fashion because this will simply give the other an advantage (however slight), and there is no sense in which this can be considered rational. All other things being equal, it is better to fight immediately at existing power levels than to fight later when the power relations have changed adversely (which is a consequence of yielding an advantage). Of course, this is precisely the character of the Prisoner's Dilemma game. As the result, it does not seem that the particular procedure suggested by Rapoport is suited to the analysis of international conflict.

From the nature of the problems discussed above, it is clear that the greatest need in considering dynamic processes in conflict situations is for a clarification of the impact of a given outcome on the way in which outcomes will be ranked subsequently. For instance, what happens to the preferences of a nation which has just yielded an advantage to an opponent? Iteration is consistent with the idea of no change by either player, and so subsequent preferences would be the same. Consequently, outcomes would be the same. This is of course possible but it does not tell us much. If change is to occur in preferences, then some indication of the nature of the change is needed. This can best be developed by the process that was employed in developing credible preference sets in the first place--namely, the statement of axioms which are logically and theoretically relevant to the problem at hand. In what follows, I shall state a limited number of such axioms and will then explore their implications for change in conflict interaction.

The following assumptions will be operative for this analysis:

1. Whenever war is the outcome, the game is ended and all existing preferences are wiped out. If both nations survive, new preferences would obviously exist. These will not be specified here; however, they will be consistent with the admissible set developed in Chapter 3. The game continues after any outcome other than war.

2. The two nations are approximately equal in power prior to the first conflict situation.

3. The Compromise outcome results in a status quo; there is therefore no relative change in power.

4. Whenever a nation obtains an advantage its power relative to the other increases. Both nations perceive this change more or less accurately.

5. Factors which are external to the game matrix are constant for both nations. Thus, domestic economic, political, etc., elements do not change from one game time to the next and so do not influence preferences. Similarly, other foreign interaction is assumed to have no effect.

6. When games are unstable, no outcome can be predicted. Cyclical rotation amongst all four outcomes will therefore be assumed. As noted, when war occurs subsequent to an unstable game, the game will be ended. When any other outcome occurs, the axioms for preference change which are associated with that particular kind of outcome will be considered operational.

In stating the axioms for preference transformations, changes in the relationship between the existing preferences rather than the absolute value of the preference is specified. This permits general change trends to be posited for any existing value. In principle, therefore, when a particular preference for a particular outcome is said to be increasing or decreasing, it may be moving from any particular value (i.e. from 1, 2, 3, or 4). In practice, of course, there will be limitations on existing values--not every outcome is assigned each preference level in the basic taxonomy.

AXIOMS FOR TRANSFORMATIONS OF PREFERENCES

Axioms for Transformations After C and W

> Axiom 4: Compromise will leave preferences unchanged.

> Axiom 5: War terminates the game and voids all preferences.

Axioms for Transformations After B*

For the purposes of explication, I shall assume that all advantages go to B. There will naturally be complementary situations in which advantage goes to A, but an analysis of these will directly correspond to what follows, except that players' roles will be reversed. I shall therefore be generating Loser's Axioms for A and Winner's Axioms for B.

Loser's Axioms

> Axiom 6: After B obtains an advantage, B* will be less preferred by A.

Since A and B were equi-potent prior to B*, both will perceive that A has fallen behind. Should B secure further advantages the gap will widen. At some point, successive gains by B will render A impotent in the face of B's newly acquired superiority. Therefore, after the first gain by B, subsequent gains will be less preferred by A.

> Axiom 7: After B*, A* will be more highly valued by A.

A will be anxious to restore parity after falling behind. This will be manifested by a desire to obtain an advantage equal to or greater than that previously secured by B.

Since A's transitions represent the fear of seeing the gap widen, these two axioms will be designated the 'fearful loser' model.

Winner's Axioms

The impact of B* upon B's preferences is somewhat difficult to estimate because B's attitude towards A has not been specified. Of course, this was also true for A in the previous set of axioms. There, however, it was possible to argue that, in general, the nation which was falling behind would always want to catch up if possible, and, in any case, prevent the other from getting further ahead. B's situation is somewhat different. It is easy to imagine that a small advantage looked very desirable. On the other hand, it is also conceivable that a small advantage might be satisfactory for a B which was not primarily offensive in outlook but was merely trying to establish secure co-existence. These two poles suggest quite different transitions in the preference orderings of the outcomes, and therefore two sets of axioms will be proposed. The first of these will be designated the Greedy Winner set, since they are associated with the desire for more power and more advantage. The second set, corresponding more closely to a status quo orientation, will be designated the Satisfied Winner set.

(a) Axioms for the Greedy Winner

> Axiom 8: After obtaining an advantage, further advantage will be highly desirable. Therefore B* will be more valuable than previously.
>
> Axiom 9: A B* outcome will give B an advantage. Thus encouraged, B will be more willing to go to war to obtain further advantage. Consequently, W will increase in value.

(b) Axioms for the Satisfied Winner

> Axiom 10: Since B hopes to maintain the newly created situation, Compromise will be more highly valued than previously.
>
> Axiom 11: Further advantage might stimulate A into aggressive action. Therefore B* will decline in vlaue for B.
>
> Axiom 12: Because B is happy with the new situation, there will be less preference for violent resolution of conflict. Therefore, W will decline in value.

Each of the above axioms specifies movement from an existing position, rather than the value of the new position that will exist after the movement. Therefore, they can be applied to all matrices regardless of the particular preferences that are associated with each outcome. In order to designate the kind of movement that is implied by the axioms, the following notational device will be employed: If an axiom specifies an increase in the preference for an outcome, let us say B*, for a given player, let us say B, then it will be identified as B^{*}_{b} /. If a decrease is indicated, then for the same outcome and the same player, it will be identified as B^*_b /. All changes will be indicated in similar manner. It is thus possible to state a transitional matrix, incorporating all relevant axiomatic preference movements, that will facilitate application of the axioms to the matrices which are classified under a given outcome. Naturally, in the matrix itself the identification of the outcome, let us say B*, will not be required.

Since there are three classes of axioms there will be three matrices.

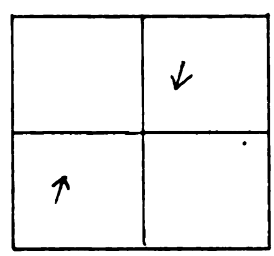


Figure 4.2 Transition Matrix For The Fearful Loser

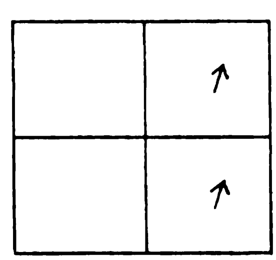


Figure 4.3 Transition Matrix For The Greedy Winner

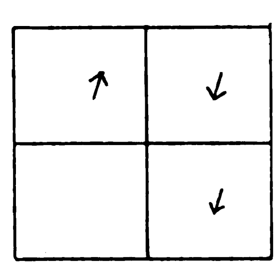


Figure 4.4 Transition Matrix For The Satisfied Winner

In the absence of arrows, values are presumed to remain constant. Let us see precisely what these transitions mean in terms of a specific matrix.

4, 3	2, 4
3, 1	1, 2

Game 4

Game 4 is a viable formulation based on the theory of preferences stated in Chapter 3, and of course is present in the basic taxonomy. From the transition matrix for the fearful loser it can be seen that for A, A* is increasingly preferable after a B* outcome. Since A* is presently ranked 3, this means that the ranking is moving towards 4. We have stressed that these are preferences (i.e. ordinal) not utilities (i.e. cardinal), and therefore the claim cannot be made that the interval between the 3 ranking and the 4 ranking is known. Therefore, it cannot be said at what precise moment the outcome A* might assume the most preferred ranking. However, it should be clear that at some point, if the preference for A* continues to increase, this outcome will be the most preferred. This can be demonstrated in the following way. Let us assume a play of Game 4 occurs. B* results, and A's preference for A* increases by some unknown amount. Let us assume that C is still preferable to A* however, and that another

play of the game occurs, again leading to B*. The outcome A* increases further in value to A. Obviously, if this continues A* must become the most preferred outcome, and Compromise must decline to next most preferred, since all preferences are assumed to be strict. In order to complete this illustration, the balance of the transition matrix will now be taken into account. A's remaining preference change is for B*. B* is declining while W is holding constant. Since B* is ranked (2) and W is ranked (1), the application of the logic just outlined for A* and C means that preferences for these two outcomes will switch. B* will then be least preferred and W will be ranked (2). In order to illustrate the impact on Game 4 of these transitions, let us assume for the moment (1) that B's preferences do not change, and (2) that the transitions for A occur simultaneously. Then, the matrix that contains the new preferences for A will be as follows:

3,3	1,4
4,1	2,2

Game $4T_1 \equiv 13$

This new Game (4T) is identical to Game 13, which leads to War (2,2). It therefore terminates the interaction situation.

Naturally, the transitions for B can be examined in a similar way. If we assume that B is a Satisfied Winner, and that all transitions are again simultaneous, then the transitions from Figure 4.4 can be applied to Game 4 and coupled with the changes for A to yield the following:

3,4	1,3
<u>4,2</u>	2,1

Game $4T_2 \equiv 4E$

Both players have a dominating strategy in this case, and the outcome is A*.

These kinds of transitions will take place in every game which leads to an advantage for B. There is an analagous transition for every equivalent game which leads to an advantage for A, but, to avoid redundancy, these will not be stated. In order to analyze the taxonomy in its entirety then, two classes of games must be examined: first, all games which lead to B* must be evaluated in terms of the transition matrices; second, all unstable games must be taken into account. The latter are assumed to have cyclical properties such that rotation among the four outcomes will occur, and consequently analysis must be able to take each of them into account. The tools for doing this already exist. Two of the four outcomes, War and

Compromise, have the same dynamic properties after they occur in unstable games that they had in stable situations. The other two outcomes, B* and A*, are simply instances of the situation that is managed by the transition matrices shown in Figures 4.2--4.4. The fact that the games are unstable has no impact on the relationship between any given outcome and the preference set at subsequent points. Therefore, except for the need to consider these games from at least two different points of view (A* outcome and B* outcome), they do not differ significantly in this context from stable games.

One further point needs elucidation before the transformation of the basic taxonomy is undertaken. The timing of the transition of any given preference is uncertain. There seems to be no clear basis for arguing that any one of the transitions, whether for A or for B, will occur before or after any other. Nevertheless, this is clearly critical. If, for instance, A's preferences in Game 4 change before B's and if a conflict then arises between the two, the game that will be played will be Game 4T. If both sets of preferences change simultaneously, then $4T_1$ is the result. What if the transitions for B are assumed to occur while those for A do not? Clearly, further complications are introduced. Consider, for instance, the satisfied winner model, which yields the following matrix.

Here the game is stable, and Compromise is the most preferred strategy for both players. The Greedy Winner model would yield yet another game.

4,4	2,3
3,2	1,1

Game $4T_2$

These examples illustrate how a single game can transpose into entirely different games, each with different outcomes, depending upon the timing of the transition points. Since there appears, at present, to be no logical argument in favor of a particular order of transition, I shall assume that all types of transitions are viable, and that all of them must be included in the transition statement. It may be observed that this is equivalent to holding constant all transitions except one. The effect of that one change can then be examined. In elaboration, what this means is that each of the individual transitions contained in Figures 4.2--4.4 will be considered viable changes. Thus, when considering the Fearful Losèr model, for instance, A* / alone will be examined; also B* / alone will be examined. Then their joint occurrence will be taken into account. The same procedure will be followed for transitions by B. Then all possible permutations of transitions for the two parties will be developed. Before proceeding to statement and analysis of the transitions it will be helpful to clarify the principles according to which the transitions will be made, and to then state the categories of transition.

<u>Principles of Transition</u>

1. Changes in rankings will be considered inadmissible unless consistent with the Axioms of Preference stated in Chapter III. For instance, in Game 17, War is most preferred by B. Thus, by Axiom 2, W and B* must be preferred to C. This is shown in the matrix:

3,2	2,3
4,1	1,4

Game 17

When considering the impact on B's preference structure of the Satisfied Winner model of transitions (C_b /, B_b^* /, W_b /), it is the case that although W is declining in importance to B it must nevertheless remain more preferred than B*. Thus C must always be less preferred than B* (and, of course, W). Therefore the change in ranking that is implied by C is in violation of Axiom 2 and is therefore inadmissible, <u>unless</u> W is also declining and B* is either increasing or remaining constant. Of course, in the Satisfied Winner model, B* never increases. Therefore, the only admissible games are those created by (C_b /) alone, or (C_b /, W_b /) in combination. All games resulting from other transitions are in violation of Axiom 2.

2. If two preferences are moving in the same direction, then, after all changes have taken place, they will maintain the same relative position. For instance, if the preferences for War and Advantage are declining for one of the players, let us say B (e.g., $W_b \downarrow$, $B^*_b \downarrow$), but War is more preferred than B* before any change in rankings takes place, then War will still be more preferred than B* after the rankings have been adjusted.

3. When the preference for any outcome is changing in accordance with the Axioms of Transition, the change will be limited to adjacently ranked outcomes, unless non-adjacently ranked outcomes are changing in an opposite direction.

Using B's preferences only for purposes of illustration, this principle operates in the following manner:

(a) Assume ($B^* = 4$, $C = 3$), and that $B^* \downarrow$) is the change taking place. Then ($B^* = 3$, $C = 4$) will be the new preferences. ($B^* = 2$, $C = 4$), for instance, will not develop.

(b) Assume ($B^* = 4$, $C = 3$) once again, but that ($B^* \downarrow$, $C \uparrow$) is the model of change. Then ($B^* = 3$, $C = 4$) will still be the new situation. Again, ($B^* = 2$) will not develop.

(c) Assume ($C = 2$, $B^* = 3$, $W = 4$), and that ($C\uparrow$ $W\downarrow$) is the model of change. In this case B* has the rank which C and W are approaching from opposite directions. It will be assumed that they reach and pass this rank simultaneously. Thus, the result will be

(C = 4, B* = 3, W = 2). Note that if either C or W is assumed to reach the B* rank first, this implies a different model--e.g. (C ↑) alone, or (W ↓) alone. These models are, of course, taken into account when the general effects of transitions are specified below.

Categories of Transition

There are nine categories of transition, listed below. The first three categories comprise unilateral change by one of the two parties. Category I, for instance, contains each of the three possible changes for the Fearful Loser, but no change for the other player. Categories II and III contain no change for the loser, but incorporate changes for the Greedy and Satisfied Winners respectively. The other categories contain all possible permutations of change for the loser in conjunction with the full range of changes for each of the models for winners.

The games that result from these transitions in each of the categories are in the appendices. Appendix I contains transitions for stable games; Appendix II contains transitions for unstable games. There are of course nine categories for each of these. They are as follows:

I. Fearful Loser And No Change For B

(1) ($A_a^* \uparrow$)

(2) ($B_a^* \downarrow$)

(3) ($A_a^* \uparrow$, $B_a^* \downarrow$)

II. No Change For A And Greedy Winner

(1) ($B_b^* \uparrow$)

(2) ($W_b \uparrow$)

(3) ($B_b^* \uparrow$, $W_b \uparrow$)

III. No Change For A And Satisfied Winner

(1) ($C_b \uparrow$)

(2) ($B_b^* \downarrow$)

(3) ($W_b \downarrow$)

(4) ($C_b \uparrow$, $W_b \downarrow$)

(5) ($C_b \uparrow$, $B_b^* \downarrow$)

(6) ($B_b^* \downarrow$, $W_b \downarrow$)

(7) ($C_b \uparrow$, $B_b^* \downarrow$, $W_b \downarrow$)

IV. Fearful Loser ($A_a^* \uparrow$) And Greedy Winner

(1) ($A_a^* \uparrow$) and no change for B

(2) ($A_a^* \uparrow$), ($B_b^* \uparrow$)

(3) ($A_a^* \uparrow$), ($W_b \uparrow$)

(4) ($A_a^* \uparrow$), ($B_b^* \uparrow$, $W_b \uparrow$)

V. Fearful Loser ($B_a^* \downarrow$) And Greedy Winner

(1) ($B_a^* \downarrow$) and no change for B

(2) ($B_a^* \downarrow$), ($B_b^* \uparrow$)

(3) ($B_a^* \downarrow$), $W_b \uparrow$)

(4) ($B_a^* \downarrow$), ($B_b^* \uparrow$, $W_b \uparrow$)

VI. Fearful Loser ($A_a^* \uparrow$, $B_a^* \downarrow$) and Greedy Winner

(1) ($A_a^* \uparrow$, $B_a^* \downarrow$) and no change for B

(2) ($A_a^* \uparrow$, $B_a^* \downarrow$), ($B_b^* \uparrow$)

(3) ($A_a^* \uparrow$, $B_a^* \downarrow$), ($W_b \uparrow$)

(4) ($A_a^* \uparrow$, $B_a^* \downarrow$), ($B_b^* \uparrow$, $W_b \uparrow$)

VII. Fearful Loser ($A_a^* \uparrow$) And Satisfied Winner

(1) ($A_a^* \uparrow$), ($C_b \uparrow$)

(2) ($A_a^* \uparrow$), ($C_b \uparrow$)

(3) ($A_a^* \uparrow$), ($W_b \downarrow$)

(4) ($A_a^* \uparrow$), ($C_b \uparrow$, $W_b \downarrow$)

(5) ($A_a^* \uparrow$), ($C_b \uparrow$, $B_b^* \downarrow$)

(6) ($A_a^* \uparrow$), ($B_b^* \downarrow$, $W_b \downarrow$)

(7) ($A_a^* \uparrow$), ($C_b \uparrow$, $B_b^* \downarrow$, $W_b \downarrow$)

VIII. Fearful Loser ($B_a^* \downarrow$) And Satisfied Winner

(1) ($B_a^* \downarrow$), ($C_b \uparrow$)

(2) ($B_a^* \downarrow$), ($B_b^* \downarrow$)

(3) ($B_a^* \downarrow$), ($W_b \downarrow$)

(4) ($B_a^* \downarrow$), ($C_b \uparrow$, $W_b \downarrow$)

(5) ($B_a^* \downarrow$), ($C_b \uparrow$, $B_b^* \downarrow$)

(6) ($B_a^* \downarrow$), ($B_b^* \downarrow$, $W_b \downarrow$)

(7) ($B_a^* \downarrow$), ($C_b \uparrow$, $B_b^* \downarrow$, $W_b \downarrow$)

IX. Fearful Loser ($A_a^* \uparrow$, $B_a^* \downarrow$) And Satisfied Winner

(1) ($A_a^* \uparrow$, $B_a^* \downarrow$), ($C_b \uparrow$)

(2) ($A_a^* \uparrow$, $B_a^* \downarrow$), ($B_b \downarrow$)

(3) ($A_a^* \uparrow$, $B_a^* \downarrow$), ($W_b \downarrow$)

(4) ($A_a^* \uparrow$, $B_a^* \downarrow$), ($C_b \uparrow$, $W_b \downarrow$)

(5) ($A_a^* \uparrow$, $B_a^* \downarrow$), ($C_b \uparrow$, $B_b^* \downarrow$)

(6) ($A_a^* \uparrow$, $B_a^* \downarrow$), ($B_b^* \uparrow$, $W_b \downarrow$)

(7) ($A_a^* \uparrow$, $B_a^* \downarrow$),
($C_b \uparrow$, $B_b^* \downarrow$, $W_b \downarrow$)

The Effects of the Transitions on Stable Games

I. Fearful Loser And No Change For B

If A's transitions are restricted to ($A_a^* \uparrow$), then, as can be seen from Appendix I, the consequences of the new games that are created are B* in every case except Game 3, which become unstable. The reason for the instability is that B has no dominant strategy in Game 3, and that A's dominant conciliatory strategy disappears when ($A_a^* \uparrow$)

takes place. In every other game which results in B*, B has a dominant aggressive strategy, and since ($A_a^* \uparrow$) affects neither A's preference for War (which is 1 throughout, in accordance with the necessary condition for B* established in Chapter III) nor B's dominant second strategy, it is inevitable that B* will occur again after A's limited transition.

When ($B_a^* \downarrow$) is considered, it is clear that the effect will be to switch A's preferences for B* and War. In all pre-transition games the former is 2 and the latter is 1. The switch means that A will always be aggressive whenever B has a dominant second strategy, which, as observed above is the case in all but Game 3. The consequence in all such games will therefore be War. But this occurs in a situation in which B is stronger than A by the margin obtained from the previous B* outcome, and is therefore in a superior position to fight. This is something of a paradox for A, since in the previous situation, A was equi-potent but yielded an advantage to B. Now, A is less powerful, but is willing and is obliged to fight.

Game 3 is again unstable, though in a different manner than before. Game 10 results from ($A_a^* \uparrow$) while Game 7 results from ($B_a^* \downarrow$). In either case, uncertainty pervades the situation.

The consequences of total change for A can be readily inferred from the observation that ($A_a^* \uparrow$, $B_a^* \downarrow$) implies a dominant second strategy for A in every case. Since B's second strategy is also dominant in all the games except 3, War is inevitable. In Game 3, since War is least preferred by B, A obtains an advantage. This is the only incidence of A* after any kind of unilateral transition by A.

In general then, it can be stated that the Fearful Loser is at a distinct disadvantage after unilateral change. Either B* or W is the consequence in all games except those which result from Game 3 and only one of these leads to an improvement for A. Interestingly, it may be observed that the latter, 11E, is a game which becomes Prisoner's Dilemma if the Fearful Loser model is applied again, this time with B in the losing position. It might be argued that when A secures an advantage in 11E this simply re-establishes parity between the two nations and that B need not be a Fearful Loser. This is plausible, but since the player's are now in 11E instead of 3, the next conflict situation will put A in the lead and will activate preference changes for B similar to those that took place for A after Game 3 was played. At that point, 11E <u>will</u> become Prisoner's Dilemma and War will result. Thus, the argument suggests delays of War for one conflict situation, but it cannot support exclusion of War as a consequence of continuing interaction.

It should be further observed that those situations which lead to successive B* results--as a consequence of ($A_a^* \uparrow$)-- are poor for A. B gets further and further ahead in terms of strategic power, and, ultimately, is likely to dominate A completely. The implication here is that A faces a dichotomy--submission or War--that is to some extent the consequence of A's fear of such a dichotomy. The main principle behind the Fearful Loser model is that A fears falling further behind. This and War are the only possibilities however. Thus, for the Fearful Loser, there is no way to unilaterally re-establish strategic parity.

II. No Change For A And The Greedy Winner

Assessment of the impact of the Greedy Winner model is straightforward. No matter what the permutation of transitions for B, B* is the result of the new game. This consequence can be derived deductively from the following observations: Since A does not change in this category, $W_a = 1$ in every game (this is a necessary condition for B*). In addition, B has a dominant second strategy in all the games except 3, and the effect of ($B_b^* \uparrow$), ($W_b \uparrow$), or ($B_b^* \uparrow$, $W_b \uparrow$) will not disturb this dominance. Therefore, B* is the result throughout. In Game 3, B* will also result since A has a dominant conciliatory strategy and B* is more preferred by B than C.

In conclusion then, when A does not react to B*, the Greedy Winner secures further advantage. Iteration of these transitions will clearly lead to strategic dominance for B.

III. No Change For A And Satisfied Winner

The effects of the elements of the Satisfied Winner model are more complex than those of the other two models simply because the number of transition permutations is greater (seven instead of three).

Therefore, it is to be expected that patterns will not be as clear cut in the former as in the latter, and, as can be seen from the Appendix, this is in fact the case. Nevertheless, some general observations can be made.

First of all, since the Satisfied Winner model embodies the notion of decreased aggressiveness by B, and since, as was demonstrated by the Greedy Winner model, aggression leads to strategic gain (B*), this decrease should introduce C and W outcomes. This is what happens, though C is much more frequent than A*. For instance, when Games 3 and 4 are amended for the transitions specified for the model, C is the result in all but 2 cases. The latter are those games that are formed after ($W_b \downarrow$) alone. This is because operations on W_b affect neither A's preferences, which yield a dominant conciliatory strategy in both games, no B's preference for B*, which is 4 in both. Consequently, B* is the outcome in that one case.

Game 5 transposes into a combination of B* and C results. B* occurs whenever B's transitions are not strong enough to destroy the dominance of the second aggressive strategy. However, as soon as C becomes the most preferred outcome for B, C is a result even though B lacks a dominating strategy at that point. The (4, 4) property of the C outcome produces this consequence.

Game 11 is the sole game in the set which transposes into advantageous situations for A. Whenever any two of B's transitions occur simultaneously, the effect is to produce a dominating first strategy for B, and since $A_a^* = 4$ it is naturally the outcome. If any one of the three possible changes for B occurs in isolation then the resulting game is unstable.

In the three remaining games, 12, 17 and 20 the results are mixed. As well as B* and C outcomes, there are unstable and inadmissible consequences of the transitions. As was discussed earlier, an inadmissible game is one which violates the basic Axioms of Preference orderings set out in Chapter 3. This situation arises mainly in Games 17 and 20. These are games in which War is the most preferred outcome for B. Axiom 2 states that whenever this is the case, both W and B* will be ranked higher than C by B. The Satisfied Winner model however specifies that ($C_b \uparrow$), and this means that it should be more preferable than B* or W, or both, at some point. Since this is impossible according to Axiom 2, those games in which it would occur if the transitions were developed are considered inadmissible.

In conclusion then, the Satisfied Winner model leads to mixed results. However, from A's point of view the possibilities for desirable outcomes are greater than in either of the other two models.

IV. Fearful Loser ($A_a^* \uparrow$) And Greedy Winner

This set of games incorporates a limited transition for A with the complete set of transitions for the Greedy Winner. The results are straightforward as they were in the unilaterally changing Greedy Winner case. In all games except 3, the Greedy Winner secures further advantage. In Game 3 one of the transitions is unstable while the balance conform to the pattern just stated. The unstable transition is a consequence of the fact that the dominance of A's first strategy is abrogated by the ($A_a^* \uparrow$) transition.

Once again then, it may be concluded that the Greedy Winner will obtain additional advantage in all cases but the single exception just noted, and will therefore come to dominate if iterations of the transitions are made.

V. Fearful Loser ($B_a^* \downarrow$) And Greedy Winner

This set of games is also very uniform. Each transition leads to a game in which War is the natural outcome, with the exception of Game 3. Here, one of the transitions leads to an unstable situation, simply because the ($B_a^* \downarrow$) transition destroys the dominance of A's conciliatory strategy, but does not provide a dominant strategy for B.

This is paradoxical for A in the same sense that unilateral change by the Fearful Loser is paradoxical. War occurs in a situation in which A is less powerful relative to B than before the original B* outcome. Thus, though A can avoid fighting for one round of conflict, violence is ultimately inevitable, given these particular transitions.

VI. Fearful Loser ($A_a^* \uparrow$, $B_a^* \downarrow$) And Greedy Winner

Though the games which are formed by these transitions are not identical to those discussed in the previous category, the consequences are the same in all cases but one. With the exception of Game 3, War is the result of every newly formed matrix. In that exception, A* results because A's transitions switch A's dominant strategy from conciliation to aggression at a time when War is still least preferred by B.

VII. Fearful Loser ($A_a^* \uparrow$) And Satisfied Winner

It has already been noted that the Satisfied Winner modifies aggressiveness, and that this introduces some C and A* outcomes. When elements of the Fearful Loser model are incorporated, it is to be expected that A* will be more common, since the Fearful Loser adjusts preferences to reflect a desire for the re-establishment of parity with B. This occurs, though not universally. Twelve of the games in this category lead to A*. Almost as many, ten, result in B*.

It is also the case that the inadmissible transitions which occurred in the unilateral change Category are repeated here. This is of course to be expected since the inadmissibility is a product of transitions by B, and these are unaffected by what happens to A.

Of particular interest is the fact that War never results from transitions in this category. Increases in aggressiveness by A do not offset the reductions in aggressiveness by B.

VIII. Fearful Loser ($B_a^* \downarrow$) And Satisfied Winner

Some elements in this category are quite similar to those in Category III, Unilateral Change by the Satisfied Winner, while others are quite different.

The similarities occur in terms of inadmissible games and Compromise outcomes. The continuation of inadmissibility is again due to transitions in B which do not vary when changes in A occur. Whenever C is the consequence of unilateral change (III), it is also the consequence after the joint change taking place in this category, even though the two sets of games are not identical. There are no new Compromise outcomes in this category.

The differences occur in the impact of ($B_a^* \downarrow$) on the situations which, in Category III, either led to B* or were unstable. In the present category there is a very strong tendency for War to be the outcome of the corresponding matrices. Sixteen of the nineteen games result in War; the three remaining games become unstable.

As a final note it may be observed that A* is again a consequence of the extrapolations from Game 11. However, only three of the seven permutations result in A* in this category, compared with four in Category III.

IX. Fearful Loser ($A_a^* \uparrow$, $B_a^* \downarrow$) And Satisfied Winner

The effect of the two transitions for A are to create a dominant aggressive strategy for A in all games. Therefore A* or W are the only possible outcomes provided the newly formed game is admissible. Whether or not it is admissible depends entirely on B, under these conditions, and once again the inadmissible transitions for the Satisfied Winner match those that were inadmissible in all previous Satisfied Winner Categories.

IX. Fearful Loser ($A_a^* \uparrow$, $B_a^* \downarrow$) And Satisfied Winner

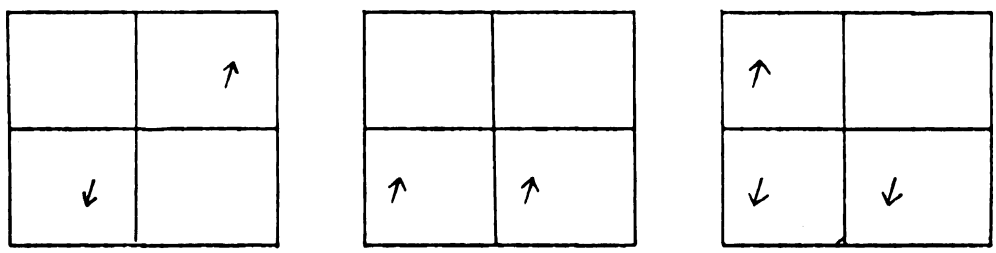
The effect of the two transitions for A are to create a dominant aggressive strategy for A in all games. Therefore A* or W are the only possible outcomes provided the newly formed game is admissible. Whether or not it is admissible depends entirely on B, under these conditions, and once again the inadmissible transitions for the Satisfied Winner match those that were inadmissible in all previous Satisfied Winner Categories.

Thirty seven games are admissible. Fifteen of them lead to A*, while the remaining twenty two lead to War. Extrapolations of three of the original seven games that lead to B* are identical to Category VIII. These are 11, 12, and 17 and the reason for the correspondence is that ($A_a^* \uparrow$) has no effect since $A_a^* = 4$ in each of them.

THE EFFECT OF TRANSITIONS ON UNSTABLE GAMES

As noted earlier, one of the characteristics of unstable games is that rational methods of decision do not yield predictions of specific outcomes for a single play of the game. It is therefore assumed that such games are cyclical and that each outcome is as likely as another. With this exception, all assumptions and axioms that exist for stable games continue to operate. This means that the transition matrices from Figures 4.2, 4.3 and 4.4 can be applied directly to the unstable case where B* is the outcome. When A* is the outcome, the transition axioms will be comparable except that A will be subject to Winner's Axioms, while B will be subject to Loser's Axioms.

Consequently, the transition matrices for A* outcomes will be as follows:



Fearful Loser Greedy Winner Satisfied Winner

Figure 4. 5 Transition Matrices After A*

The new games developed from the two unstable games (7 and 10) are presented in Appendix II. Since Game 10 is symmetric the consequences after A* are equivalent to those after B*, except for reversal of roles, and therefore no analysis of the former is required.

I. Unilateral Change By The Fearful Loser

A. Changes After B* Outcomes

In general, the Fearful Loser does better after unstable than after stable situations. Four of the six transpositions from Games 7 and 10 lead to A* outcomes, while the two remaining games are repetitions of the unstable matrices from which transitions were made. This finding is of course consistent with the idea that, especially in games like Chicken, the player who can declare first is at an advantage, since by being aggressive this player can force the other to choose between the least and next least preferred outcomes. Those transitions that lead to A* here are analagous to such a declaration.

B. Changes After A* Outcomes

Game 7 transposes into two situations where War results and one which is a repetition of the original situation. This is because ($A_b^* \downarrow$) creates a dominant aggressive strategy for B, thus forcing A into War. This is obviously more comparable to the Fearful Loser's lot in stable situations, where War is a frequent occurrence. Game 10 as noted, is equivalent after A* to the situations derived from B* and therefore needs no discussion.

II. Unilateral Change By The Greedy Winner

A. Changes After B* Outcomes

Game 7 leads to a repetition of itself and to two instances of War. Game 10 is also repeated, and, in addition, leads to two B* outcomes. In this sense, unilateral reaction by the Greedy Winner can be said to be profitable (i.e., B*) a third of the time, but risky at other times.

B. Changes After A* Outcomes

The Greedy Winner fares much better here than in the previous sub-category. Two of the transpositions of Game 7 lead to A*, while one is inadmissible. After Game 10, one extrapolation is unstable (Game 10 again), while the other two lead to A*.

III. Unilateral Change By The Satisfied Winner

A. Changes After B* Outcomes

Six of the seven transitions for Game 7 lead to Compromise. The exception, which occurs after ($W_b \downarrow$) is a repetition of the original game. There is also a repetition of Game 10, after the same transition, while the balance of the games lead to A*. These trends are consistent with the idea of reduced aggressiveness by B, which is at the base of the Satisfied Winner model.

B. Changes After A* Outcomes

Four of the seven games developed from Game 7 are inadmissible because of a violation of Axiom 2. Two of the remaining games lead to B* while the third is unstable. Game 10, as discussed leads to B* in six of seven cases. Again, these developments are consistent with the principles of the Satisfied Winner model.

IV. Fearful Loser ($A_a^* \uparrow$ after B*, and $B_b^* \uparrow$ after A*) And Greedy Winner

A. Change After B* Outcomes

In Game 7, the transitions for A lead to a dominant second strategy and consequently B must choose between A* and War. As soon as ($W_b \uparrow$) is introduced into the situation therefore, B will also be aggressive and the outcome will be War. This occurs in two of the three extrapolations. In the other, A* is the result. In Game 10, ($A_a^* \uparrow$) has no effect since A* is already randed 4. Therefore the

Winner's greed dominates and B* is the consequence in two of the three matrices. In the other, Game 10 is repeated.

B. Change After A* Outcomes

The transition rule for B has no impact on B's preferences in either game since B* = 4 prior to the transition. Reactions by the Greedy Winner are therefore the determinants of the new consequences. In four of the six games, the Greedy Winner secures further advantage. In one of the two remaining games the unstable situation is repeated (Game 10), while the other is inadmissible.

V. Fearful Loser ($B_a^* \downarrow$ after B*, and $A_b^* \downarrow$ after B*) And Greedy Winner

A. Changes After B* Outcomes

In Game 7 the posited transitions for A, the Fearful Loser, do not affect preferences since $B_a^* = 1$ already. In one instance therefore, where B's transitions also have no effect, Game 7 is simply repeated. However, as soon as B acquires a dominant aggressive strategy, which occurs as a result of ($W_b \uparrow$) in two of the three transition permutations, then War must result. The developments from Game 10 on the other hand are such that A acquires a dominant aggressive strategy and therefore obtains an advantage in one of the three cases. In the other two, both of which are instances of Prisoner's Dilemma, War is again the result.

B. Changes After A* Outcomes

B's transition introduces a dominant second strategy for B. Since the Greedy Winner is also becoming more aggressive, the trend towards W outcomes is clear. This is what happens in four of the six games in this class. One of the other two is inadmissible, while the remaining game leads to B*.

VI. Fearful Loser (Total Changes) And Greedy Winner

A. Changes After B*

Since the impact of ($A_a^* \uparrow$, $B_a^* \downarrow$) on Game 7 is the same as the impact of ($A_a^* \uparrow$) alone, the Category VI set of transposed games is identical to the Category IV set. By similar reasoning (i.e., ($B_a^* \downarrow$) is equivalent to ($A_a^* \uparrow$, $B_a^* \downarrow$) the Category VI set for Game 10 is the same as the Category IV set. Thus, for a discussion of these transitions, see Category IV.

B. Changes After A*

By reasoning similar to that conducted above, the transitions after A* are identical to those that take place in Category IV for unstable games. For a discussion of these transitions, see that Category.

VII. Fearful Loser ($A_a^* \uparrow$ after B*, and $B_b^* \uparrow$ after A*) And Satisfied Winner

A. Changes After B*

The Fearful Loser is becoming more aggressive while the Satisfied Winner is becoming less so. A* and C outcomes are therefore to be expected. In every game except one the first of these tendencies is what happens in this set. Either acquires a dominant second strategy (Game 7), or B acquires a dominant first strategy (Game 10). The single exception is in developments from Game 10 after ($A_a^* \uparrow$, $W_b \downarrow$) which has no effect on either preference set, thus leading to a repetition of Game 10.

B. Changes After A*

Since ($B_b^* \uparrow$) has no effect upon B's preference set ($B_b^* = 4$ already), this set of games is identical to those already discussed under Category III, Unilateral Change by the Satisfied Winner After A* Outcomes.

VIII. Fearful Loser ($B_a^* \downarrow$ after B*, and $A_b^* \downarrow$ after A*) And Satisfied Winner

A. Changes After B*

This set is a combination of A* and C outcomes. With the exception of one unstable situation (Game 7 again) that develops after ($B_a^* \downarrow$, $W_b \downarrow$), all developments from Game 7 lead to C. Without exception, Game 10 leads to A*.

B. Changes After A*

Changes in this set that follow from Game 10 are equivalent to those just discussed and so lead to B* without exception. Game 7 is more complicated. The transitions for A after A* lead to four inadmissible situations (again because of a violation of Axiom 2). Two of the three remaining games lead to B* while the other leads to War.

IX. Fearful Loser (Total Change) And Satisfied Winner

A. Changes After B* Outcomes

Since, in Game 7, $B_a^* = 1$, $(A_a^* \uparrow, B_a^* \downarrow)$ is equivalent to $(A_a^* \uparrow)$ alone. Therefore the games in this class that are developed from Game 7 are identical to those already discussed in Category VII after B*. By similar reasoning, those games developed from Game 10 are identical to the same class in Category VIII, since $(A_a^* \uparrow)$ has no effect when $A^* = 4$.

B. Changes After A* Outcomes

Since $B_b^* = 4$ in both Games 7 and 10, total changes are identical to $(A_b^* /)$ alone. Thus this set of games is identical to those discussed already in Category VIII after B*.

SUMMARY

Based upon the Axioms of Transition developed in this chapter, each of the games which leads to an advantage for one of the players has been amended to reflect all possible permutations of change in the preferences of the players. Nine Categories of Transition are formed by these operations, and the games contained in each category are presented in Appendixes I and II.

Though there are no summarizing rules which can be applied to all games, some general observations can be made. The three models of transition, Fearful Loser, Greedy Winner and Satisfied Winner, all embody specific principles of reaction to B* and A* outcomes. The Fearful Loser becomes more aggressive in order to prevent the opponent from getting further ahead; the Greedy Winner seeks further advantage, and, therefore, also becomes more aggressive; the Satisfied Winner becomes more conciliatory in order to maintain the slight advantage just obtained.

Given these principles, it is to be expected that certain clear trends should emerge in the games that are formed after transition of preferences takes place. For instance, the fact that the Fearful Loser and the Greedy Winner are both becoming more aggressive suggests that War will be a frequent development from their interaction. As can be seen from Categories IV, V and VI for stable games this expectation is realized with one exception,[3] whenever the two possible transitions for A take place simultaneously, or when the ($B_a^* \downarrow$) transition occurs before the ($A_a^* \uparrow$) transition. Furthermore, when unilateral change by the Fearful Loser is examined (Category I) it can be seen that the results are almost identical. War is again the outcome in all but the ($A_a^* \uparrow$) situation.[4] When War does not occur, that is, when ($A_a^* \uparrow$) is the only transition for A, the result in each case, except 3, is B*. Obviously, this is not encouraging for A, since it provides further advantage for B and suggests ultimate dominance by the latter over the former. This trend also exists if A does not react at all to B*. Category II demonstrates that B* is the universal outcome whenever B is the Greedy Winner while A maintains existing preferences. Because of this, a quick general response by the Loser appears to be preferable to slow reaction, if the Winner is Greedy. The problem, naturally, is to determine whether the Winner is Greedy or Satisfied. Of course, even if the latter is the case, the results are not unequivocally satisfactory for the Loser. As can be seen from Categories III, VII, VIII and IX, C and A* result only in a limited number of situations. There are for instance 149 admissible games in these categories. Only 60 of them result in C or A* outcomes, while the balance lead to B* or W, or are unstable.

In general then, in stable situations, it can be seen that any outcome which provides strategic advantage to one of the players is likely to introduce changes which will lead to increased imbalance in relative power, or results in War. These consequences can be avoided only under the limited conditions just stated.

The assessment of unstable situations differs from the above in the case of the Satisfied Winner model, but is similar in the Fearful Loser and Greedy Winner case. In the latter, further advantage for the Winner, or War, are much more frequent than re-establishment of parity or compromise. In the former however out of a total of 96 admissible games, only 2 lead to War. None lead to further advantage for the Winner. Some of the games are unstable, but the majority lead to Compromise or to Advantage for the Loser. Naturally, this does not make unstable situations more attractive conflict settings than stable ones, particularly since there is no knowledge about the intentions of the Winner.

ENDNOTES

[1]For instance, see among others Saaty (1968), especially part III; Green (1966); Smoker (1969).

[2]An argument that a conflict situation could be iterated in the games theoretic sense is more than an argument that conflict can continue between the same parties. It implies that the Cuban Missile Crisis or the Berlin Blockade, or other crises could happen more than once, with the same parameters.

[3]The exception to this principle is Game 3 which yields an unstable situation after (B_a^* /), and results in A^* after (A_a^* /, B_a^* /). This game is also deviant after (A_a^* /) above.

[4]Again Game 3 is an exception.

CHAPTER V

IMAGES IN THE GAME REPRESENTATION OF INTERNATIONAL CONFLICT

At the beginning of this discussion of game models of international conflict, it was explicitly assumed that nations were in possession of complete and accurate information concerning the preferences held by opponents. It was then possible to predict outcomes based on rational choices by the players. The analytic problem of prediction was straightforward, given the 2x2 two person game with strict preference orderings. Dominant strategies were assumed to be chosen, if they existed, and, even if only one player possessed such a strategy, this determined the outcome of the game. When no such strategies existed, the game was designated unstable, and prediction was declared to be impossible unless one outcome was prominent (i.e., a pareto-optimal equilibrium). Despite this analytic simplicity, the approach was justifiable on the grounds that it permitted a comprehensive statement of the nature and results of all admissible conflict situations. In addition, it can be argued that the dominance assumption does capture the decision problem faced by opponents in a 2x2 game.

Towards the end of Chapter III, the assumption of complete information was relaxed somewhat, and it was shown that necessary and sufficient conditions can be stated for the occurrence of each outcome. Since these are substantially less than the amount of information needed to fill in all preferences of the opponent for each outcome, they provide a basis for estimating results of conflict under conditions of incomplete information. This is clearly an advance both in terms of predictive capacity of the model and in terms of isomorphism with the international conflict situation, since nations frequently reveal only partial information about their preferences and intentions. However, it was still assumed at that stage that the information available, though limited, was nevertheless accurate. This is also artificial, since accuracy of information about preference structures in international conflict is dependent upon the willingness of decision makers to state their positions truthfully. There is obviously no necessary reason why this should be the rule rather than the exception. If concealment or misrepresentation of positions and intentions can lead to improved results, then it is rational for decision makers to employ such techniques. What I wish to do in this chapter is to investigate the manner in which images--which either conceal or misrepresent within the context of the game model--can influence the outcome of conflict, and to relate this to the international situation.

Surprisingly little has been written about the role of images in international relations generally and virtually nothing is available in game theoretic representations of international conflict in particular. Robert Jervis (1970) has conducted the most ambitious analysis in the general category. He has argued convincingly that a rational structure of deception can be built around the ideas of 'signals and indices'.

> Signals are statements or actions the meanings of which are established by tacit or explicit understandings among the actors. As all actors know, signals are issued mainly to influence the receiver's image of the sender. Both the sender and the perceiver realize that signals can be as easily issued by a deceiver as by an honest actor...Signals then can be thought of as promissory notes. They do not contain inherent credibility. They do not, in the absence of some sort of enforcement system, provide their own evidence that the actor will live up to them...
>
> In contrast to signals, indices are statements or actions that carry some inherent evidence that the image progected is correct because they are believed to be inextricably linked to the actor's capabilities or intentions. Behavior that constitutes an index is believed by the perceiver to tap dimensions and characteristics that will influence or predict an actor's later behavior and to be beyond the ability of the actor to control for the purpose of projecting a misleading image (1970, p. 18).

In a conflict situation such as the one being investigated in this essay, signals may be thought of as transmissions to the opponent of preferences with respect to outcomes which are more or less specified and known to both parties. Obviously, each side can and probably will send signals. Each will then have to decide whether the signals are true or false, and what they imply in terms of action. Judgement will then have to be made whether or not the actions which are so implied can be carried out, and whether or not the necessary preparations for such actions are underway. In other words, are the indices that are available consistent with the signals being transmitted? In the Cuban Missile crisis for instance the U.S. transmitted public signals to the Soviet Union that the continued presence of the missiles in Cuba was unacceptable to the U.S. and that if they were not removed, drastic action, up to and including the possibility of military invasion of Cuba, would be taken. To support these signals, the U.S. established a blockade to hinder further development of missiles and sites already in place and to prevent expansion of capacities; in addition, a high degree of mobilization was undertaken in the southern United States in preparation for the possible invasion.[2] The latter of course are indices, and there is a good deal of consistency between them and the signals. Had the indices not been present the signals would have been much less believable. It need not be inferred from this discussion of the missile crisis that the image transmitted to the Soviet Union was false. In fact, all indications are that the Kennedy administration was willing to face the risk of general war with the Soviets in order not to lose on this issue.[3] The image was probably true. Thus, this particular crisis was an instance in which signals and indices were employed by one side in order to clarify a position so that no misunderstanding could occur.

It is clear that the element of image which can be represented by the game model is the signal and not the index. A nation may transmit statements about preference orderings with or without accompanying activity, and in each case the signal would be the same. I am concerned here with the signals and will therefore not attempt any discussion of indices, but will simply acknowledge that a larger and broader investigation into conflict would need to take them into account. In order to operationalize the concept of signal, the following definitions will be employed:

Definitions

1. An image is a set of preferences with respect to outcomes. It may or may not be complete; it may or may not be accurate.

2. A signal is a transmission of an image. It may or may not be believed.

3. A deceptive signal is a transmitted image which does not correspond to the true preference set, and which is intended to influence the decisions of the other.

As has already been observed, the international conflict situation is complex and uncertain. In order to model the effects of misrepresentation on dyadic interaction it is necessary to make a number of simplifying assumptions. Some of these are re-iterations of earlier conditions, but the majority are specifically associated with the development of the idea of deception.

Assumptions

1. Preferences are strong.

2. Both players know their own true preferences.

3. In stable games, players who have dominating strategies know the true preferences of the other player, independent of any signals the other player might send. Players without dominating strategies do not know the true preferences of the other, but assume that signals represent true preferences.

This assumption is critical for several reasons. The purpose of misrepresentation is of course to induce a strategy which would otherwise not be chosen. This implies that the deceiver knows the strategy of choice, given true preferences, and that a superior outcome can be obtained if the opponent can be persuaded to choose the other strategy. Clearly, this cannot be accomplished if the other has a dominating strategy since by definition this guarantees the best possible outcome for any strategy choice by an opponent. Thus, fooling an opponent who has a dominating strategy does not affect strategic choice, and so does not change the outcome. As a consequence, if both players have dominating strategies, no change can be induced by either. Naturally, in actual conflict conditions, this does not mean that misrepresentation must be unsuccessful--each may transmit an image which is believed, but which is essentially irrelevant to strategic choice. It does mean that nothing can be added to an exposition of the logic of deception by complicating the model to incorporate this element of uncertainty. It is of course necessary to keep in mind that the probable real world situation is that neither nation knows the true preference structure of the other, but that both make estimates of that structure and transmit images in terms of those estimates. It should also be noted that it is impossible to deceive a player who has complete and accurate information. The deceptive signal would simply not be believed. Hence, it is necessary to assume that one player is informed while the other is not.

One obvious consequence of this assumption is that the only player who can be induced to choose one strategy rather than another is he who has no dominating strategy.

4. In unstable games, where neither player has a dominating strategy and both can consequently be fooled, it will first be assumed that A knows the true preferences of B, but that B must rely upon A's signals. On this basis, A's potential for deception will be explored. The situation will then be reversed so that B is assumed to be informed of A's preferences while A is ignorant except for signals.

5. Strategies are chosen on the basis of true preferences for both players if these are known. If one player is informed while the other is not, then the latter will base strategic choice upon the matrix derived from a combination of the other's signals and known true preferences.

6. Signals will always be consistent with the basic taxonomy. This means that no player will signal a preference set which is inadmissible in terms of the axioms stated in Chapter III.

Since players with dominating strategies are immune to inducements to change strategies, all games in which both players have dominating strategies are irrelevant to this analysis of deception. Thus, Games 1, 4, 5, 13, 15, 16, 18, 19, and 20 are excluded. In some of the remaining games, it is not profitable for the player with a dominating strategy to transmit a deceptive image, since, if believed, the transmission will lead to a strategy change which will produce an outcome that is inferior to the outcome that is already the rational consequence of the two preference sets. For instance, consider Game 11:

3,3	2,4
4,1	1,2

Game 11

B has a dominating strategy and is therefore not susceptible to influence. Player A, on the other hand, lacks such a strategy, and so can be induced to play either strategy, depending upon the image transmitted by B. If B transmits an image which corresponds to the true preference set--as set out in the Game matrix--then (2, 4) is the result and B obtains an advantage. Let us assume that B transmits a false image, indicating to A that the first strategy, conciliation, is dominating. The deceptive image can be achieved simply by switching the two columns for B only. To a, the matrix will look as follows:

3, 4	2, 3
4, 2	1, 1

Figure 5. 1 A Deceptive Version of Game 11

Consequently, A will obtain the maximum possible return by choosing the second strategy, aggression. B will choose the dominating strategy of the true preference set, also aggression, and war will be the outcome. In true preference terms (see Game 11), this is ranked (1, 2), and is clearly worse for B than the outcome to be derived from the strategies chosen if A knows B's true preferences. In the latter case, of course, the outcome is B*, ranked (2, 4) by the two players. Thus, deception is counter-productive for B, and, incidentally, for A. Both are better off if B is honest.

A similar situation exists in Games 2, 12, 17 and 21. In the former, A is the player with complete information, and when both act on the basis of true preferences, both obtain the most preferred outcome, which happens to be Compromise. This is Pareto optimal and is in equilibrium. B can be fooled into being aggressive by a transmission by A which makes the matrix look--to B--like the following:

3,4	1,3
4,1	2,2

Figure 5.2 A Deceptive Version of Game 2

The outcome here is of course B* (2,3) and this is jointly dominated by Compromise (4,4).

Game 12 leads to B* and is exactly like Game 11, except that for B War is preferable to Compromise. The aggressive strategy is still dominant however. Pretending that a conciliatory strategy is dominant simply pushes A into aggression, and leads to War, which is a jointly inferior outcome to B*.

In general, it may be stated that, even if one player has the capacity to deceive the other, such deception will be irrational if the outcome to be derived from the true preference sets is inferior to the outcome which results from successful deception. In practice, this means that deception is never rational if the player with the capacity to deceive is already in a position to obtain the most preferred outcome. Whenever a lower preference is the natural outcome, deception may pay off, but, of course, will again be irrational if the first condition (inferior payoff for at least the deceiver) exists. This is the case in Game 17. B has a dominating strategy--aggression--and B* (2, 3) is the outcome of strategy choices based on true preferences. Deception by B leads to Compromise (3, 2) which is, of course, better for A but worse for B. Consequently, B has no incentive to transmit deceptive images.

Two general conditions must be met for deception to be possible and worthwhile. First, the deceiver must be able to obtain an improved outcome if the other can be manoeuvred into a strategy change; second, the deceived must not have a dominating strategy. The games that satisfy these conditions are 8, 9 (both leading to War), 3 (leading to B*), 7 and 10 (both unstable). These will be grouped and analyzed by outcome. The nature of the deceptive image and the consequences it induces will first be considered; then, the dynamic effects of deception on subsequent preferences for both players will be taken into account.

Deception In Games That Lead To War

Three of the nine games that lead to war are susceptible to deceptive practices by one of the players. It has already been shown that in one of these--Game 21--deception leads to no improvement for the deceiver, and therefore it will not be reintroduced here. The two remaining games are 8 and 9. In both of these B has a dominating aggressive strategy, and since A is fearful that B will develop a commanding power advantage (i.e. B* is ranked (1) by A), War is the outcome. However, War is not the most preferred outcome for B in either game. B would rather obtain an advantage as can be seen from Figure 3.

4, 3	1, 4
3, 1	2, 2

Game 8

4, 2	1, 4
3, 1	2, 3

Game 9

Figure 5.3 The War Games in Which Deception is Possible and Profitable

The B* outcome however is clearly unattainable as long as A believes that B's preference structure is as represented in these matrices. B's problem therefore is to convince A that an alternate preference structure is the truth so that A will be induced to select the first strategy (conciliation). Assumptions 3 and 5 are relevant to this problem. The former states that B is fully informed about A's preferences, while A is dependent on B's signals: the latter specifies that strategies will be chosen on the basis of true preferences for both, if known, or on signals from one plus true preferences for the other. Thus, B will be operating with complete information, while A will have partial information (A's preferences) along with a transmitted image from B. Under these circumstances, B can examine the matrices for Games 8 and 9 and can observe that A prefers compromise to all other outcomes. Therefore if A could be persuaded to believe that B had a dominating conciliatory strategy, A would also be conciliatory. B could then act, not in terms of the deceptive image transmitted to A, but rather in terms of true preferences, and the consequence would therefore be B*, which is B's most preferred outcome. Since this is possible under Assumptions 3 and 5, B's single remaining problem is to find a deceptive image which, in accordance with Assumption 6, is consistent with the basic taxonomy. In other words, the image or images must be chosen from among the admissible sets of preference orderings presented in Chapter III. Only one of these (P1) contains a dominating first strategy. When B transmits an image corresponding to P1, then the game matrices upon which A must base strategic choice look as follows:

4,4	1,3
3,2	2,1

Deceptive Version
of Game 8

4,4	1,3
3,2	2,1

Deceptive Version
of Game 9

Figure 5.4 The Transformation by Deceptive Images of Games 8 and 9

From these it appears to A that B's Conciliatory strategy is dominating, and therefore A will also be Conciliatory since the Compromise outcome is most highly valued in both cases. Of course, A has been tricked by B, for B is operating on the basis of the matrices in Figure 5.3, and will choose an aggressive strategy in both cases. The real outcome of both games will consequently be B*.

Deception in Games that Lead to an Advantage for One Player

Though deception is possible in Games 3, 11, 12 and 17, it is only in Game 3 that it is profitable. As was shown earlier, the other three games will yield a less preferred outcome to B if B deceives A with a false image. Honesty pays, in these games at least. In addition, it should be noted that A cannot deceive B, since B has a dominating strategy. In Game 3, however, this is not the case. B obtains an advantage because A has a dominating first strategy, and therefore B can be aggressive with impunity. The problem for A is to convince B that aggression is the dominating strategy rather than conciliation. B's first strategy will then be induced in order to avoid War. This is easily done. A, given a dominating strategy, is assumed to know B's true preferences, while B is dependent upon A's signals. A's only problem, therefore, is to find an admissible preference set which is dominatingly aggressive. There are in fact three of these--P4, P5 and P6--and transmission of any one of them to B will accomplish the desired purpose, given the assumption that B must believe A's signal. The three preference sets that will serve as deceptive images in this situation form the matrices in Figure 5 when they are combined with B's true preferences.

4, 3	2, 4
3, 2	1, 1

Game 3

3, 3	1, 4
4, 2	2, 1

2, 3	1, 4
4, 2	3, 1

2, 3	1, 4
3, 2	4, 1

Figure 5.5 Three Deceptive Versions of Game 3

In each of these B is faced with a unilaterally aggressive A, and must choose a conciliatory strategy, believing that this will lead to an A* outcome in each case. This is the only way B can avoid war, which is least preferred. A, of course, will base strategic choice upon the true preferences depicted in Game 3, and will therefore be conciliatory. The actual outcome will thus be Compromise (4, 3).

Though it is true that the assumptions upon which deception is based require B to believe all A's transmissions, it is probable that in international conflict a nation in B's position will be aware that A has some deceptive potential, without necessarily being able to specify its' scope. A is therefore likely to have a credibility problem. The probability of B believing the signals sent by A will be higher if these signals are consistent with indexes of the kind discussed earlier. These will presumably reflect to some extent A's true preference structure as set out in Game 3 (see also P1), as well as being under A's manipulative control to greater or lesser degree. Consequently, the closer the deceptive image is to the true preference set, the more likely it is that it will be believable. Therefore when faced with the problem of which of the three deceptions to transmit, A will be wise to choose the image that most closely matches P1. Of course, no set will be identical to P1, since each set is unique. Of the three images set out above then, the first (using P4) is probably the best choice.

Deceptive Images in Unstable Games

In unstable games both players lack dominating strategies, and therefore both can be induced to change by the appropriately deceptive transmission from the other. Naturally, if both have the capacity to deceive, as defined in this Chapter, neither will be able to, for such capacity presumes the possession of perfect information, and this precludes the possibility of being fooled. Therefore, it will be assumed first, that A has the capacity to deceive but that B does not, and then the situation will be reversed. In this way the potential for deception of both can be explored.

Deception by A--Game 7

4, 3	1, 4
3, 2	2, 1

A's problem is to induce a conciliatory strategy by B. At present, no clear strategy choice exists, and so any outcome is as likely as another, on a probably cyclical basis. If B believed that A was dominatingly aggressive however then B's real options would be to choose between A* and War. Since A* is more preferred, the strategy containing it would be selected, B would be conciliatory, and this would give A the opportunity to also be conciliatory, thereby achieving the (4, 3) payoff associated with Compromise. Three preference sets offer A a dominatingly aggressive strategy--P4, P5 and P6. When associated with B's true preferences in Game 7 these yield the following matrices:

3, 3	1, 4
4, 2	2, 1

2, 3	1, 4
4, 2	3, 1

2, 3	1, 4
3, 2	4, 1

Figure 5.6 Three Deceptive Versions of Game 7 with A as the Deceiver

In each case, a deceived B will select the Conciliatory strategy, believing A is going to be aggressive. A however, acting upon true not deceptive preferences will also be Conciliatory and Compromise will result. As in the previous discussion of Game 3, A must decide which of the three deceptive images transmit. Again, it is logically sound to employ the image which most closely matches true preferences, and therefore A should probably choose P4. Of course, it makes no difference to this analysis, since it has been assumed that all three will be deceptive--in actual conflict however A's believability might be critical.

Deception by B--Game 7

When B is assumed to have perfect information, while A is dependent upon B's signals, B's problem is to induce conciliation in order that B can be aggressive, thus achieving B* (1, 4). Since C is ranked (4) by A, B needs a deceptive image which implies a dominatingly conciliatory strategy. P1 is the only admissible preference set which will do the job. When associated with A's true preferences the following matrix is formed:

4, 4	2, 3
3, 2	1, 1

Figure 5.7 Deception by B in Game 7

A's choice is to be conciliatory, while B--acting upon true preferences as expressed in Game 7--is aggressive, and so B* is the outcome--highly desirable for B, highly undesirable for A.

Deception by A in Game 10 (Chicken)

3, 3	2, 4
4, 2	1, 1

Game 10

When A has complete information about B's preferences, it is clear that B will be conciliatory anytime that A appears to have a dominatingly aggressive strategy. We already know, from the analysis of Game 3 and Game 7 that P4, P5 and P6 provide such a strategy. When coupled with B's true preferences, these form the following:

3, 4	1, 3
4, 2	2, 1

2, 4	1, 3
4, 2	3, 1

2, 4	1, 3
3, 2	4, 1

Figure 5. 8 Deception by A in Game 10

In each case B must be conciliatory, and therefore A can be aggressive without the risk of the (1, 1) outcome occurring.

Each of the three images will work for A. Again, the image closest to true preference is preferable in an actual conflict situation, and therefore P4 is likely to appear most believable to B.

Deception by B in Game 10

Since Game 10 is symmetrical, the deceptive opportunities available to B must be the mirror image of those available to A, and the analysis of the situation must be the same except with a reversal of roles. It will therefore suffice to state the three deceptive versions of 10 with B rather than A as the deceiver, and to note that discussion is identical with that just concluded.

3,3	2,4
4,1	1,2

3,2	2,4
4,1	1,3

3,2	2,3
4,1	1,4

Figure 5.9 Deception by B in Game 10

Game 10 is different from all other games in the taxonomy in that deception by one or other of the players cannot be detected even after the game is played. This is because the eventual strategy choice of the deceiver is consistent with the choice implied by the deceptive image. In the two versions of deception in 10 for instance, the deceiver transmits an image of dominating aggressiveness. When actual strategies are chosen, aggression is the deceiver's strategy,

based on true preferences. Therefore, it appears to the deceived that the opponents image is still true. In all other deceptive situations (3, 8, 9, and 7), the deceiver must disclose the deception in order to take advantage of it. The disclosure occurs of course when strategies are selected, and the deceiver chooses a strategy which is the opposite of the one suggested by the transmitted image. At this point, the deceived player knows that he has been had.

The implication behind this difference is that in Game 10 there exists considerable potential for long term deception which, probably, is absent from the other situations. This is somewhat disturbing in that many analysts consider Chicken to be the closest representation of the kind of confrontation that occurs periodically between the U.S. and the Soviet Union. Of course, this issue is closely connected to the broader question of dynamic transformation after deception. Just as it was argued in Chapter 4 that an outcome based on the interlocking of true preferences will affect preference structure in the future, so it can be posited that a similar impact will occur here. Of course, since the outcome after deception is different than the natural outcome, the dynamic transformations after deception will also be different. These transformations will now be explored.

Dynamic Transformations After Deception

There are seven situations where deception is possible and profitable. Four of these involve deception of A by B; the other three involve deception of B by A. The seven games are presented in Figure 5. 10 and the induced rather than the natural outcomes are underlined.

4, 3	$\underline{1, 4}$
3, 1	2, 2

8

4, 2	$\underline{1, 4}$
3, 1	2, 3

9

4, 3	$\underline{1, 4}$
3, 2	2, 1

7

3, 3	2, 4
4, 2	1, 1

10

Deception by B

$\underline{4, 3}$	2, 4
3, 2	1, 1

$\underline{4, 3}$	1, 4
3, 2	2, 1

3, 3	2, 4
$\underline{4, 2}$	1, 1

Deception by A

Figure 5. 10 Outcomes in Deceptive Games

In considering the effect of the induced outcomes on the future preferences of the players, all Axioms, Assumptions and Principles that were developed in Chapter IV will continue to be operative. Consequently, those games which lead either to War or to Compromise will be assumed to have no effect upon preferences. This eliminates Game 3, and the version of Game 7 in which A deceives B. Thus there are four games in which B* is induced and one in which A* is induced where dynamic transformations can take place. Since transformations for Game 7 and 10 have already been explored in Chapter IV and stated in Appendix II, they will not be analyzed here. It may of course be observed that deception introduces no new elements into the dynamic consequences of unstable games. The remaining two games, 8 and 9, represent preferences which lead to War as a natural outcome, but which lead to B*, when B successfully transmits a deceptive image. It should be kept in mind that the equivalent games, 8E and 9E, are situations in which A can deceive B, with equivalent results. It is therefore possible to apply to 8 and 9 the three transition models developed earlier. There will again be nine categories, based upon all possible permutations of the models. The games that result from these transitions are presented in Appendix II. As can be seen there is a great deal of regularity in the transformations.

First, it may be noted that the transformations for the Greedy Winner result in situations that lead to War, regardless of the changes by the Loser. Secondly, when the loser is unilaterally Fearful (Category I), War is again the result in every case. These consequences are of course consistent with the general principles behind both the Greedy Winner and Fearful Loser model. Third, even when the winner is Satisfied, it is necessary that the Loser maintain existing preferences--that is, remain susceptible to deception--in order for an outcome other than War to occur. For instance, as soon as (A^*_a) takes place, A acquires a dominant second strategy in both situations. Thus, War is inevitable at the second round of conflict and has only been postponed, not indefinitely deferred. Of course, this consequence is better for B than the natural outcome from the original game since B has acquired some strategic gain. When A remains in a position susceptible to deception, there is a possibility, though not a certainty that a C or A* outcome will be natural in the new circumstances. For instance, in Category III, Unilateral Change by the Satisfied Winner, Compromise is the result in six of the seven permutations of Game 8, while the seventh is unstable. In Game 9, however, four games result in War, while only two result in Compromise.

In general, it may be stated that where deception is possible and profitable in the short run the consequences over time are never worse, and are sometimes better than the natural outcome. Furthermore, the capacity of the deceiver to handle the consequence of war is enhanced, even if only to a slight extent, by the strategic advantage secured by deception. The situation from the point of view of the deceived party is somewhat paradoxical. If the Winner is Greedy, then the War that could have occurred previously if the Loser had not been deceived will occur at the next subsequent conflict, and the Loser will be weaker. However, if the Winner is Satisfied, then, in some circumstances (transformations of Game 8 and some transformations of Game 9), it is in the interest of the Loser to have been deceived, since the C outcome is preferable in all cases to W. Of course, the deceived does not know the true preferences of the deceiver, but since the aggressiveness of the deceiver was contradictory to the conciliatory image which induced a conciliatory strategy on the part of the deceived, there must be some sort of evidence of a change of heart by the Winner in order for the Loser to believe a new conciliatory image. Naturally, the Loser has no guarantee that the new evidence is not also deceptive.

ENDNOTES

[1]See especially Chapter 1.

[2]For documentation on this point see, among others Abel (1966); Allison (1971); Kennedy (1969).

[3]See Kennedy (1969), pp. 160-170.

CHAPTER VI

SUMMARY

Three main themes are developed in this essay. First is the idea that the application of the game theoretic mode of analysis to dyadic international conflict situations is more effective when substantive structural and behavioral considerations are incorporated from the outset. Second is the extension of this concept to dynamic situations. Third is an examination of the potential for deception that exists in the game theoretic formulation. In the conclusion, the main elements of each of these three themes will be briefly summarized, and an assessment of the general approach to analysis of international conflict will be made.

COMBINING GAME THEORY AND BEHAVIORAL AXIOMS IN TAXONOMIC DEVELOPMENT

Customarily, the use of games in analysis of international conflict has been restricted to Prisoner's Dilemma or Chicken, or some combination of the two. This can be enlightening for particular case studies, but it is difficult to move from these individual games to general statements about the conflict situation which they represent. In other words, this approach tends to be ideographic not nomothetic.

In order to broaden the scope of game theoretic applications, an examination of the class of 2x2 games and their utility in conflict inquiry has been undertaken. An immediate difficulty is that the class is too large (576) to be conceptually manageable. Clear patterns of relationships are obscured by the magnitude of the set. In order to reduce this number to more manageable proportions, theoretically generated constraints upon admissibility of game formulations are introduced. These are stated as Axioms of Preference for individual outcomes of the basic 2x2 paradigm of international conflict. It is found that a small number of constraints has a drastic effect on the size of the admissible set. Instead of having to consider 576 games, the researcher need only examine 21, provided the Axioms of Preference are accepted. Even further reduction is possible in that general principles concerning necessary and sufficient conditions for the occurrence of any given outcome can be established inductively from examination of the basic taxonomy. This means that the outcome of any given game can be predicted from the knowledge of a very limited number of parameters. For instance, it is possible to show (in Figure 3.8) that War will never be the outcome of any game in which W_a <u>or</u> $W_b = 1$. In other words, all that is necessary for the avoidance of War is that either player assign that outcome at least preferred ranking.

One of the most frustrating things about game theory in its present state is its static character. It is difficult, if not impossible, to develop dynamic analyses employing games because transition from one conflict point to the next does not depend upon game theoretic considerations but rather upon behavioral elements which the game model cannot incorporate. This is a particularly relevant problem if a set of games rather than an individual game is being considered. However, it is possible to apply to the set of games behavioral principles of preference transformation which are developed separately from game theoretic considerations. When these principles are applied to a given set of games the effect of any given outcome at one point in time on preference structure for the outcomes of the basic paradigm at subsequent points in time can be stated.

Dynamic transformations which are developed in this manner are superior to the traditional way of handling sequentially compounded games (iteration) in at least two important ways. First, a theoretical basis for transition is clearly stated. Whether or not the theory is acceptable is ultimately a matter of scientific validation. For that very reason, a theoretical rationale is better than an atheoretical one. It can be evaluated, and, in principle, evidence can be accumulated to support or reject, or perhaps, amend. Second, when applying game theory to a substantive area, it is obviously desirable to seek isomorphism between the main properties of the model and those of the situation being modelled. In the case of international conflict, iteration of situations occurs rarely, if ever. While the claim is not being made here that the dynamic transformations developed in this essay are completely isomorphic with the international scene, the impetus for the Axioms of Transformation is drawn from consideration of the structural properties of dyadic international conflict, and this establishes a higher degree of correspondence between the model and the real world than would otherwise exist.

DECEPTION AND IMAGES

Game theory has traditionally operated on the assumption that the preferences of the players are known and that the problem to be answered is one of optimal decision concerning strategy. Clearly this is not isomorphic with international conflict, where preference structure can be concealed at will by any or all of the parties involved. It is also not consistent with the idea that in conflict any player can seek to influence the strategic choice of the other by judiciously chosen misrepresentations of position. In order to model this function certain limiting assumptions are made in Chapter V. These are primarily concerned with structuring the model so that the deceptive potential of the paradigm can be explored. For instance, assumptions are developed concerning the degree of information possessed by specific players about the preferences of the other. These are a simplification, in the sense that the situation faced by decision makers in international conflict is one where true preferences of the opponent are rarely known, but where images (signals) which are perhaps false, perhaps contradictory, are transmitted back and forth with the intention of influencing the choices made by the other. Nevertheless, they are required if the model is to be explored.

The analysis in Chapter V demonstrated that deception can be successfully and profitably practiced in a number of games in the taxonomy. The procedure is that the deceiver transmits a false image to the opponent and thereby induces a strategic choice which would otherwise not have been made. The deceiver then acts in terms of true preferences and is thereby able to engineer an outcome which yields a higher payoff than would have occurred without deception. In most cases the deception must be revealed in order for it to be profitable. That is, the deceiver sends an image which implies a particular strategic choice. The actual choice however is the opposite of the implied choice. The only exception to this is the Game of Chicken where the implied and actual choice coincide. Thus, in Chicken, a game which is often considered to be the archetype of game models of international conflict, there is a capacity for long term deception. Naturally, this can be abrogated by the fact that both players will react to the outcome of a conflict which contains deception in the same way they react to games which do not. Their preference structure will be affected by the outcome. Thus, dynamic transformations will take place, and these are likely to alter the structure of the game in such a way that deception is no longer possible. As was demonstrated in Chapter V, the introduction of deception leads very quickly to War in many instances.

CONCLUSION

The game theoretic mode of analysis of international conflict is intuitively appealing in that the assumptions of rational choice upon which it is based and the assignment of preference structures to specified outcomes seem to parallel dyadic conflict quite closely. Clearly it is a simplification to represent complex issues and situations in 2x2 form, as if choice faced by decision makers were dichotomous. However, examination of events such as the Cuban Missile Crisis suggests that during stress there is a tendency for simplification to take place in the real world, and for opinions about the opponent to focus on the question of whether or not intentions are aggressive or conciliatory. When Russian ships were approaching the U.S. blockade, for instance, the Kennedy administration attempted to assess the contradictory messages sent by Kruschev. One was conciliatory, one was aggressive. Each represented a particular kind of preference structure with respect to the possible outcomes of the conflict. Which was to be believed? Ultimately, the U.S. stood firm, thereby making a strategic choice based upon what appear to have been the true preferences of the Kennedy Administration and a judgement that Kruschev's conciliatory communication represented his true preference's. While it is certainly possible to model this conflict in different ways (see, for instance, Allison, 1969 and 1971), there appears to be some clear merit in the game model.

This merit is enhanced when the model is combined with behaviorally grounded theoretical axioms such as those developed in this essay. While it is certainly the case that considerable difficulties stand in the way of operationalizing a logical structure of this kind (not the least of which is shortage of information about preference structures), it may be claimed that a clear theoretical formulation performs the function of clarifying ideas about the structure of conflict and provides a basis for new ideas and new applications to develop. At the least, then, such a work has heuristic value.

APPENDIXES

APPENDIXES

In all Appendixes, the games to which dynamic transformations are to be applied are listed in the column on the left of the table. The effects of the dynamic transformations are represented in the remainder of the columns. Changes for one of the players are stated by category while changes for the other are stated by columns within Categories. Thus, all games in Category I in Appendix I contain no change for B. For A, three permutations of transformations are possible and so there are three columns of new games, each column containing the impact of one permutation. In this particular Appendix, the first transformation column reflects ($A_a^* \uparrow$, the second represents ($B_a^* \downarrow$) and the third represents ($A_a^* \uparrow$, $B_a^* \downarrow$). These transformations are stated at the head of the appropriate column. Thus, in the first row, Game 3 is transformed into Games 10, 7, and 11E respectively.

If a game is transformed into a stable game, then the stable outcome is underlined. If the transformation yields an unstable game, no outcome is underlined. This format is followed throughout the three Appendixes.

APPENDIX I

DYNAMIC TRANSFORMATIONS OF STABLE GAMES

I. Fearful Loser And No Change For B

	$A_a^* \nearrow$		$B_a^* \swarrow$		$A_a^* \nearrow$ $B_a^* \swarrow$	
Game 3	3,3	2,4	4,3	1,4	3,3	1,4
	4,2	1,1	3,2	2,1	$\underline{4,2}$	2,1
	10		7		11E	
Game 4	3,3	$\underline{2,4}$	4,3	1,4	3,3	1,4
	4,1	1,2	3,1	$\underline{2,2}$	4,1	$\underline{2,2}$
	11		8		13	
Game 5	3,2	$\underline{2,4}$	4,2	1,4	3,2	1,4
	4,1	1,3	3,1	$\underline{2,3}$	4,1	$\underline{2,3}$
	11		13		13	

Game 11

3,3	$\underline{2,4}$	3,3	1,4	3,3	1,4
4,1	1,2	4,1	$\underline{2,2}$	4,1	$\underline{2,2}$
11		13		13	

Game 12

3,2	$\underline{2,4}$	3,2	1,4	3,2	1,4
4,1	1,3	4,1	$\underline{2,3}$	4,1	$\underline{2,3}$
12		14		14	

Game 17

3,2	$\underline{2,3}$	3,2	1,3	3,2	1,3
4,1	1,4	4,1	$\underline{2,4}$	4,1	$\underline{2,4}$
17		18		18	

Game 20

3,2	$\underline{2,3}$	4,2	1,3	3,2	1,3
4,1	1,4	3,1	$\underline{2,4}$	4,1	$\underline{2,4}$
17		21		18	

II. No Change For A And Greedy Winner

Game 3

$B_b^* \nearrow$		$W_b \nearrow$		$B_b^* \nearrow$ $W_b \nearrow$	
4,3	$\underline{2,4}$	4,3	$\underline{2,4}$	4,3	$\underline{2,4}$
3,2	1,1	3,1	1,2	3,1	1,2
3		4		4	

Game 4

$B_b^* \nearrow$		$W_b \nearrow$		$B_b^* \nearrow$ $W_b \nearrow$	
4,3	$\underline{2,4}$	4,2	$\underline{2,4}$	4,2	$\underline{2,4}$
3,1	1,2	3,1	1,3	3,1	1,3
4		5		5	

Game 5

$B_b^* \nearrow$		$W_b \nearrow$		$B_b^* \nearrow$ $W_b \nearrow$	
4,2	$\underline{2,4}$	4,2	$\underline{2,3}$	4,2	$\underline{2,4}$
3,1	1,3	3,1	1,4	3,1	1,3
5		20		5	

Game 11

$B_b^* \nearrow$		$W_b \nearrow$		$B_b^* \nearrow$ $W_b \nearrow$	
3,3	$\underline{2,4}$	3,2	$\underline{2,4}$	3,2	$\underline{2,4}$
4,1	1,2	4,1	1,3	4,1	1,3
11		12		12	

Game 12

3,2	2,4
4,1	1,3

12

3,2	2,3
4,1	1,4

17

3,2	2,4
4,1	1,3

12

Game 17

3,2	2,4
4,1	1,3

12

3,2	2,3
4,1	1,4

17

3,2	2,3
4,1	1,4

17

Game 20

4,2	2,4
3,1	1,3

5

4,2	2,3
3,1	1,4

20

4,2	2,3
3,1	1,4

20

III. No Change For A And Satisfied Winner

	$C_b \nearrow$	$B_b^* \swarrow$	$W_b \swarrow$	$C_b \nearrow$ $W_b \swarrow$	$C_b \nearrow$ $B_b^* \swarrow$	$B_b^* \swarrow$ $W_b \swarrow$	$C_b \nearrow$ $B_b^* \swarrow$ $W_b \swarrow$
3	$\underline{4,4}$ 2,3 3,2 1,1	$\underline{4,4}$ 2,3 3,2 1,1	4,3 $\underline{2,4}$ 3,2 1,1	$\underline{4,4}$ 2,3 3,2 1,1	$\underline{4,4}$ 2,3 3,2 1,1	$\underline{4,4}$ 2,3 3,2 1,1	$\underline{4,4}$ 2,3 3,2 1,1
	1	1	3	1	1	1	1
4	$\underline{4,4}$ 2,3 3,1 1,2	$\underline{4,4}$ 2,3 3,1 1,2	4,3 $\underline{2,4}$ 3,2 1,1	$\underline{4,4}$ 2,3 3,2 1,1	$\underline{4,4}$ 2,3 3,1 1,2	$\underline{4,4}$ 2,3 3,2 1,1	$\underline{4,4}$ 2.3 3,2 1,1
	2	2	3	1	2	1	1
5	4,3 $\underline{2,4}$ 3,1 1,2	4,2 $\underline{2,3}$ 3,1 1,4	4,3 $\underline{2,4}$ 3,1 1,2	4,3 $\underline{2,4}$ 3,1 1,2	INADMISSIBLE	$\underline{4,4}$ 2,3 3,1 1,2	$\underline{4,4}$ 2,3 3,1 1,2
	4	20	4	4		2	2

11	$\begin{array}{\|c\|c\|}\hline 3,4 & 2,3 \\ \hline 4,1 & 1,2 \\ \hline\end{array}$ 7E	$\begin{array}{\|c\|c\|}\hline 3,4 & 2,3 \\ \hline 4,1 & 1,2 \\ \hline\end{array}$ 7E	$\begin{array}{\|c\|c\|}\hline 3,3 & 2,4 \\ \hline 4,2 & 1,1 \\ \hline\end{array}$ 10	$\begin{array}{\|c\|c\|}\hline 3,4 & 2,3 \\ \hline \underline{4,2} & 1,1 \\ \hline\end{array}$ 3E	$\begin{array}{\|c\|c\|}\hline 3,4 & 2,3 \\ \hline 4,1 & 1,2 \\ \hline\end{array}$ 7E	$\begin{array}{\|c\|c\|}\hline 3,4 & 2,3 \\ \hline \underline{4,2} & 1,1 \\ \hline\end{array}$ 3E	$\begin{array}{\|c\|c\|}\hline 3,4 & 2,3 \\ \hline \underline{4,2} & 1,1 \\ \hline\end{array}$ 3E
12	$\begin{array}{\|c\|c\|}\hline 3,3 & \underline{2,4} \\ \hline 4,1 & 1,2 \\ \hline\end{array}$ 11	$\begin{array}{\|c\|c\|}\hline 3,2 & \underline{2,3} \\ \hline 4,1 & 1,4 \\ \hline\end{array}$ 17	$\begin{array}{\|c\|c\|}\hline 3,3 & \underline{2,4} \\ \hline 4,1 & 1,2 \\ \hline\end{array}$ 11	$\begin{array}{\|c\|c\|}\hline 3,3 & \underline{2,4} \\ \hline 4,1 & 1,2 \\ \hline\end{array}$ 11	INADMISSIBLE	$\begin{array}{\|c\|c\|}\hline 3,4 & 2,3 \\ \hline 4,1 & 1,2 \\ \hline\end{array}$ 7E	$\begin{array}{\|c\|c\|}\hline 3,4 & 2,3 \\ \hline 4,1 & 1,2 \\ \hline\end{array}$ 7E
17	INADMISSIBLE	INADMISSIBLE	$\begin{array}{\|c\|c\|}\hline 3,2 & \underline{2,4} \\ \hline 4,1 & 1,3 \\ \hline\end{array}$ 12	$\begin{array}{\|c\|c\|}\hline 3,4 & 2,3 \\ \hline 4,1 & 1,2 \\ \hline\end{array}$ 7E	INADMISSIBLE	INADMISSIBLE	INADMISSIBLE

20	INADMISSIBLE	INADMISSIBLE	12	2	INADMISSIBLE	INADMISSIBLE	INADMISSIBLE

Game 12:

4,2	<u>2,4</u>
3,1	1,3

Game 2:

<u>4,4</u>	2,3
3,1	1,2

IV. Fearful Loser ($A_a^* \nearrow$) And Greedy Winner

	$B_b^* \nearrow$	$W_b \nearrow$	$B_b^* \nearrow \quad W_b \nearrow$
Game 3	$\begin{array}{\|c\|c\|}\hline 3,3 & 2,4 \\ \hline 4,2 & 1,1 \\ \hline\end{array}$	$\begin{array}{\|c\|c\|}\hline 3,3 & \underline{2,4} \\ \hline 4,1 & 1,2 \\ \hline\end{array}$	$\begin{array}{\|c\|c\|}\hline 3,3 & \underline{2,4} \\ \hline 4,2 & 1,2 \\ \hline\end{array}$
	10	11	11
Game 4	$\begin{array}{\|c\|c\|}\hline 3,3 & \underline{2,4} \\ \hline 4,1 & 1,2 \\ \hline\end{array}$	$\begin{array}{\|c\|c\|}\hline 3,2 & \underline{2,4} \\ \hline 4,1 & 1,3 \\ \hline\end{array}$	$\begin{array}{\|c\|c\|}\hline 3,2 & \underline{2,4} \\ \hline 4,1 & 1,3 \\ \hline\end{array}$
	11	12	12
Game 5	$\begin{array}{\|c\|c\|}\hline 3,2 & \underline{2,4} \\ \hline 4,1 & 1,3 \\ \hline\end{array}$	$\begin{array}{\|c\|c\|}\hline 3,2 & \underline{2,3} \\ \hline 4,1 & 1,4 \\ \hline\end{array}$	$\begin{array}{\|c\|c\|}\hline 3,2 & \underline{2,4} \\ \hline 4,1 & 1,3 \\ \hline\end{array}$
Game 11	$\begin{array}{\|c\|c\|}\hline 3,3 & \underline{2,4} \\ \hline 4,1 & 1,2 \\ \hline\end{array}$	$\begin{array}{\|c\|c\|}\hline 3,2 & \underline{2,4} \\ \hline 4,1 & 1,3 \\ \hline\end{array}$	$\begin{array}{\|c\|c\|}\hline 3,2 & \underline{2,4} \\ \hline 4,1 & 1,3 \\ \hline\end{array}$
	11	12	12

Game 12

3,2	$\underline{2,4}$
4,1	1,3

12

3,2	$\underline{2,3}$
4,1	1,4

17

3,2	$\underline{2,4}$
4,1	1,3

12

Game 17

3,2	$\underline{2,4}$
4,1	1,3

12

3,2	$\underline{2,3}$
4,1	1,4

17

3,2	$\underline{2,3}$
4,1	1,4

17

Game 20

3,2	$\underline{2,4}$
4,1	1,3

12

3,2	$\underline{2,3}$
4,1	1,4

17

3,2	$\underline{2,3}$
4,1	1,4

17

V. Fearful Loser ($B^* \swarrow$) And Greedy Winner

Game 3

$B_b^* \nearrow$

4,3	1,4
3,2	3,1

7

$W_b \nearrow$

4,3	1,4
3,1	$\underline{2,2}$

8

$B_b^* \nearrow$ $W_b \nearrow$

4,3	1,4
3,1	$\underline{2,2}$

8

Game 4

4,3	1,4	4,2	1,4	4,2	1,4
3,1	$\underline{2,2}$	3,1	$\underline{2,3}$	3,1	$\underline{2,3}$
8		9		9	

Game 5

4,2	1,4	4,2	1,3	4,2	1,4
3,1	$\underline{2,3}$	3,1	$\underline{2,4}$	3,1	$\underline{2,3}$
9		21		9	

Game 11

3,3	1,4	3,2	1,4	3,2	1,4
4,1	2,2	4,1	2,3	4,1	2,3
13		14		14	

Game 12

3,2	1,4	3,2	1,3	3,2	1,4
4,1	$\underline{2,3}$	4,1	$\underline{2,4}$	4,1	$\underline{2,3}$
14		18		14	

Game 17

3,2	1,4	3,2	1,3	3,2	1,3
4,1	$\underline{2,3}$	4,1	$\underline{2,4}$	4,1	$\underline{2,4}$
14		18		18	

Game 20

4,2	1,4	4,2	1,3	4,2	1,3
3,1	2,3	3,1	2,4	3,1	2,4
9		21		21	

VI. Fearful Loser Model ($A^*_a \nearrow$, $B^*_a \swarrow$) And Greedy Winner

Game 3

$B^* \nearrow$		$W \nearrow$		$B^* \nearrow$ $W \nearrow$	
3,3	1,4	3,3	1,4	3,3	1,4
4,2	2,1	4,1	2,2	4,1	2,2
11E		13		13	

Game 4

3,3	1,4	3,2	1,4	3,2	1,4
4,1	2,3	4,1	2,3	4,1	2,3
13		14		14	

Game 5

3,2	1,4	3,2	1,3	3,2	1,4
4,1	2,3	4,1	2,4	4,1	2,3
14		18		14	

Game 11

3,3	1,4
4,1	$\underline{2,2}$

13

3,2	1,4
4,1	$\underline{2,3}$

14

3,2	1,4
4,1	$\underline{2,3}$

14

Game 12

3,2	1,4
4,1	$\underline{2,3}$

14

3,2	1,3
4,1	$\underline{2,4}$

18

3,2	1,4
4,1	$\underline{2,3}$

14

Game 17

3,2	1,4
4,1	$\underline{2,3}$

14

3,2	1,3
4,1	$\underline{2,4}$

18

3,2	1,3
4,1	$\underline{2,4}$

18

Game 20

3,2	1,4
4,1	2,3

14

3,2	1,3
4,1	2,4

18

3,2	1,3
4,1	2,4

18

VII. Fearful Loser ($A_a^* \nearrow$) And Satisfied Winner

	$C_b \nearrow$	$B_b^* \swarrow$	$W_b \swarrow$	$C_b \nearrow$ $W_b \swarrow$	$C_b \nearrow$ $B_b^* \swarrow$	$B_b^* \swarrow$ $W_b \swarrow$	$C_b \nearrow$ $W_b \swarrow$ $B_b^* \swarrow$
3	3,4 2,3 $\underline{4,2}$ 1,1 3E	3,4 2,3 $\underline{4,2}$ 1,1 3E	3,3 2,4 4,2 1,1 10	3,4 2,3 $\underline{4,2}$ 1,1 3E	3,4 2,3 $\underline{4,2}$ 1,1 3E	3,4 2,3 $\underline{4,2}$ 1,1 3E	3,4 2,3 $\underline{4,2}$ 1,1 3E
4	3,4 2,3 4,1 1,2 7E	3,4 2,3 4,1 1,2 7E	3,3 2,4 4,2 1,1 10	3,4 2,3 $\underline{4,2}$ 1,1 3E	3,4 2,3 4,1 1,2 7E	3,4 2,3 $\underline{4,2}$ 1,1 3E	3,4 2,3 $\underline{4,2}$ 1,1 3E
5	3,3 $\underline{2,4}$ 4,1 1,2 11	3,2 $\underline{2,3}$ 4,1 1,4 17	3,2 $\underline{2,4}$ 4,1 1,2 11	3,3 $\underline{2,4}$ 4,1 1,2 11	3,4 2,3 4,1 1,2 7E	3,4 2,3 4,1 1,2 7E	3,4 2,3 4,1 1,2 7E

11	$\begin{bmatrix}3,4 & 2,3\\ 4,1 & 1,2\end{bmatrix}$ 7E	$\begin{bmatrix}3,4 & 2,3\\ 4,1 & 1,2\end{bmatrix}$ 7E	$\begin{bmatrix}3,3 & 2,4\\ 4,2 & 1,1\end{bmatrix}$ 10	$\begin{bmatrix}3,4 & 2,3\\ \underline{4,2} & 1,1\end{bmatrix}$ 3E	$\begin{bmatrix}3,4 & 2,3\\ 4,1 & 1,2\end{bmatrix}$ 7E	$\begin{bmatrix}3,4 & 2,3\\ \underline{4,2} & 1,1\end{bmatrix}$ 3E	$\begin{bmatrix}3,4 & 2,3\\ \underline{4,2} & ,1,1\end{bmatrix}$ 3E
12	$\begin{bmatrix}3,3 & \underline{2,4}\\ 4,1 & 1,2\end{bmatrix}$ 11	$\begin{bmatrix}3,2 & \underline{2,3}\\ 4,1 & 1,4\end{bmatrix}$ 17	$\begin{bmatrix}3,3 & \underline{2,4}\\ 4,1 & 1,2\end{bmatrix}$ 11	$\begin{bmatrix}3,3 & \underline{2,4}\\ 4,1 & 1,2\end{bmatrix}$ 11	INADMISSIBLE	$\begin{bmatrix}3,4 & 2,3\\ 4,1 & 1,2\end{bmatrix}$ 7E	$\begin{bmatrix}3,4 & 2,3\\ 4,1 & 1,2\end{bmatrix}$ 7E
17	INADMISSIBLE	INADMISSIBLE	$\begin{bmatrix}3,2 & \underline{2,4}\\ 4,1 & 1,3\end{bmatrix}$ 12	$\begin{bmatrix}3,4 & 2,3\\ 4,1 & 1,2\end{bmatrix}$ 7E	INADMISSIBLE	INADMISSIBLE	INADMISSIBLE

20	INADMISSIBLE	INADMISSIBLE	$\begin{array}{\|c\|c\|}\hline 3,2 & \underline{2,4} \\ \hline 4,1 & 1,3 \\ \hline\end{array}$ 12	$\begin{array}{\|c\|c\|}\hline 3,4 & 2,3 \\ \hline 4,1 & 1,2 \\ \hline\end{array}$ 7E	INADMISSIBLE	INADMISSIBLE	INADMISSIBLE

VIII. Fearful Loser ($B_a^* \swarrow$ And Satisfied Winner

	$C_b \nearrow$	$B_b^* \swarrow$	$W_b \swarrow$	$C_b \nearrow$ $W_b \swarrow$	$C_b \nearrow$ $B_b^* \swarrow$	$B_b^* \swarrow$ $W_b \swarrow$	$C_b \nearrow$ $B_b^* \swarrow$ $W_b \swarrow$
3	$\begin{array}{\|c\|c\|}\hline \underline{4,4} & 1,3 \\ \hline 3,2 & 2,1 \\ \hline\end{array}$ 2E	$\begin{array}{\|c\|c\|}\hline \underline{4,4} & 1,3 \\ \hline 3,2 & 2,1 \\ \hline\end{array}$ 2E	$\begin{array}{\|c\|c\|}\hline 4,3 & 1,4 \\ \hline 3,2 & 2,1 \\ \hline\end{array}$ 7	$\begin{array}{\|c\|c\|}\hline \underline{4,4} & 1,3 \\ \hline 3,2 & 2,1 \\ \hline\end{array}$ 2E	$\begin{array}{\|c\|c\|}\hline \underline{4,4} & 1,3 \\ \hline 3,2 & 2,1 \\ \hline\end{array}$ 2E	$\begin{array}{\|c\|c\|}\hline \underline{4,4} & 1,3 \\ \hline 3,2 & 2,1 \\ \hline\end{array}$ 2E	$\begin{array}{\|c\|c\|}\hline \underline{4,4} & 1,3 \\ \hline 3,2 & 2,1 \\ \hline\end{array}$ 2E
4	$\begin{array}{\|c\|c\|}\hline \underline{4,4} & 1,3 \\ \hline 3,1 & 2,2 \\ \hline\end{array}$ 6	$\begin{array}{\|c\|c\|}\hline \underline{4,4} & 1,3 \\ \hline 3,1 & 2,2 \\ \hline\end{array}$ 6	$\begin{array}{\|c\|c\|}\hline 4,3 & 1,4 \\ \hline 3,2 & 2,1 \\ \hline\end{array}$ 7	$\begin{array}{\|c\|c\|}\hline \underline{4,4} & 1,3 \\ \hline 3,2 & 2,1 \\ \hline\end{array}$ 2E	$\begin{array}{\|c\|c\|}\hline \underline{4,4} & 1,3 \\ \hline 3,1 & 2,2 \\ \hline\end{array}$ 6	$\begin{array}{\|c\|c\|}\hline \underline{4,4} & 1,3 \\ \hline 3,2 & 2,1 \\ \hline\end{array}$ 2E	$\begin{array}{\|c\|c\|}\hline \underline{4,4} & 1,3 \\ \hline 3,2 & 2,1 \\ \hline\end{array}$ 2E

5	4,3	1,4	4,2	1,3	4,3	1,4	4,3	1,4	INADMISSIBLE	4,4	1,3	4,4	1,3
	3,1	2,2	3,1	2,4	3,1	2,2	3,1	2,2		3,1	2,2	3,1	2,2
	8		21		8		8			6		6	

11	3,4	1,3	3,4	1,3	3,3	1,4	3,4	1,3	3,4	1,3	3,4	1,3	3,4	1,3
	4,1	2,2	4,1	2,2	4,2	2,1	4,2	2,1	4,1	2,2	4,2	2,1	4,2	2,1
	8E		8E		11E		4E		8E		4E		4E	

12	3,3	1,4	3,2	1,3	3,3	1,4	3,3	1,4	INADMISSIBLE	3,4	1,3	3,4	1,3
	4,1	2,2	4,1	2,4	4,1	2,2	4,1	2,2		4,1	2,2	4,1	2,2
	13		18		13		13			8E		8E	

17	INADMISSIBLE	INADMISSIBLE	3,2 1,4 4,1 $\underline{2,3}$ 14	3,4 1,3 4,1 $\underline{2,2}$ 8E	INADMISSIBLE	INADMISSIBLE	INADMISSIBLE
20	INADMISSIBLE	INADMISSIBLE	4,2 1,4 3,1 $\underline{2,3}$ 9	$\underline{4,4}$ 1,3 3,1 2,2 6	INADMISSIBLE	INADMISSIBLE	INADMISSIBLE

IX. Fearful Loser ($A_a^* \nearrow$, $B_a^* \swarrow$) And Satisfied Winner

	$C_b \nearrow$	$B_b^* \swarrow$	$W_b \swarrow$	$C_b \nearrow$ $W_b \swarrow$	$C_b \nearrow$ $B_b^* \swarrow$	$B_b^* \swarrow$ $W_b \swarrow$	$C_b \nearrow$ $W_b \swarrow$ $B_b^* \swarrow$
3	3,4 1,3 $\underline{4,2}$ 2,1 4E	3,4 1,3 $\underline{4,2}$ 2,1 4E	3,3 1,4 $\underline{4,2}$ 2,1 11E	3,4 1,3 $\underline{4,2}$ 2,1 4E	3,4 1,3 $\underline{4,2}$ 2,1 4E	3,4 1,3 $\underline{4,2}$ 2,1 4E	3,4 1,3 $\underline{4,2}$ 2,1 4E

4	3,4	1,3	3,4	1,3	3,3	1,4	3,4	1,3	3,4	1,3	3,4	1,3	3,4	1,3
	4,1	$\underline{2,2}$	4,1	$\underline{2,2}$	$\underline{4,2}$	2,1	$\underline{4,2}$	2,1	4,1	$\underline{2,2}$	$\underline{4,2}$	2,1	$\underline{4,2}$	2,1
	8E		8E		11E		4E		8E		4E		4E	

5	3,3	1,4	3,2	1,3	3,3	1,4	3,3	1,4	INADMISSIBLE		3,4	1,3	3,4	1,3
	4,1	$\underline{2,2}$	4,1	$\underline{2,4}$	4,1	$\underline{2,2}$	4,1	$\underline{2,2}$			4,1	$\underline{2,2}$	4,1	$\underline{2,2}$
	13		18		13		13				8E		8E	

11 Identical to Category VIII For This Game

12 Identical to Category VIII For This Game

17 Identical to Category VIII For This Game

20	INADMISSIBLE	INADMISSIBLE	3,2 1,4 4,1 $\underline{2,3}$ 14	3,4 1,3 4,1 $\underline{2,2}$ 8E	INADMISSIBLE	INADMISSIBLE	INADMISSIBLE

APPENDIX II

DYNAMIC TRANSFORMATIONS OF UNSTABLE GAMES

A. Transformations After A*

I. Fearful Loser Model And No Change For A

Game 7

$B^*_b \nearrow$

4,3	1,4
3,2	2,1

7

$A^*_b \swarrow$

4,3	1,4
3,1	2,2

8

$B^*_b \nearrow$ $A^*_b \swarrow$

4,3	1,4
3,1	2,2

8

Game 10 Since this is a symmetric game, all transitions are equivalent to changes under Category I after B*.

II. Change For B And Greedy Winner

Game 7

$A^*_a \nearrow$

3,3	1,4
4,2	2,1

11E

$W_a \nearrow$

INADMISSIBLE

$A^*_a \nearrow$ $W_a \nearrow$

2,3	1,4
4,2	3,1

12E

Game 10 Symmetric. See Category VII after B*

III. No Change For B And Satisfied Winner

Game 7

$C_a \nearrow$

4,3	1,4
3,2	2,1

7

$A^*_a \swarrow$

INADMISSIBLE

$W_a \swarrow$

4,3	2,4
3,2	1,1

3

$C_a \nearrow$ $W_a \swarrow$

4,3	2,4
3,2	1,1

3

$C_a \nearrow$ $A^*_a \swarrow$

INADMISSIBLE

$A^*_a \swarrow$ $W_a \swarrow$

INADMISSIBLE

$C_a \nearrow$ $A^*_a \swarrow$ $W_a \swarrow$

INADMISSIBLE

Game 10 See unstable games after B* (Category III) for equivalent set

IV. Fearful Loser Model ($B^*_b \nearrow$) And Greedy Winner

Game 7

$A^*_a \nearrow$

3,3	1,4
4,2	2,1

11E

$W_a \nearrow$

INADMISSIBLE

$A^*_a \nearrow$ $W_a \nearrow$

2,3	1,4
4,2	3,1

12E

Game 10 Symmetric. Therefore Class I after A* is equivalent to Class I after B*. The only change is that roles are reversed.

V. Fearful Loser Model ($A^*_b \swarrow$) And Greedy Winner

Game 7

$A^*_a \nearrow$

3,3	1,4
4,1	<u>2,2</u>

13

$W_a \nearrow$

INADMISSIBLE

$A^*_a \nearrow$ $W_a \nearrow$

2,3	1,4
4,1	<u>3,2</u>

14E

Game 10 Symmetric. See Class II after B* for the equivalent set.

VI. Fearful Loser Model ($B^*_b \nearrow$, $A^*_b \swarrow$) And Greedy Winner

Game 7 Since ($B^*_b \nearrow$, $A^*_b \swarrow$) has the same effect on B's preference set as ($A^*_b \swarrow$) alone, Category VI is identical to Category V.

Game 10 By similar reasoning, it can be seen that the effect of ($A^*_b \swarrow$) alone is the same as the joint effect of ($B^*_b \nearrow$, $A^*_b \swarrow$). Therefore, Category VI for Game 10, is also Category V.

VII. Fearful Loser ($B^* \nearrow$) And Satisfied Winner

Game 7 Identical to Category III after A*.

Game 10 Identical to Category III after A*.

VIII. Fearful Loser ($A^*_b \swarrow$) And Satisfied Winner

Game 7

$C_a \nearrow$

4,3	1,4
3,1	2,2

8

$A^*_a \swarrow$

INADMISSIBLE

$W_a \swarrow$

4,3	2,4
3,1	1,2

4

$C_a \nearrow$ $W_a \swarrow$

4,3	2,4
3,1	1,2

4

$C_a \nearrow$ $A^*_a \swarrow$

INADMISSIBLE

$A^*_a \swarrow$ $W_a \swarrow$

INADMISSIBLE

$C_a \nearrow$ $A^*_a \swarrow$ $W_a \swarrow$

INADMISSIBLE

Game 10 Equivalent to Category VIII after B*.

IX. Fearful Loser ($A^*_b \swarrow$, $B^*_b \nearrow$) And Satisfied Winner

Game 7 Since $B^*_b = 4$, ($A^*_b \swarrow$, $B^*_b \nearrow$) = ($A^*_b \swarrow$). Thus this set is identical to Category VIII after A*.

Game 10 This set is equivalent to Category VIII after B*.

B. Transformations After B*

I. Fearful Loser Model And No Change For B

Game 7

$A_a^* \nearrow$

3,3	1,4
4,2	2,1

11E

$B_a^* \swarrow$

4,3	1,4
3,2	2,1

7

$A_a^* \nearrow$ $B_a^* \swarrow$

3,3	1,4
4,2	2,1

1 11E

Game 10

3,3	2,4
4,2	1,1

10

3,3	1,4
4,2	2,1

11E

3,3	1,4
4,2	2,1

11E

II. No Change For A And Greedy Winner

Game 7

$B_b^* \nearrow$

4,3	1,4
3,2	2,1

7

$W_b \nearrow$

4,3	1,4
3,1	2,2

8

$B_b^* \nearrow$ $W_b \nearrow$

4,3	1,4
3,1	2,2

8

Game 10

3,3	2,4
4,2	1,1

10

3,3	2,4
4,1	1,2

11

3,3	2,4
4,1	1,2

11

III. No Change For A and Satisfied Winner

7

$C_b \nearrow$

$\underline{4,4}$	1,3
3,2	2,1

2E

$B_b^* \swarrow$

$\underline{4,4}$	1,3
3,2	2,1

2E

$W_b \swarrow$

4,3	1,4
3,2	2,1

7

$C_b \nearrow$ $W_b \swarrow$

$\underline{4,4}$	1,3
3,2	2,1

2E

$C_b \nearrow$ $B_b^* \swarrow$

$\underline{4,4}$	1,3
3,2	2,1

2E

$B_b^* \swarrow$ $W_b \swarrow$

$\underline{4,4}$	1,3
3,2	2,1

2E

$C_b \nearrow$ $B_b^* \swarrow$ $W_b \swarrow$

$\underline{4,4}$	1,3
3,2	2,1

2E

10

3,4	2,3
$\underline{4,2}$	1,1

3E

3,4	2,3
$\underline{4,2}$	1,1

3E

3,3	2,4
4,2	1,1

10

3,4	2,3
$\underline{4,2}$	1,1

3E

3,4	2,3
$\underline{4,2}$	1,1

3E

3,4	2,3
$\underline{4,2}$	1,1

3E

3,4	2,3
$\underline{4,2}$	1,1

3E

IV. Fearful Loser Model ($A_a^* \nearrow$) And Greedy Winner

Game 7

$B_b^* \nearrow$		$W_b \nearrow$		$B_b^* \nearrow$ $W_b \nearrow$	
3,3	1,4	3,3	1,4	3,3	1,4
$\underline{4,2}$	2,1	4,1	$\underline{2,2}$	4,1	$\underline{2,2}$
11E		13		13	

Game 10

3,3	2,4	3,3	$\underline{2,4}$	3,3	$\underline{2,4}$
4,2	1,1	4,1	1,2	4,1	1,2
10		11		11	

V. Fearful Loser Model ($B_a^* \swarrow$) And Greedy Winner

Game 7

$B_b^* \nearrow$		$W_b \nearrow$		$B_b^* \nearrow$ $W_b \nearrow$	
4,3	1,4	4,3	1,4	4,3	1,4
3,2	2,1	3,1	$\underline{2,2}$	3,1	$\underline{2,2}$
7		8		8	

Game 10

3,3	1,4	3,3	1,4	3,3	1,4
$\underline{4,2}$	2,1	4,1	$\underline{2,2}$	4,1	$\underline{2,2}$
11E		13		13	

VI. Fearful Loser Model ($A_a^* \nearrow$, $B_a^* \swarrow$) And Greedy Winner

Game 7 Since the impact of ($A_a^* \nearrow$, $B_a^* \swarrow$) on Game 7 is the same as the impact of ($A_a^* \nearrow$) alone, the class VI set is identical to the class IV set.

Game 10 By similar reasoning (i.e. $B_a^* \swarrow$ is equivalent to $A_a^* \nearrow$, $B_a^* \swarrow$) the class VI set for Game 10 is the same as the class IV set.

VII. Fearful Loser ($A^*_a \nearrow$) And Satisfied Winner

	$C_b \nearrow$		$B^*_b \swarrow$		$W_b \swarrow$		$C_b \nearrow$ $W_b \swarrow$		$C_b \nearrow$ $B^*_b \swarrow$		$B^*_b \swarrow$ $W_b \swarrow$		$C_b \nearrow$ $B^*_b \swarrow$ $W_b \swarrow$	
7	3,4	1,3	3,4	1,3	3,3	1,4	3,4	1,3	3,4	1,3	3,4	1,3	3,4	1,3
	$\underline{4,2}$	2,1	$\underline{4,2}$	2,1	$\underline{4,2}$	2,1	$\underline{4,2}$	2,1	$\underline{4,2}$	2,1	$\underline{4,2}$	2,1	$\underline{4,2}$	2,1
	7		4E		4E		11E		4E		4E		4E	
10	3,4	2,3	3,4	2,3	3,3	2,4	3,4	2,3	3,4	2,3	3,4	2,3	3,4	2,3
	$\underline{4,2}$	1,1	$\underline{4,2}$	1,1	4,2	1,1	$\underline{4,2}$	1,1	$\underline{4,2}$	1,1	$\underline{4,2}$	1,1	$\underline{4,2}$	1,1
	3E		3E		10		3E		3E		3E		3E	

VIII. Fearful Loser ($B^*_a \swarrow$) And Satisfied Winner

7	$\underline{4,4}$	1,3	$\underline{4,4}$	1,3	4,3	1,4	$\underline{4,4}$	1,3	$\underline{4,4}$	1,3	$\underline{4,4}$	1,3	$\underline{4,4}$	1,3
	3,2	2,1	3,2	2,1	3,2	2,1	3,2	2,1	3,2	2,1	3,2	2,1	3,2	2,1
	2E		2E		7		2E		2E		2E		2E	

10	3,4	1,3	3,4	1,3	3,3	1,4	3,4	1,3	3,4	1,3	3,4	1,3	3,4	1,3
	4,2	2,1	4,2	2,1	4,2	2,1	4,2	2,1	4,2	2,1	4,2	2,1	4,2	2,1
	4E		4E		11E		4E		4E		4E		4E	

IX. Fearful Loser ($A^*_a \nearrow$, $B^*_a \swarrow$) And Satisfied Winner

7 Since, for A, $B^* = 1$, ($B^* \swarrow$) has no effect. Therefore ($A^* \nearrow$, $B^* \swarrow$) $\equiv$ ($A^* \nearrow$) and transitions for Game 7 are identical to Category VII.

10 Since for A, $A^* = 4$, ($A^* \nearrow$) has no effect. Therefore, ($A^* \nearrow$, $B^* \swarrow$) $\equiv$ ($B^* \swarrow$) and transitions for Game 10 are identical to Category VIII.

APPENDIX III

DYNAMIC TRANSFORMATIONS AFTER DECEPTION LEADING TO B*

I. Unilateral Change By The Fearful Loser

	$A^*_a \nearrow$		$B^*_a \swarrow$		$A^*_a \nearrow$ $B^*_a \swarrow$	
Game 8	3,3	1,4	4,3	1,4	3,3	1,4
	4,1	$\underline{2,2}$	3,1	$\underline{2,2}$	4,1	$\underline{2,2}$
	13		8		13	
Game 9	3,2	1,4	4,2	1,4	3,2	1,4
	4,1	$\underline{2,3}$	3,1	$\underline{2,3}$	4,1	$\underline{2,3}$
	14		9		14	

II. Unilateral Change By The Greedy Winner

	$B^*_b \nearrow$	$W_b \nearrow$		$B^*_b \nearrow$, $W_b \nearrow$	
Game 8	NO EFFECT	4,2	1,4	4,2	1,4
		3,1	$\underline{2,3}$	3,1	$\underline{2,3}$
		9		9	

Game 9 NO EFFECT

4,2	1,3
3,1	<u>2,4</u>

NO EFFECT

21

III. Unilateral Change By The Satisfied Winner

	$C_b \nearrow$	$B^*_b \swarrow$	$W_b \swarrow$	$C_b \nearrow$ $W_b \swarrow$	$C_b \nearrow$ $B^*_b \swarrow$	$B^*_b \swarrow$ $W_b \swarrow$	$C_b \nearrow$ $W_b \swarrow$ $B^*_b \swarrow$
8	$\underline{4,4}$	1,3	$\underline{4,4}$	1,31	4,3	1,4	$\underline{4,4}$	1,3	$\underline{4,4}$	1,3	$\underline{4,4}$	1,3	$\underline{4,4}$	1,3
	3,1	2,2	3,1	2,2	3,2	2,1	3,2	2,1	3,1	2,2	3,2	2,1	3,2	2,1
	6	6	7	2E	6	2E	2E
9	4,3	1,4	4,2	1,3	4,3	1,4	4,3	1,4	INADMISSIBLE	$\underline{4,4}$	1,3	$\underline{4,4}$	1,3
	3,1	$\underline{2,2}$	3,1	$\underline{2,4}$	3,1	$\underline{2,2}$	3,1	$\underline{2,2}$		3,1	2,2	3,1	2,2
	8	21	8	8		6	6

IV. Fearful Loser ($A^*_a \nearrow$) And Greedy Winner

	$B^*_b \nearrow$		$W_b \nearrow$		$B^*_b \nearrow$ $W_b \nearrow$	
Game 8	3,3	1,4	3,2	1,4	3,2	1,4
	4,1	2,2	4,1	2,3	4,1	2,3
	13		14		14	
Game 9	3,2	1,4	3,2	1,3	3,2	1,3
	4,1	2,3	4,1	2,4	4,1	2,4
	14		18		18	

V. Fearful Loser ($B^*_a \swarrow$) And Greedy Winner

Since $B^*_a = 1$ in Games 8 and 9, ($B^*_a \swarrow$) has no effect. Therefore, Category V is identical to Category II.

VI. Fearful Loser ($A^*_a \swarrow$, $B^*_a \swarrow$) And Greedy Winner

As noted $B^*_a = 1$, and so ($B^*_a \swarrow$) has no effect. Consequently, Category VI is identical to Category IV.

VII. Fearful Loser ($A_a^* \nearrow$) And Satisfied Winner

Game	$C_b \nearrow$	$B_b^* \swarrow$	$W_b \swarrow$	$C_b \nearrow$ $W_b \swarrow$	$C_b \nearrow$ $B_b^* \swarrow$	$B_b^* \swarrow$ $W_b \swarrow$	$C_b \nearrow$ $B_b^* \swarrow$ $W_b \swarrow$
8	3,4 1,3 4,1 $\underline{2,2}$	3,4 1,3 4,1 $\underline{2,2}$	3,3 1,4 $\underline{4,2}$ 3,1	3,4 1,3 $\underline{4,2}$ 2,1	3,4 1,3 4,1 $\underline{2,2}$	3,4 1,3 $\underline{4,2}$ 2,1	3,4 1,3 $\underline{4,2}$ 2,1
	8E	8E	11E	11E	8E	11E	11E
9	3,2 1,4 4,1 $\underline{2,2}$	3,2 1,3 4,1 $\underline{2,4}$	3,3 1,4 4,1 $\underline{2,2}$	3,3 1,4 4,1 $\underline{2,2}$	INADMISSIBLE	3,4 1,3 4,1 $\underline{2,2}$	3,4 1,3 4,1 $\underline{2,2}$
	13	18	13	13		8E	8E

VIII. Fearful Loser ($B_a^* \swarrow$) And Satisfied Winner

Since $B_a^* = 1$, in Games 8 and 9, $B_a^* \swarrow$) has no effect. Therefore, Category VIII is identical to Category III.

IX. Fearful Loser ($A_a^* \nearrow$, $B_a^* \swarrow$) And Satisfied Winner

Because ($B_a^* \swarrow$) has no effect, Category IX is identical to Category VII.

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