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A Discussion of Issues in Need of Resolution:

Toward a Specification of the

Decision Module

by

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Introduction

The goal of the project is the development of forecasting techniques to the point where alternative United States policies towards specific countries can be unambiguously ordered with respect to their utility in light of certain U.S. national objectives. As a means for attaining that goal, complex simulations of five Middle Eastern countries are being developed. The simulations consist of four modules. The oil, agriculture, and human resource modules are designed to reflect the environment that the decision makers in the various countries face. The modules describe the effects of a particular actions by the decision makers, as well as the actions that are available. In order to be in a position to evaluate the effectiveness of alternative U.S. policies toward these countries, we must know how the five Middle Eastern countries can be reasonably expected to behave. The purpose of the decision module is to give reasonable projections of the behavior of these countries (both foreign and domestic) in light of: 1) actions by the United States; 2) actions of other countries; and 3) changing "environmental" conditions, e.g., demand for oil, draught, etc. There are an infinite number of different behaviors (inputs to the three modules) that a country could exhibit (investment in agriculture, fertilizer usage level, oil production level, et cetera). The decision module must be able to determine which inputs each of the five countries can be expected to choose. The sector modules represent the choices--the decision module must make them. In addition to domestic sorts of behaviors, the decision modules must be able to reflect those foreign policy behaviors that the countries could be reasonably expected to exhibit.

Basic Properties of the Decision Module

There are three properties we believe characterize nations that have guided how we have approached the construction of the decision module: 1) Nations are goal seeking systems; 2) Nations hold a multiplicity of goals simultaneously; and 3) Nations are responsive to a perceived (rather than objective) environment.

At first glance the notion of a nation as a goal seeking system doesn't seem that unique. When we talk about the behavior of nations in ordinary (as opposed to theoretical) language terms we constantly make reference to teleological concepts, e.g., national interest or national goals. Consider a statement like the following: The Arabs cut-off our oil supply in order to influence our position on the resolution of the Middle East conflict. We are attributing to the oil producing Arab nations, goals (a preferred resolution of the Middle East conflict) and interpreting their behavior (the oil embargo) as an attempt to realize those goals. On the other hand, when we start to theorize about international relations in a scientific manner we do so in a language filled with notions of social forces (Rummel 1971) and correlates of war (Singer and Small 1972).

There are two points to be made in relation to nations as goal systems: 1) It is scientifically respectable to talk about purposive systems; and 2) Not only is it respectable, it is also fruitful to think theoretically about nations in terms of teleological systems. Social scientists still carry some of the scars that were left from the slaying of the structural -- functional dragon by the philosophers of science. Hemple (1959) and Merton's (1956) critiques of functionalism resulted in many scholars abandoning functional forms of explanation. General Systems Theory embraced the notion of telos, but the version of GST practiced in international relations strips away the heart of

the formulation, leaving only an empty input -- output shell with which to work. Many scholars in IR talk about adaptation, but one has the feeling that most of them really aren't quite sure about it, since once they leave the broad brush approach of verbal theorizing and start getting explicit, it's back to the old input -- output formulation of the nation. If one looks around at psychology, one finds a very different picture of the nature of the individual than was popular in the hey-days of behaviorism. Purposive system are respectable! As Miller, Galanter, and Pribram noted in 1960: "Once a teleological mechanism could be built out of metal and glass psychologists recognized that it was scientifically respectable to admit that they had known it all along." (Miller, et. al. 1960:43) The notion of goal seeking is central to Newell and Simon's work dealing with computer simulations of human problem solving (Newell and Simon 1972) Norbert Weiner (1961) has shown that one does not need to ascribe vital forces to an entity to call it purposive. The traditional mechanistic conceptions of behavior that we in international relations seem so comfortable with (in our theoretical work) is not incompatible with the notions of goal seeking.

A second characteristic that we believe is descriptive of nations is that they hold several goals simultaneously. As will be discussed more fully below, it is this property that differentiates efforts by economists at the specification of a firm or individual as a goal seeking system from the efforts of political scientists and psychologists to treat behavior as a product of a goal directed system. Economists can treat the firm as if it had only one goal, the maximization of profit, subject to certain constraints. On the other hand, when dealing with nations or individuals political scientists and psychologists must deal with the fact that there is no single goal which can adequately describe the operation of the system. If the goals of the system are inconsistent (as is often the case) one goal be achieved only at the expense of another. In

that case, the system (nation, organization, or individual) must determine what sorts of trade-offs are acceptable. Even if the goals are consistent, because the systems have only a finite amount of resources, all goals may not be achieved at the same time. Again the system must decide what allocation of resources is in some sense optimal.

The third characteristic that we posit of nations is probably the most well accepted in the field today. Ever since the efforts of Snyder, Bruck, and Sapin's Foreign Policy Decision Making (1962), the "man -- milieu hypothesis" of the Sprouts (Sprout and Sprout, 1956; 1965), and the investigation of crisis decision making by the Stanford group (Holsti, 1965; Holsti et. al. 1965, 1968; North et. al. 1963) scholars in international relations have realized that what counts as far as the decision maker is concerned is what the decision maker(s) perceives to be real, rather than some "objective reality" gleamed on the part of some analyst. While it is recognized that objective reality is an illusion, the efforts that have taken perceptions seriously have primarily been concerned with demonstrating the effects of perceptions of the situation. Very little has been invested in the investigation of the process of perception per se. If we are to be in a position where we can give reasonable projections of the behavior of the five Middle Eastern countries, we must determine how they process inputs from the environment. What aspects of the environment are the decision makers most sensitive to; how do they interpret those aspects; how do they react to changes in those aspects; what elements of the environment are they likely to miss because of the method by which they encode the myriad of incoming stimuli?

Prelude

These three characteristics that we posit of nations have guided the manner in which we have attempted to specify the properties that the decision module must have, and they have led to a fairly clear specification of the issues that are in need of resolution if a working decision module is to be built. The remainder of the report will consist of 1) a specification of the issues that must be resolved; and 2) a discussion of the framework with which we propose to resolve the issues.

The issues that are in need of resolution can be grouped into two classes. The first are those that are derivative from the specification of the nation as a goal seeking system. The second follow from the fact that nations cannot be adequately conceptualized as having only one goal.

The structure in which we are attempting to resolve these issues is composed of two interrelated concepts: 1) the notion of production systems as a means for expressing the operation of the decision processes within each of the five countries; and 2) the notion of a grammar which specifies the language with which the nations communicate with the domestic sector modules, channel internal bureaucratic flows, and communicate with other international actors.

Elements of Goal Seeking Systems

There are three basic elements of any goal seeking system -- receptors, effectors, and a decision mechanism. Receptors scan the environment. The decision mechanism compares the picture of the environment that the receptors send with the system's preferred environment. The decision mechanism then decides on appropriate actions to bring the environment closer to the goal and sends instructions to the effectors to take those actions. At that point the process starts again --- perceive, compare, decide, react . . . and so on. Using this notion of the nation as a goal seeking system, behavior simply becomes the system's attempt to steer or control the environment closer to some desired goal state (Cf. Simon 1969). While the notion of steering is central to the argument that Deutsch (1966) makes in his Nerves of Government, the conceptual model that he presents is very heavily influenced by the concepts of information flow and communication. Less central in his analysis is the notion of the decision mechanism and how it works.

The receptors play a very crucial role in the determination of the behavior of the system. A nation, or any other goal seeking system, cannot respond to features of the environment that it doesn't think is there. Because of the complexity of the environment that the system is surrounded by, the system cannot observe all features of the environment. The system selects some features of the environment as important and the receptors are only sensitive to changes in those features. While the problem of measurement taken on the "real" environment will always be problematical, as will be the process by which the information about the environment is transmitted to the decision mechanism, for the time being it will be assumed to be perfect. The problem now becomes

one of what sort of features of the environment are important. Since the totality of the environment cannot be scanned, some elements of that environment must be selected as important. When dealing with human systems, it is helpful to use the notion that the system has some model of how the environment works. Included within this model are the set of important variables which may impact on the ability of the nation to meet its goals. The decision maker's (or mechanism's) model of how the environment works "tells" him which feature of the environment are important and should be attended to. Thus the receptors are only sensitive to those variables that the decision maker's model says are important. It also follows from this that the environment that the decision mechanism is "really" responding to is not the environment itself but some image of the environment.

The images that the decision mechanism has of the environment it is responding to also plays a crucial role in the operation of the decision mechanism itself. The decision mechanism takes the inputs from the environment it has instructed the receptors to measure and compares that information with the stated goals of the decision system. The decision mechanism then evaluates the degree of correspondence between the goal state and the perceived state of the environment. Thus the image of the environment the decision mechanism has, specifies not only the important variables but also the relationships between them. Based upon the perceived way the world works and its perception of the degree of goal achievement, the decision mechanism determines changes in its outputs it expects will in some manner "maximize" its goal achievement. (While more will be said on the manner in which the decision mechanism makes changes in its output

variables, this basic notion will be sufficient for now.)

The only other step remaining in the functioning of the system is the communication of instructions for changes from the decision mechanism to the effectors, or the access interface with the environment (Cf. Thorson 1972). As was the case of the receptors, we shall assume the communication channel between the decision mechanism and the effectors is perfect. We will also assume the receptors are capable of carrying out the instructions of the decision mechanism.

Conceptually at least, this completes the specification of a goal seeking system. While it is known that the operation of the effectors and the receptors is by no means unproblematical -- the bureaucratic politics "paradigm" (Allison 1971, Allison and Halperin 1972) is centrally concerned with the contingent character of these processes -- it simplifies our conceptual model greatly to make this assumption. Since we have made these simplifying assumptions about the nature of the receptors and the effectors, we are now in a position to begin talking about the decision process and the role of environmental images or models in the operation of the decision mechanism. It will be recalled that there were three steps specified in the operation of the decision process: 1) A comparison of the degree of difference between the observed and goal environments; 2) The use of the decision mechanism's image of the environment to "predict" changes in the environmental state as a function of the behavior of the effectors; and 3) A choice of effector actions based upon some sort of "maximization" criteria applied to goal achievement. They will be dealt with below in the order presented above.

We really aren't sure what calculus decision makers use in determinating goal achievement. Common sense would indicate that the decision

mechanism is not physically capable of considering all goals at the same time. In fact it could be argued that the receptors are only capable of scanning a proper subset of the variables the decision mechanism would like to scan. One factor that must be dealt with is since the system cannot be equally cognizant of all goals and their associated environmental indicators, at any given point in time the decision mechanism must in some manner select those goals to which it will be attentive. The question becomes: By what process are certain goals selected for more attention than others? Another issue that becomes important in this context is, once the environment has been scanned with receptors sensitive to only a subset of the "important" variables, how does the decision mechanism rank order all possible environmental states with respect to goal achievement? Notice that for a simple decision mechanism, a servo mechanism for example, there is only one goal. In this case the process of goal attentiveness or the definition of a preference ordering of all environmental states is straight forward. Consider a servo mechanism attached to the motor of a phonograph turntable. The goal is a rotation speed of 33 1/3 revolutions per minute. The environmental state is the actual speed of the rotation. The servo mechanism can easily define a preference ordering over all environmental states. To further simplify the example let us suppose that the mechanism finds any speed other than 33 1/3 revolutions per minute equally undesirable. The system finds the decision as to which environmental variables to monitor and which goal to be attentive to unproblematical. Thus the servo mechanism has the task of monitoring the speed of the rotation of the turntable (or some analog for it) and adjusting the speed accordingly. But it is not unproblematical how often the receptors scan the environment. This point will be discussed in more detail below. In a situation

where the system is faced with two or more goals, it must somehow determine a preference ordering over all of the possible environmental states. In the case of the servo mechanism there was only one goal; instead consider the case of a person in the midst of an energy shortage. The individual has two goals -- save energy and maintain a certain level of comfort. (The fact that these goals can be considered mutually exclusive makes the point clearer, but does not imply that this relationship holds only in the case of mutually exclusive goals.) The issue the individual must face is whether saving energy or staying warm is more important. Is the dissatisfaction greater when the room is cooler than desired, but more energy is being saved -- or the situation when the room is comfortable, but energy is not being conserved? The question is not merely so simply as it was when there was only one goal. One solution that is often posed for this type of problem is the introduction of something called utility. All one needs to rank order the possible environmental states is a utility function over them. Unfortunately utility is easier posited than measured. Using the notion of utility in the above example, the vector of goal differences would be computed by subtracting the goal room temperature and the preferred energy usage rate from the actual temperature and the actual energy rate. The elements in this goal difference vector would be multiplied by a vector of utility/dimensionality constants, and the resulting scalar would be the amount of total goal dissatisfaction. Unfortunately that process carrys with it many assumptions that seem to evade empirical test. Until the problem of vector maximization has been worked out, we will have to be satified with utility -- its all we have got. As will be indicated below, this problem of preference over environmental states

crops up again when the decision mechanism is faced with determining what set of output (inputs to the environment) will maximize goal satisfaction. The resolution to this problem becomes crucial when the decision mechanism does not have the resources or the capability to achieve all of its goals at the same time.

Even though the problems outlined above have not been solved, let us assume that some suitable preference ordering over all environmental states has been achieved, and that we know how the decision mechanism evaluates the various possible mixes of environmental states. (which defines the preference ordering). The next topic that will be considered will be how the decision mechanism "decides" what is the "best" way to decrease goal dissatisfaction. The major assumption or observation about the ability of humans to make decisions that is crucial to this element of the process, is that humans do not have the capacity to consider all of the possible variables they could manipulates; they do not have sufficient information at their disposal to accomplish that task, even if they had the power to do so; and finally since the decision mechanism must depend upon its fallable mental model of how the system works, even if they had all of the information and the ability to process it, they are not sure enough how the world works to make a "best" choice. One of the first to recognize that humans were not the "all powerful and rational beings" that much of decision theory held them to be was Herbert Simon. Simon (1955) introduced the notions of satisficing and bounded rationality as descriptions of how men really behaved. Under Simon's conception of the decision process, decision makers did not search until they found the "ideal" best solution, but rather they looked until they found one that they thought was good enough. Once they found

a solution that satisfied their minimum criteria of acceptance they stopped looking. This notion of the decision process seems very close to the manner in which decision makers seem to behave. Using this conception of the decision process, the decision mechanism takes the amount of goal satisfaction and compares it with its satisficing limit. If the amount of the dissatisfaction is less than the minimum amount of dissatisfaction, the decision mechanisms declares that all is right with the world and goes back to sleep until the next measurement comes in from the receptors. An alternative conception of the decision process would posit that the decision mechanism, if it perceives any goal dissatisfaction will search for an alternative solution. But, if the initial amount of goal dissatisfaction is less than the minimum level, the decision mechanism will simply try to better the current situation -- and not search until it finds a set of inputs that it thinks will lead to complete goal attainment. Using this alternative representation of the satisficing notion, the decision mechanism always searches, but depending upon the level of the current dissatisfaction its search for alternatives will be more encompassing and further reaching if the goal achievement is below the satisficing limit. The choice between these two competing interpretations of the behavior of the decision mechanism under a satisficing sort of procedure is not really decidable on an a priori basis. It could be either way. The only way that a determination can be made is by the actual observation of decision behavior.

Once the decision mechanism has decided whether or not it is going to search, and how broadly it is going to search, the decision mechanism is faced with finding a set of outputs that will increase the current level of goal achievement. The decision mechanism uses its mental model to project the state

of the environment based upon its behavior. The mental model, as was mentioned above, is not a perfect one. One would expect that the relationship specified in the model would be fairly close to the manner in which the world really worked, (otherwise the decision mechanism would have been replaced either by some orderly means, or it might have destroyed itself). The decision mechanism searches for sets of output values for the variables that it thinks are important and checks, by means of its model, whether or not it can be reasonably expected the outputs will achieve their intended consequences. Since the model is not perfect they will make mistakes. Since the decision mechanism has some idea of how the world works, one would expect that its search for variable values would not proceed in an entirely random basis. Derived from the model and experience would be some expectations as to the effects of various outputs on the behavior of the environment. It would be expected that the decision makers would use these expectations as a guide in their search. Now it will not always be the case that the decision mechanism proceeds in a totally "rational" fashion. If the basic model that the mechanism uses to think about the environment is bad, inconsistent, or largely unspecified, the search behavior would be expected to be influenced accordingly. Another factor that would influence the pattern of search behavior would be the complexity of the conceptual model. A model, fairly complex and sensitive to the various inputs the decision maker can feed it, would be expected to result in a very different pattern of search behavior than would a model based upon some very gross and crude notions about how the world works. The search behavior could also be greatly influenced by the manner in which the decision mechanism defined its preference ordering over the environment. If it thought that one variable in particular was useful in decreasing the dissatisfaction of one of the major goals was the major goal that largely was responsible for

the under achievement it could be expected the decision mechanism would spend more time searching along that one variable for possible candidates than it would on another variable considered less central. Needless to say, the interaction between goal achievement and alternative search is strong.

While it has not been mentioned specifically, when the decision mechanism thinks that it has a possible candidate for decreasing the dissatisfaction, it uses its model to determine the expected performance of the system given those inputs. If effect the system generates the expectations of what the receptors will be sending it on the next decision cycle, contingent upon that particular set of inputs being applied to the environment. If the proposed solution takes the (or at any rate the decision mechanism thinks it takes) it further away from its goal, the decision mechanism will try a different route. On the other hand, if the mechanism perceives that a particular class of the manipulable variables is taking it closer to its goal, it will continue search in that same direction. The decision maker will continue searching until either one of two things happen: 1) A proposed input mixture brings the goal satisfaction below some level; or 2) Some sort of time or length of search limit has been reached. In the first case there are two possible interpretations for the behavior of the decision mechanism. One case, already mentioned above, is when the minimum acceptable absolute level of dissatisfaction has been reached. Another possible interpretation is that the decision mechanism does not search for some absolute level, but rather for a relative increase in goal achievement. Using this second notion, the satisficing criteria might be something like: Decrease the current dissatisfaction by 30%. The time limit criteria is needed for those cases when the decision mechanism is not able to locate a set of inputs that would bring the goal achievement up to some minimally acceptable level. Since it is assumed that there is some urgency associ-

ated with the decision process, when the time or length of search limit has been reached, the decision mechanism will take the best alternative that it has uncovered so far and use it, hoping that it can find something better next time.

There is one other point that should be made in relation to this act -- observe -- decide -- act cycle. The length of time between act and observe, i.e., how often observations are taken on the environment, has implications for the behavior of the decision mechanism. If the time period is too long, the system may experience such a deviation from the goal state that it collapses. On the other hand if the observations are taken too often, the actions of the decision mechanism may not have had time to achieve their intended consequences. If it is the case that the receptors are instructed to take observations at a rate faster than the environment is capable of responding to the decision outputs, one could expect the net effect would be the decision mechanism would over-compensate in its levels of the output variables, causing the behavior of the system to widely oscillate around the goals. Thus in the ideal case, one would want the receptors to take observations on the environment at a rate such that the environment had time to "respond" to the decision mechanism's outputs. (For some systems an appropriate rate would be somewhat slower than the environment, if it were the case that it took several environmental "cycles" for the full impact of the effector's outputs to become known.) But as was noted above, the conception that the decision mechanism can know the environment in totality is a false one. It therefore follows that if the model is to be of use the system must have some learning capabilities. The mechanism must be capable of fine tuning its model to more accurately reflect the dynamics of the environment that it is facing. What this learning process would look like is an open question, but one would expect that it would essentially involve the

comparison of the behavior of the environment with the behavior predicted by the decision mechanism's model. Based upon that comparison, one would expect there would be some sort of iterative process where changes in the mode's structure would be compared with the change in the accuracy of its predictions.

This completes the discussion of the decision process element of purposive systems. To recapitulate, the system is composed of receptors that scan the environment on certain key variables, a decision mechanism which determines the level of goal achievement and chooses an appropriate strategy determined by the decision mechanism. The next part of this paper will be a consideration of the applicability of some goal seeking systems approaches that have been used in economics to ascess their applicability to the field of international relations.

Single versus Multiple Goal Seeking Systems

While both psychology and economics have used the concept of goal seeking as the basis for the analysis of human behavior, economics with its "rational man" model has probably invested more time and resources into questions of goal seeking behavior than any of the other social sciences. Of particular interest to political scientists has been the work dealing with theories of the firm. In the theories of the firm, economics has been centrally concerned with Simon's concepts of satisficing and bounded rationality (in fact, Simon introduced those concepts in order to deal with the behavior of the firm). One recent attempt to deal with this problem has been the work of Nelson, Winter, and Schuette on technological growth and evolutionary change (Nelson and Winter 1972, 1973; and Nelson, Winter, and Schuette 1973). While this is not the place to go into a detailed discussion of what their theory of growth looks like, the following observations can be made about it.

Nelson et. al. have modeled their firms (or goal seeking systems) as facing an environment of prices, labor, and capital. The goal of the system is to maximize profits. The amount of the good the firms produce is determined by the investment of capital and labor. The constraints the firms face deal with the wage rate and the price that they can get for their product. The question that Nelson et. al. are attempting to deal with is what are the dynamics that will lead a firm to use different scales of production, i.e., the amount of labor and capital, in attempting to maximize their profit.

As was discussed earlier, a goal seeking system must have three elements -- effectors, a decision mechanism, and receptors. In order to evaluate the Nelson et. al. formulation, these three structures in their theory will be analyzed. As is often the case with social theorizing, Nelson et. al. have assumed away receptors and effectors by allowing their firms to have perfect perception and control. In other words the effectors carry out exactly the directions of the decision mechanism, and the receptors perfectly measure the profit for the current input coefficients (labor and capital). The element of the system that Nelson et. al. pay most attention to is the operation of the decision mechanism. As will be recalled from the above discussion, some properties of the decision mechanism are the inability to be "globally rational", and the use of models of the environment to predict or forecast the behavior of the environment contingent upon certain outputs from the system. Nelson et. al. deal with the satisficing notions of Simon by setting a minimum level of return on investment that the firms will be satisfied with. This minimum level of profit is the satisficing limit discussed above. They further incorporate the notions of search for alternatives by positing that their firms, when faced with a profit level below their satisficing limit, will search for alternative input coefficients to increase their profit above

the minimum level. In their specification of the search algorithm for their firms, Nelson et. al. posit the firm will search for and consider a larger range of alternatives the greater their dissatisfaction. This is not saying that a larger number of alternatives will be considered, but rather the probability an alternative very "far" from the current set of input coefficients will be considered is greater, the greater is the dissatisfaction with the current set of input coefficients. Nelson and Winter also give their decision mechanism a model of the environment with which to test the profitability of a given alternative. The model the firms employ to forecast the effects of a given level of labor and capital does not perfectly reflect the actual behavior of the environment. The model distorts the proposed input coefficients according to a probabilistic sort of procedure so that the decision mechanism has an equal chance of under or over estimating the profitability of a given set of input coefficients.

It seems that Nelson et. al. have included most of those elements of goal seeking systems that were mentioned. Unfortunately the one that they don't deal with, while not crucial to their work in economics, seriously detracts from the applicability of their work in international relations. It will be recalled that one of the problems that the decision mechanism must face is the definition of a preference ordering over all environmental states. As was pointed out, this problem is not too difficult when only one goal is being held by the decision mechanism, but it reaches very great and problematical proportions when the single goal restriction is lifted. While the assumption of a single goaled system is central to economic theory, when we think about international relations, we see that the nations hold more than one goal at the same time. It is not that the problem of multi-goaled systems cannot be handled, but just that the conceptualization necessary

becomes a conceptualization of a different kind. Somehow the notions of multiple goals, how they are weighted, the factors influencing their weight, and how they change over time must be dealt with. Before we can start to talk about the behavior of a nation under some form of the satisficing criteria, we must have a very definite notion of what the decision mechanism is attempting to maximize. Thus the crucial difference between goal seeking systems economists have developed and the goal seeking systems international relations scholars would like to develop, while being of the same class, are of very different types. Where economics can make the assumption that the sole goal of the firm is to maximize profits, international relations is not in a position to posit some single thing that nations maximize (other than utility). Thus in order for international relations to make use of the goal seeking systems approaches that have benefitted economics, additional conceptualization will be required.

Multi-Goal Seeking Systems

When one leaves the realm of single goal seeking systems two problems immediately arise: 1) How does the decision system rank order the goals in terms of importance; and 2) How do the goals of the decision system change as a function of time, the environment, and experience? The question of ranking becomes crucial since it will be the case that either the goals are inconsistent, i.e., one goal can be achieved only at the expense of another, or because of finite resources not all goals can be achieved at the same time. In order for a decision system to operate in such an environment, it is necessary that the decision system somehow rank the goals in terms of importance. This ranking or ordering of goals has several implications for the operation of the decision mechanism. As will be recalled from the above discussion on goal seeking systems, the system cannot be attentive

to all aspects of the environment at the same time. It must choose those aspects of the environment that it is trying to control will be paid attention to. These facets of the environment that the system will monitor will be influenced by the goals that the system is attempting to achieve (it will monitor the performance of variables that reflect the amount of goal attainment). The causal image the system has of the environment will also influence those aspects of the environment to which it will be attentive. Given the same goal (reduce inflation), depending upon the causal image that the decision system has of the environment (Friedman or Samuelson) the system will pay more attention to a particular economic indicator than the other. It will also apply different controls depending upon the causal theory. Thus the behavior of the system is a function of 1) the goals that it has; and 2) the causal theory or image the system has of the environment. Since both the causal theory and the goal structure is open to change, knowledge of only one of them is insufficient for the determination of the behavior of the system. This brings out the importance of goal change. In order to give reasonable sorts of forecasts of the behavior of the system we must know how the goals of the decision system change. The goals of a system can change in two sorts of ways. Either the ordering of the goal structure may change, or the content of the goal structure may shift. This second sort of change can either be a result of old goals being deleted, new goals being introduced, or both. It therefore becomes important to know by what process and under what influences the goals are ordered, and the nature of goal change.

Just about the only effort to date that has seriously considered the nature of goal rankings and change has been the work of Bossel and Hughes (1973) in the context of the Mesarovic-Pestel World Model Project. As an aid to the identification of the issues involved when dealing with multi-goaled

decision systems, their work will be discussed from the perspective of the issues that they see as important and their attempt at their resolution.

Bossel and Hughes make the argument that the normative components of a decision system are hierarchically ordered sets of three types: values, general goals, and operational goals or norms. For Bossel and Hughes, there is no clear distinction between these three types of normative elements. The only thing that distinguishes a value from a general goal is the level in the hierarchy (or abstractness) of the component. Values, or superior norms, give an overall direction to the decision making effort; general goals are determined from the values and control the policy choice; operational goals or norms derive from the general goals and control the individual decisions. As an example consider the value of the system to be survival. From this value there might be the general goals of preservation of vital resources and the maintenance of health. Flowing down from these two goals might be the operational goals or norms of saving energy, saving water, save materials (from resource preservation), and moderation in eating, drinking, and work (from the preservation of health). Bossel and Hughes have conceptualized this collection of norm elements as being the nodes of a tree graph. See Figure I for an illustration of this norm structure taken from Bossel and Hughes. Bossel and Hughes characterize the norms structure as follows:

- Norms are characterized by location in the normative structure.
- The quantities characterizing norms (location, content, weight) and the dynamics of norms change are fuzzy concepts.
- Inconsistencies with the norms stratum (with respect to structure, content, and weight) will tend to be minimized.
- Norms contents are generally expressed as verbal statements.
- Norms contents and structures generally change by discrete amounts.
- As relative norms weight decreases, the relative uncertainties associated with norms location, content, and weight increase.

(Bossel and Hughes 1973: Sec. 3.2)

The notion of location has already been discussed; it refers to the position of the node in the graph. The content or state of a norm (node) is the statement associated with it, e.g., preserve vital resources. The weight associated with a norm rank orders the norm with respect to the needs (or desires) of the system. Under Bossel and Hughes' conceptualization of the norm or value structure, the weights are subject to dynamic change as a result of changes in superior norms and of real or imagined consts and benefits derived from holding and applying a certain norm. Bossel and Hughes point out that different weights to the norms at different times will give rise to quite different decisions about comparable issues. This falls in line with the above discussion about the importance of goal orderings for the behavior of the decision system. Bossel and Hughes have conceptualized the manner in which weights influence the decision process by stating that the content and weight of the values (abstract goals) will determine the content of the operational goals (the specific things the decision system wants to achieve) and the manner in which the system will order the goals, the weights.

The way Bossel and Hughes have conceptualized the norms structure, there are three modes of change of the norms structure: 1) there may be a change of the norms content; 2) there may be a change in the structure; and 3) there may be a change of the norm weights. A change in the norms content means that while the linkages between the various norms in the structure remains unchanged, but the meaning of a particular node in the structure is altered. A change in the structure means that either new linkages are formed between existing norms, or that an additional norm or value is introduced into the existing structure. A change in the weight means that the importance of a particular norm to the system changes. It is important to note that weight implies importance to the system irrespective of the state

of the environment. For example if the maintainence of an adequate supply of water is a goal of the system, no matter how much water there is in the environment, the weight of the particular norm concerned with the necessity of water will remain unchanged. Now it will be the case that the operational goal of the system pertaining to water conservation will be relaxed, i.e., the system will not have as one of its primary goals the conservation of water.

Bossel and Hughes have posited four basic mechanisms that are responsible for changes in the norms structure: 1) adoption; 2) adaption; 3) imposition; and 4) diffusion. The first two types of mechanisms are what could be considered conscious. The structure is changed by the process of adoption by the conscious change of an old norm of the planned introduction of a new one, or the willful change of norm weights. Bossel and Hughes state that this process is undertaken as the result of observation of the environment, and that usually it will take the form of adoption of a norm from a list of ranked priorities which the system keeps and modifies according to the circumstances it finds itself in with respect to the environment. The norm will be adopted if the system "thinks" it will be able to handle the consequences. Imposition is a change dictated by an outside force. An example are the norms and values imposed by occupational forces. The norms structure is changed through the process of adaption in response to either changes in the environment or within the system itself. Adaption is much like adoption except that it is not a conscious change and generally takes place at a rate much slower than imposition (which is the fastest) or adoption. The process of diffusion is a means toward consistency within the norms structure itself and is not an autonomous source of change. The processes of adaption, imposition, and adoption will generally affect only portions of the structure.

The process of diffusion attempts to reconcile these changes with the rest of the value structure. The diffusion process can take place either from the top down (what Bossel and Hughes call downward diffusion) or from the bottom up (upward diffusion). In the case of bottom up diffusion, superior norms are changed in response to changes in lower or inferior norms. Top down diffusion is just the reverse -- lower norms are changed in response to an initial change in the upper portion of the norms structure.

In order to link the norms structure to the decision process and the environment, Bossel and Hughes introduce the concept of monitor variables. As can be seen in Figure 1, assigned to each operational norm or goal is a monitor variable. Paired with the operational goal of save energy is the monitor variable measuring the current energy supply. Now it will not generally be the case that there will be a one to one pairing of monitor variables and goals. The system determines the monitor variables as a function of the specific goals in addition to the causal image the system has of the environment it faces. The manner in which Bossel and Hughes have conceptualized the linkage between monitor variables and the system's goals is at the top of the hierarchy and not at the specific operational goals. For illustrative purposes consider the example that Bossel and Hughes use in their simulation of a valued controlled decision system. The simulation is concerned with the energy sector. Sample nodes from the value structure are concern about the future, concern about dependence on imports, concern about the harmful effects of pollution. A few of the goals are level of energy imports, goal for industrial output per capita, and the energy consumption per capita. Examples of the monitor variables that they use are level of industrial development, perceived level of pollution, negative balance of payments, and uncertainty about technological progress with respect to energy supply. As they have conceptualized it, changes in monitor variables

will cause changes in the values. These changes in the value structure will cause additional changes in the values because of their interrelated nature. The combined effects of changes in the values caused by the monitor variables and internal value changes will result in the change of specific goals of the system. If it were the case that the monitor variable, perceived level of pollution increased, one would expect changes in the values of expectations about the standard of living, harmful effects of pollution, and concern about the efficiency of energy usage. These changes could be expected to decrease the specific goal of energy consumption per capita.

While Bossel and Hughes talk about changes in the content, weight, and location of values through the processes of adoption, adaption, imposition, and diffusion they only simulate and get explicit about changes in the weights of the various norms through the processes of adoption (the effects of monitor variables on values) and diffusion (the effects of changes in values on the value structure itself). They do not explicitly state exactly how the processes of adaption and imposition work. Nor do they begin to deal with changes in the content and location of the value nodes. While this is not meant to degrade their efforts, it does point out how far we have to go in order to begin to talk about the process of change in the value or norms structure. They are one of the few to have recognized that the problem even exists.

Currently our efforts in regard to the goal structure of the five Middle Eastern nations is primarily directed toward the identification of the goals (at all levels of abstraction). Exactly how we propose to incorporate the elements of value controlled decision making in our simulations will be discussed more fully below. It is our predeliction to embed the normative components of the decision process directly into the simulation structure, rather than have it as a separate structure as Bossel and Hughes have done.

Production Systems: A Theory and Language for Process Models

Allen Newell has stated that with regards to cognitive psychology in order to "predict (the behavior of) a subject you must know: (1) his goals; (2) the structure of the task environment; and (3) the invariant structure of his processing mechanisms. (Newell 1973a:293) Since Newell et. al. have approached the simulation of cognitive psychology from an information processing standpoint, in the same manner as we view the nation, we feel that there is much to be gained from the cognitive psychology literature. The notion of goals has been discussed previously. The structure of the task environment is identical to the manner in which the system perceives the environment it is attempting to control. Production systems represent a means for expressing the third element in Newell's list -- the structure of the processing mechanism.

When one sets out to build a process theory or model of some phenomenon, one of the first steps is the identification and exposition of the constituent parts of the system. In the case of Bossel and Hughes, they developed the notions of value, diffusion, weight, et cetera. Once the parts and sub-processes of the system have been identified, they must be put together to form a process model. As Newell (1973a) has pointed out, this putting together of the parts of the model is generally an informal affair, very poorly specified. What Newell has called the control structure is rarely specified. The control structure specifies how the system is to be coordinated, the timing of the various events, what order certain operations, tests, and processes are to be performed, and the step by step operation of the various processes. It generally seems to be the case that the control structure is ignored by the theoreticians and specified by the computer programmers (and even the programming language writers). The theoriticians may be able to give some theoretical basis for a general flowchart of the operations of

the system, but a flow diagram is much too informal a method for the specification of theory. Very often the choice of a programming language will go a long way toward the specification of the control structure. The sequencing of the computations in a program, even large blocs of code may be determined by the pecularities of the programming language. The programming language will actually control the way in which the theory can be expressed. What passes notice in many efforts is that the "architecture of the system" has very real implications for the operation of the system and the predictions that it makes. Common programming languages are not neutral affairs. The common problem orientated programming languages (FORTRAN, COBOL, PL/1) were designed to be neutral only for a very specific class of problems. FORTRAN (FORmula TRANslator) was designed to handle algebraic sorts of manipulations. As long as the problem involves simple computing of numbers FORTRAN is neutral. But if the problem contains more than just a system of algebraic equations, FORTRAN is a very biased language. Some operations are simply impossible to execute in FORTRAN. Unfortunately theories are not always simply strings of addition and subtraction. If an inappropriate language is used, the theory must often be compromised because of restrictions and pecularities of the programming language. At the same time, there is too much freedom since the general purpose language will "allow" choices to be made about the architecture of the system that have serious implications for the way the theory works. Very often it is not realized that the choice has even been made.

Production systems represent a different form for describing processing models -- a theory laden programming structure. Production systems explicitly incorporate theoretical assumptions. They restrict the types of expressions allowable in the language , and provide a means of expressing the control structure explicitly. In fact they force one to be explicit about the control structure by making it an integral part of the specification of the process. Production

systems have been used in psychology (Newell, 1973b,1966; Newell and Simon, 1972) for the expression of theories of human problem solving. As will be discussed in the section on grammar, production systems also have another use -- the specification of a language along with grammatical sentences in that language. Thus we will be using production systems in two senses. One for the specification of the processes, and secondly for the way in which the nations communicate with the environment.

Processing models written as production systems are formed by a collection of independent rules, called productions.* The rules (or productions) are stated in the form of a condition and an action: C→A. The condition refers to the symbols in the short-term memory (STM) of the system. (The role of STM in national decision systems will be discussed more fully below. For the time being it will be sufficient to note that the STM is in effect a stack of symbols.) The contents of STM represents the goals and knowledge elements existing in the system's knowledge state. As Klahr (1973:528) has put it, the actions of the productions "consists of transformations on STM including the generation, interpretation, and satisfaction of goals, modification of existing elements, and addition of new ones." A production system obeys simple operating rules:

i. The productions are considered in sequence, starting with the first.
ii. Each condition is compared with the current state of knowledge in the system, as represented by the symbols in STM. If all of the elements in a condition can be matched with elements (in any order) in STM, then the condition is satisfied.
iii. If a condition is not satisfied, the next production rule in the ordered list of production rules is considered.
iv. If a condition is satisfied, the actions to the right of the arrow are taken. Then the production system is reentered from the top (Step i).
v. When a condition is satisfied, all those STM elements that were matched are moved to the front of STM.
vi. Actions can change the state of goals, replace elements, apply operators, or add elements to STM.
vii. The STM is a stack in which a new element appears at the top pushing all else in the stack down one position. Since STM is limited in size, elements may be lost. (Klahr 1973: 528-529)

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* This discussion of production systems relies heavily on Klahr (1973)

As a simple example of a production system consider the illustration in Figure II. The first four lines are the individual productions. The fifth is the short term memory (STM). The operation of the production system starts at the top. The condition for the first production is AA and BB. Since these two elements are not in STM, the next production is checked. It is not satisfied. This process continues until production 4 is checked. The symbol AA is in STM. This production is then executed, and the symbols CC and DD are placed in the STM. This causes the last two symbols in STM, RR and SS, to be lost, since the maximum number of symbols in the STM is five. Control is then passed to the top of the production system and the first production is checked. The first production that is satisfied is production 3. As is explained in the above list of rules, those symbols that satisfy the production are moved to the top of the STM. Thus the STM before the action portion of the production is executed is: (DD (EE FF) CC AA QQ). Production 3 results in the symbol BB being placed in the STM, and QQ is lost. Notice that even though production 4 is also satisfied, it is not executed. Only the first production in the list that is satisfied is executed. (If it happened that no production were satisfied, the program would form an infinite loop.) Control is then passed to the first production. The condition portion of the production is specified and the action taken. The OLD ** operator is a replacement operation that modifies the contents of STM. After the matched symbols have been moved to the top of STM the first symbol in STM is replaced by (OLD **), where ** is replaced by the first symbol. Thus after the action is taken, the contents of STM is: ((OLD AA) BB DD (EE FF) CC). The system then loops back to the top and production 2 is evoked. The effect is to move the test symbols CC and BB to the top of the STM and to emitt the statement III. On the next

cycle, production 2 is again satisfied and the system says HI. The system as written will continue to cycle through saying HI until someone pulls the computer's plug. If the second production had been written as: (CC and BB → (SAY HI) (OLD**)), and the following production inserted immediately before production 2: ((OLD CC) → (STOP)), the system would have shut itself off after saying HI once.

One of the striking things about production systems is that the control structure is exposed. The order in which the productions are ordered has very real consequences for the operation of the system. If production 4 were moved to the top, the system would have continuously cycled through executing that production forever. While this system may not be the best example, the behavior of the production system is very much influenced by the order in which they are executed. The next production system is an instance where the order of the productions will make a great difference in the behavior of the system.

The production system in Figure III is an example with more theoretical interest than the preceeding one. (Although it should be noted that in terms of complexity and the resolution of the issues raised in this report, the system in Figure III bears about as much resemblance to our goal as does the flowchart for making fudge that is used as an illustration of a program in introductory programming texts.) The production system in Figure III is a system that attempts to describe the behavior of the Libyan Revolutionary Command Council. Recently Kaddafi was asked to step down from his political-diplomatic position but retain his position as Commander-in-Chief of the Libyan armed forces. The example production system is an attempt to specify those conditions under which the Council will request that Kadaffi step down (or go to the desert for meditation). This production system was built upon the assumption that the reasons that Kaddafi was asked to step down amount to the perception on the part

of the members of the Council that things are not going well for Libya. Some of the indicators or monitor variables that the Council might consider are: fiscal irresponsibility, food shortages, excessive religious orthodoxy. It was also assumed that the Council was more willing to ignore some of the bad points if there were favorable aspects of the situation to off-set the bad points (or as they are expressed in the production system, marks). Thus if Sadat looses face, there is an increase in skilled labor, or if there is a food surplus (relatively), the council will overlook some of the bad points about Kaddafi's management. If it is the case that even with the good points, Kaddafi has managed to accumulate four marks, the Council will request his resignation. The actual operation of the production system is very much like the preceeding example. Initially the STM of the Council is filled with NIL or blank symbols. Since none of the first 15 productions will be satisfied, the sixteenth production, which contains no condition and will always be executed if none of the other productions are satisfied. The action READ means that the Council looks at the environment and takes a reading of the current state. As long as the symbol read from the environment does not invoke a production, the system will continue reading until one is found. Let us say that the first "recognizable" symbol is a food shortage. After it is placed in the STM by the READ operation, production 5 will be executed. This results in FOOD SHORTAGE being marked as OLD. This prevents the system from counting FOOD SHORTAGE twice, since FOOD SHORTAGE and (OLD FOOD SHORTAGE) are not the same. The production also reaults in a MARK being placed in STM. If at any time, Kaddafi has supported four radical foreign causes with no noticable achievement, production 7 is executed, which results in all four supports of radical foreign causes being marked as old, and the addition of a MARK to the STM. If it happens that there is an increase in skilled labor when there is also

a MARK in STM, both the skilled labor increase and the MARK are masked. In essense, one of the strikes is erased -- although it still takes up a position in the STM. If at any time, Kadafi has managed to accumulate four MARKS, the symbol REQUEST will be placed in STM. This results in the Revolutionary Command Council asking Kadaffi for his resignation.

This production system is a better illustration of the presense of the control structure than was the previous one. Notice that all of the productions that erase 'marks' from the STM are at the end of the system. This means that a mark can only be erased if there are no 'bad things' in the STM. If the set of productions that erased marks were to be moved to the top of the system, the chance for an erasure would be greater (and the chance for removal less). If production 3 were placed at the end, the only time that Kadaffi would be asked to step down would be when neither anything good or bad was happening. If it were inserted after production 11, the only time that he would be asked to go the desert is when he had accumulated four strikes, and at the present time all was going well, i.e., the short term memory was filled either with junk or positive symbols. Depending upon the sorts of things that the Council could be expected to receive from the environment, by rearanging the individual productions, the chance that Kadaffi would be requested to step down could ba varied. Thus it is not enough to say that fiscal irresponsibility and food shortages count against Kadaffi in the eyes of the Council. One must be more specific about exactly what the conditions are that will cause the Council to request his removal.

This completes the general discussion of production systems. Before going on to discuss the role of language and the notion of a grammar, it would be useful to discuss a little more fully how we intend to structure the production systems for the decision modules of the five countries, and

exactly what properties we feel must be represented in the productions if they are to be of use in the generation of reasonable forecasts of behavior. As was discussed above, one of the prime assumptions we are making about nations is that they react to a perceived environment. All nations are at least in principle capable of recieving the same observations from the environment. But nations do not all react the same way to environmental conditions. In addition to the fact that there are obvious distinctions according to the face of the issue (the oil embargo was favored by the oil producing Arabs, or Saudi Arabia is in favor of lower oil prices but Iran is not) there are also cases of misperception. If the decision modules for the various countries are to be capable of making such distinctions, they must have some capacity to take incoming messages from the environment and interpret them according to the beliefs, presumptions, presuppositions, and biases peculiar to the decision makers in each of the countries. Thus based upon the contents of the STM of the national decision system, elements recalled form long term memory, and Newell's invariant processing routines, the system must decode the raw stimulus or message into the cognitive map of the decision makers. The production system must also have the capability to rewrite the goals of the system based upon experience according to some predefined process. The production system must have the capability of rewriting the perceptual coding rule, and well as changing those features of the environment to which the decision mechanism is attentive. The production rules must allow the generation of responses to incoming messages from the environment. The productions should invoke a cognitive image of the environment in its attempts to determine appropriate reactions. In other words, the production systems must be able to make decisions. The system must take incoming messages about the status of the environment, interpret these inputs according to the peculiarities of the decision system,

evaluate the current goal satisfaction, make trade-off decisions about resource investment towards the achievement of certain goals, determine appropriate actions that will increase the amount of goal satisfaction, and put those actions into operation. At the same time, the system must evaluate goals and their achievement and make appropriate changes in the goal structure. As was mentioned in the section on multi-goaled decision making, we intend to embed the goals and their rewrite rules (change process) directly within the production system rather than conceptualize it as a separate and independent structure. Another structural decision that we have made is not to treat the nation as a single decision system, but rather introduce some of the notions of bureaucratic politics (Allison 1971; Allison and Halperin 1972; among others) into the decision process. The finest level of detail that we anticipate including in the simulation is bureaus or ministries. The detail required to model specific individuals would be too great and would probably not add any accuracy to the final product -- the error factor in the specification of the individual characteristics would be fairly high. This is not to say that we will ignore specific individuals where they have a strong influence on the operation and outputs of various sub-structures in the national bureaucracy.

As the project is currently conceptualized there are essentially two types of communication linkages that must be dealt with: 1) the linkage between the national decision system and the environment; and 2) the internal communication between the various bureaus and ministries. The first is essential since the decision mechanism must have some means for determining the current status of goal achievement and it must be capable of effecting the environment with its actions. If we are to model the national decision system as a composite bureaucracy, the various levels in the bureaucracy must have the capability of communicating with each other. We propose to create these

linkages by means of a language and its associated grammar -- a language of policy behavior and a language of internal directives and communications.

The Role of Language and a Grammar

When we communicate with another person or a computer we do so by using a set of symbols that we both are able to perceive, and in addition only certain strings of those symbols make sense (or convey the intended meaning). We can't communicate with a computer by shouting at it, since it cannot perceive our attempts to communicate. In addition we can't just tell it anything, since it has the capability of making sense out of very specific strings of special symbols. The system that we use to communicate is called a language, the symbols are elements of the alphabet of that language, and the rules for forming possibly intelligible strings of symbols is called a grammar. The grammar will not insure that the meaning that was intended is actually conveyed, since others can misinterpret what we had intended. It is also the case that the context in which the sentence is communicated will affect the meaning. Even though the sentence: "My dog has fleas" is grammatical, if we were to walk up to a stranger and utter that sentence, he would not know what we were talking about. The sentence "Green dreams sleep quietly." might be considered a grammatical sentence but it does not make sense in any context. The basis for communication is a language, and the rules for creating acceptable sentences in that language is the grammar. What we intend to do is to construct a language and its associated grammar for the specification of the behaviors of the national decision systems. The only actions that the systems will be capable of generating will be grammatical sentences in the language that we specify. Any information that enters the national decision system must be a grammatical sentence in the language or else the system cannot decode the string of symbols to determine its meaning.

communications between the various parts of the decision system must also be in the proper form or no meaning will be conveyed. Any actions that a nation takes in attempting to control its environment must be in the proper form if it is to have any impact on the environment (one cannot just tell inflation to go away) and if other nations or actors in the system are to be able to understand the action.

This notion of a grammar is really not as alien to the field of international relations as first might be imagined. One of the main sources or types of data that has been used in the field is events data. (McClelland and Young 1969; Hermann et. al. 1974). Events are actions by national decision systems, and events data simply represents the coding of these actions a single coding scheme, generally of the form: action, actor, target. Language is very much like a coding scheme. It is the representation (coding) of meaning according to a set of rules (a grammar). Our approach to the representation of action differs from the standard events data approach in two respects. The first difference is in the level of detail (the information content of the event). A common events coding category is official diplomatic protest. While there has been some effort to also include in the coding scheme the context of the protest, in all cases almost all of the actual content (what the protest was about) has not been coded. While we can conceive of situations in which one could make sense out of correlations between event type categories, we find it impossible to begin to build a process model of international relations in which the only means of communication between the various national bureaucracies is by contentless statements. In order to go beyond the type of theorizing that says that if a nation receives a diplomatic protest it will respond with an unofficial warning and an armed force mobilization, exercise and/or display (to use two of the categories from WEIS), a different sort of language will be

required. That language must have content (meaning) as well as form (the type of action). Since we take seriously our assumption that nations are goal seeking systems, it is imperative that the language that "nations talk with" be able to express the goals of the decision makers. While Callahan's (1974) analysis of the goals of the five oil producing nations identified a wide range of goals, none of the goals that he identified were of the form: "Decrease the number of formal diplomatic protests by three-fourths." We need a language capable of expressing a much richer content than any of the existing event category schemes are capable of providing. The second difference between typical events coding and our language building efforts stems primarily from our assumption that nations perceive incoming messages within the context that they are generated, and from our desire for a comparatively rich language for the expression of national decision outputs. The standard approach followed by all existing events data efforts is the use of the coding category for the interpretation of actions. There is an explicit attempt to make perceptual decisions. Common categories include threats, accusations, and rewards. It is our predilection to leave the perception of the meaning of the actions to the decision system. We want our language to be as neutral as possible. What is a negative deed from the perspective of one nation may be a very desirable action as far as some other nation is concerned. This perceptual role in the standard approach to the recording of international interactions is handled by the coders, who are assigned with the responsibility of making the distinction between a threat and a promise. (A threat is really nothing more than a promise with a negative consequence.) We want the nations to make that distinction.

If the language is to be a neutral affair intended only for the transmission of ideas and not predetermined perceptions by some third party the

language must be structured so as to avoid the gross pre-processed perceptual categories of the standard events data approach. This implies that the basic units of the language should be statements of action rather than perceptual categories. It will then be up to the perceptual portion of the decision system to parse the action message into its own cognitive map or conceptual categories. This is not to say that the word "threat" cannot appear in the language, but that it will be the job of the decision system to determine whether it really is a threat, the consequences the action will have on the goals for the system, as well as the credibility of the action. This conception of the role of the language has some implications for the structure of the language, the second distinction between events coding schemes and our approach. The manner in which events people have approached the structure of their coding categories is to devise a mutually exclusive and collectively exhaustive typology for the classification of international interactions. In essence they have listed all of the possible sentences in their language. They then look at the event or interaction and determine which of the sentential forms fits the action. Our approach differs from this approach in that we have elected to specify rules for generating sentences in the language rather than listing them individually. If one has a small language capable of having only a few sentences, the list approach has some merit. On the other hand, if the language is large and capable of expressing a wide variety of sentences, some of which may be appropriate only in certain circumstances, i.e., My dog has fleas, the exhaustive listing of all sentences may be impossible. These rules for generating sentences in a language is called a grammar. The rules of grammar for English specify what words may follow other words. Thus if we had a dictionary of all of the words in the English language, and if we had all of the rules for generating acceptable sentences, it would be in

principle possible to generate all sentences that could ever be spoken in English. Not all of them would make sense (Green dreams sleep quietly). Grammatical sentences are not necessarily sentences that make sense; grammar does not determine meaning, only form. (As with the perceptual aspects, it would be the responsibility of the decision module to determine appropriate sentences.) The way that formal linguists generally express it is that a grammar is the set of rules specifying admissible manipulations (stringing together) of the words of language. By taking a finite set of words and a finite set or rules, it is possible to generate an infinite number of sentences. The advantages of listing the rules over listing all possible sentences is substantial. By basing our language on a modest set of objects (actions and actors) on a small set of rules, we will be able to develop a language of greater precision, breadth, depth, complexity, and richness that could be hoped to be generated by coming up with a list of possible sentences. We will have a more complex, conceptually leaner, and theoretically powerful system for expressing the behavior of a nation than an event coding typology could ever hope to generate.

We are placing some very large demands upon our language. It must be able to describe a context that will allow the perceptual system of the decision modules to determine meaning; it must be able to describe the current state of the environment so that a decision can be made; it must be medium by which the actions of a nation can be transmitted between and within nations. In fairness to those who have taken the events coding approach, it should be mentioned that our demands upon the language are much more severe than those of the events people. They wish only to describe very gross types of behavior, while we have to express not only the type of behavior, but also the substance of the act. While we are making more

severe demands of our language, because of the conceptual power of the approach to language building through a grammar, the task in some ways is simplified. Because of the approach that we are taking we can break the entire problem down into manageable hunks. Rather than being forced to consider the language as a whole, we can break it down into the problems of a grammar, sentential forms, and objects.

As crude example of the power of approach, consider the specification in Figure IV. Structurally, this list of six sentence forms is sufficient to express all 63 of the WEIS ('McClelland and Young, 1969) coding categories. For example, sentence for 5 would be coded as a threat, promise, the offer or a proposal, a demand, a warning, or an ultimatum (to use some of the WEIS categories). The scheme does have the major shortcoming of not having listed the actors and most importantly the actions, but it does, at least at a structural level, show that a simple schema can reproduce event typologies. The language as specified in Figure IV is defficient in other several respects. It is not rich enough to serve as the basis for the language that we need -- sentences of the form of questions are not included as well as sentences of the form X will give A to Y in order for Y to B to Q (The United States give military assistance to Israel to stem Syrian aggression). But even this simple scheme has the capability of generating sentence structures that are much more complex than WEIS or any other event coding schema attempts to specify. For example the sentence: Since X will not do A then if X does B, Y will do C. This sentence represents the embedments of sentence type 1 in type 6. It is this ability of the grammar to define embedments in a recursive manner that accounts for its generality and power. While this scheme is insufficient for the specification of the language, it does illustrate that the approach has the ability to express both the substance and form of international

activity.

In addition to the specification of a language that is suitable for the expression of the output of the decision process, we are in the process of determining whether or not the language that serves as a communication medium between the various bureaucratic parts requires a structure that is in some manner different from that used for the conveying of final decisions. While it is too early to report on that effort, it does seem that there are different requirements for this internal language. Whether or not a new structure will be required is unknown at this time.

One of the very powerful aspects of this effort at specifying a language for the communication of the decisions of national decision systems is the potential linkage with current events data collection efforts. While our basic approach is somewhat different there is a very important linkage between the two types of efforts. If we are successful, we should be in a position to generate a data source that would be expressible in an event type coding typology. We should be able to generate the raw data of events data collection efforts. This fact has two important implications: 1) our approach is not alien to much of the work now being done in the field of international relations; and 2) existing events data collections can serve as an important source of validating data. It should be possible to take the output from the simulations (sentences in the language) and code them according to an events coding typology. That coding could be compared to current data sets to assess the amount of agreement. This interface between events data and our efforts at the specification of language also has the implication that propositions that we generate could be translated into event type propositions. Thus there is a potential source of mutual benefit.

Another very important aspect of our efforts is that the language and

the technique of specifying the decision process as a production system will not be limited only to the Middle East. It will serve as a means for the specification of the decision process and decision outputs for any country. This aspect coupled with the interface with events data efforts should represent not only a substantial increase in our understanding of the Middle Eastern situation, but also a potential means for increasing our knowledge about the international relations of nations in general.

Summary and Overview

When fully specified, we conceive that the decision module (structured as a production system) will receive strings of symbols (sentences in the language) from the environment. The decision module will take these input strings and according to the rules of the grammar and the perceptual rules written in the production system, will parse the input strings to determine their meaning. This picture of the environment that the system has perceived will then be evaluated with respect to the goals that the system has for the environment. Based upon the model that the nation has for how the world works (its model of the environment) it will determine behaviors (other sentences in the language) that it thinks appropriate for controlling the environment. Besides the output of final decisions, the decision module will also make changes in it goal structure and update its model of the environment based upon past experience. We also anticipate that the decision module will be structured so as to include various bureaucratic actors. It will be the interaction of these various sub-structures that will in the final analysis determine the behavior of the national decision system.

The first portion of this report has laid out the issues that we see as relevant to the specification of the decision system. These issues include the areas of general goal seeking systems and problems peculiar to

multi-goal seeking systems. The second portion of the report represents a discussion of the structure within which we propose to resolve these issues. Our approach consists of the specification of the process of decision making as a production system. The notion of a grammar and language was introduced to handle the problems of communication between nations as well as within nations. The importance of the language concept becomes especially relevant with our assumption that nations are goal seeking perceptual systems.

The work that remains to be done falls into three groups: 1) the further specification of the issues that must be resolved; 2) the specification of more complex production systems that incorporate the notions of multi-goal seeking systems; and 3) the specification of an acceptable language for the communication of decisions. While there is much to be done, the fact that we have been able to identify somewhat separable issue clusters should promote the attainment of our final goal, the production of reasonable forecasts of the behavior of the five oil producing Middle East nations.

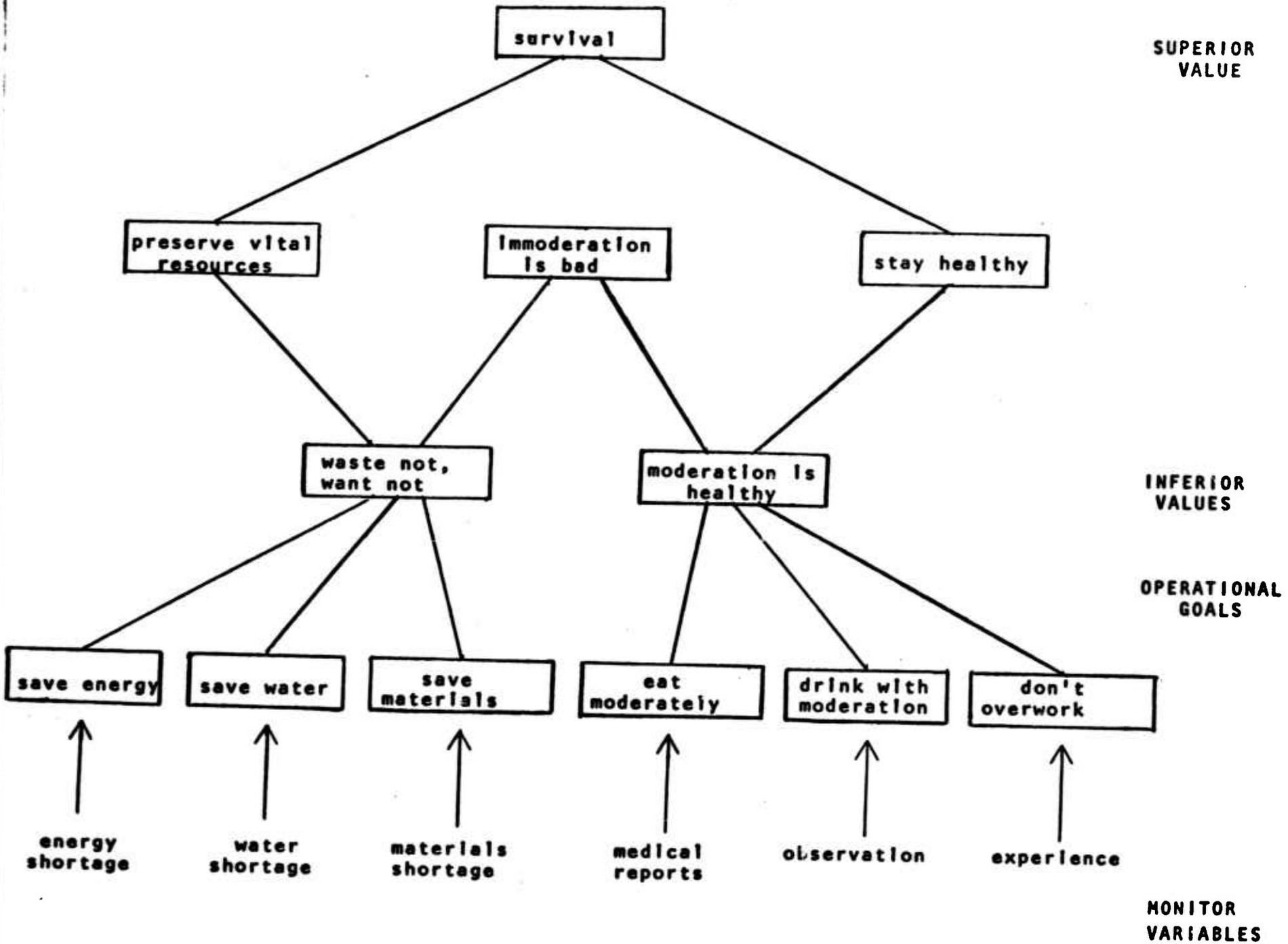

Figure 1 - Sample Norms Structure

FIGURE II

1: (AA AND BB → (OLD **))

2: (CC AND BB → (SAY HI))

3: (DD AND (EE) → BB)

4: (AA → CC DD)

5: STM(AA QQ (EE FF) RR SS)

(from Newell 1973b: 466)

FIGURE III

1: (STOP) → END

2: (REQUEST) → (OUTPUT "GO TO DESERT", STOP)

3: (MARK,MARK,MARK,MARK) → (OLD(**),REQUEST)

4: (FOOD SHORTAGE,FISCAL IRRESPONSIBILITY,NEGATIVE FOREIGN COMMENT BY AN ALLY) → (OLD (**), REQUEST)

5: (FOOD SHORTAGE) → (OLD(**),MARK)

6: (SUPPORT OF RADICAL FOREIGN CAUSES,NO ACHIEVEMENT) → (OLD(**),MARK)

7: (SUPPORT OF RADICAL FOREIGN CAUSES,SFRC*,SFRC,SFRC) → (OLD(**), FISCAL IRRESPONSIBILITY)

8: (FISCAL IRRESPONSIBILITY) → (OLD(**),MARK)

9: (NEGATIVE FOREIGN COMMENT BY AN ALLY → (OLD (**), MARK)

10: (BAN BROTHELS or BAN CIGARETTES or BAN ALCHOHOL or BAN LUXURYS) → (OLD(**), ORTHODOXY)

11: (ORTHODOXY,ORTHODOXY,ORTHODOXY,ORTHODOXY) → (OLD(**),MARK)

12: (FOOD SURPLUS,MARK) → (OLD(**))

13: (SUPPORT RADICAL FOREIGN CAUSES,ACHIEVEMENT,MARK) → (OLD(**))

14: (INCREASE IN SKILLED LABOR,MARK) → (OLD(**))

15: (SADAT HAS TROUBLES,MARK) → (OLD(**))

16: → READ

* SFRC = SUPPORT OF RADICAL FOREIGN CAUSES

FIGURE IV

1 <actor> <will | will not> do <action>*,**

2 <actor> <should |should not> do <action>

3 <actor> <did |did not> do <action>

4 <actor> <does| does not> do <action>

5 if <1,2,3,4,5,6,> then <1,2,3,4,5,6,> ***

6 since <1,2,3,4,5,6,> then <1,2,3,4,5,6,>

* The actor and action terms refer to a list (not shown) of acceptable action types and acceptable actors.
** Vertical bar means that one of the options is to be selected.
*** The number within the brackets refer to the numbers associated with the sentence types.

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