SUPPORTING NEGOTIATIONS: METHODS, TECHNIQUES, AND PRACTICE

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INTRODUCTION

What is most apparent to anyone who has participated in, analyzed, or sat through a public international negotiation are the often lengthy, seemingly haphazard, meandering of the debates, and the positioning and posturing that appears to skirt the issues at stake. It certainly bears the image of a most unsystematic process. While some of this conspicuously roundabout behavior may be driven by conscious strategies and tactics, it would seem reasonable to assume that the efficiency of the joint decision making process of negotiation can be enhanced significantly by the judicious application of logical and quantitative methodologies from the management sciences, psychology, economics, statistics, and computer sciences.

This special issue of *Theory and Decision* explores the extent to which such quantitative approaches, typically employed to analyze and explain past negotiation processes, are appropriate or can be transformed into effective tools that can support international negotiators and their staffs *during* the process itself. The central question asked of our authors is: can methodologies typically used to understand and explain historical negotiation processes be used as normative and prescriptive tools to assist negotiators as well? To be sure, many problems and issues will be encountered in attempting to introduce scientific methodologies that are essentially alien to negotiation practitioners who largely view their profession as more art than science. The papers published in this issue each begin to address the major obstacles – and possible solutions – to effective implementation of eight quantitative approaches in international negotiation settings. The methods assessed include those that can help negotiators assess alternate strategies and estimate likely outcomes, namely, decision analysis (Spector), multi-criteria optimization (Wierzbicki, Kruś and Makowski), statistical analysis (Druckman), and game theory (Munier and Rullière), and those methods that help diagnose the negotiation process itself, for example, cognitive theory (Bonham), simulation modeling (Samarasan), rule-based systems (Kersten), and information management (Andriole). The benefits of each method for enhancing

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joint decision processes and the difficulties inherent in reasonably implementing each are compared and contrasted by the presentations.

The concept for this issue emanated from a workshop on systems analysis techniques for international negotiation sponsored by the Processes of International Negotiation (PIN) Project at the International Institute for Applied Systems Analysis (IIASA) in Laxenburg, Austria in October 1991. Fifteen methodologists, negotiation researchers, and practitioners dialogued in that workshop, seeking to find answers that could bridge the gaps and identify realistic opportunities between practical negotiation needs and methodological approaches. A subset of the papers developed for that workshop are collected in this issue, hopefully, to guide the research agendas of negotiation researchers interested in policy outreach and applied negotiation support.

There has been relatively little research accomplished on how analytical methodologies can be engineered to assist international negotiators in a practical way, either to diagnose, plan and develop strategies independently or bargain interactively. Several critical challenges must be addressed by collaborative efforts between the negotiation and methodological research communities:

1. The transformation of descriptive and explanatory approaches into normative and prescriptive approaches. Researchers have focused primarily on developing methods that can describe and explain the negotiation process in a post hoc fashion, not on normative or prescriptive tools that can assist in a practical way in the negotiation itself. Existing approaches need to be examined to assess whether they can be transformed into meaningful and useable tools.

2. The synthesis of process and substantive models. Issue-specific research has resulted in models that can help negotiators analyze the substance of disputes being debated. One excellent example is the Regional Acidification Information System (RAINS) (Alcamo *et al.*, 1990) developed by IIASA. This complex meteorological model is employed by the United Nations Economic Commission for Europe (UNECE) to simulate and test alternate negotiation formulas or solutions concerning NO_2 and SO_2 emission and deposition targets in

Europe. Such substantive models provide negotiators with an in depth understanding of an issue, the capacity to examine it from all sides, and importantly, the ability to test various assumptions. Essentially, these substantive tools assist negotiators in defining and framing the problem, as well as testing what-if scenarios that can help them generate alternate proposals and formulas for agreement. Decision making research, on the other hand, has resulted in many analytical approaches that can help explain the *processes* of convergence and divergence in negotiation. Such process techniques can help negotiators analyze proposals, construct strategies, test strategies, evaluate strategies of other actors, and assess possible outcomes. These process tools can take the proposals and formulas developed using the substantive models and evaluate them in the light of what is politically possible, given the realities of the negotiation situation and the negotiators' interests, values, and goals.

Substantive models without their processual counterparts may be perceived by practical negotiators as yielding ideal solutions that are unrealistic, while process models alone can be viewed as overly abstract. Researchers need to evaluate the possibilities of integrating these two types of models to support both the practical issue and behavioral requirements of negotiators to develop mutually beneficial agreements.

3. Application of end user-focused strategies rather than technique-focused approaches. Methodologists know the benefits and capabilities that their techniques can provide to negotiators. Negotiation practitioners, however, are usually traditional in their approach, have no quantitative training, and know little about research conducted on negotiation processes. The typical result of technique-focused activities is practitioner resistance to using the available tools. An alternative approach to introducing analytical methods into the negotiation workplace is to take an end user perspective. Using this strategy, researchers seek to understand the negotiators' requirements for information and analysis during the course of negotiations (from prenegotiation through to the endgame). Given this understanding, researchers can apply the appropriate techniques to satisfy information needs. The following questions need to be answered to implement this

end user approach: What are the informational and analytical needs of the negotiators? How do these needs change as the negotiation progresses through its stages? Under what conditions is this information and analysis needed most? When is there likely to be a need for urgent responsiveness?

4. *Design of effective presentation and delivery*. It is important to find the right approach to present and deliver analytical tools to the negotiator. Central is the question of whom such negotiation tools are for. At least initially, these techniques will likely support the negotiation and policy making staffs, not the negotiators directly. The staff's role is to assess data and read signals from the various involved actors to diagnose the situation, analyze the problem, and evaluate alternate strategies. Are the tools to be used by individuals or by groups? Are they needed by parties to the negotiation who will use them independently or as part of a joint problem solving exercise? Are they needed by staff back home or at the negotiation site? How can the results be stated in jargon-free terms? What form or package would deliver the information and analysis most effectively to the end user?

These are the challenges with which we confronted our workshop participants and which are addressed in the papers in this issue. Each paper provides the perspective of a major *methodological family* that has been applied to the study of negotiation processes. Decision analysis, for example, is considered to be a family that includes specific techniques such as multiattribute utility analysis, decision trees, cross-impact analysis, and cost-benefit analysis. Each family of related techniques has a solid foundation of negotiation research results that can serve as a springboard to stimulate further investigation, refinement, and design of analytical approaches and suggest how they might best be implemented to support international negotiators in a practical way.

Each paper briefly reviews the current state of the method, describes its technical underpinnings, and offers an illustration or two of how this approach has been used in a descriptive, explanatory or prescriptive way in negotiations. While the principal focus of the papers is on supporting complex negotiations at an international level, examples

are drawn from many types of negotiations in which the specific techniques have been applied. The papers address the four challenges described above, identifying necessary modifications to the techniques to facilitate practical implementation in negotiation settings. Finally, each paper focuses on the anticipated benefits to negotiators of using the method, how it can help, and under what circumstances. Additional development of the techniques, testing, validation, data collection methods, and generalizability issues are discussed.

These eight methodological perspectives are compared in two concluding papers written by Hafner, a negotiation practitioner, and Zartman, a negotiation researcher, who reflect on the applicability and limitations of the range of analytical methods. The practitioner paper assesses the feasibility, practicality, and utility of negotiation support systems from a user's viewpoint. The researcher paper places the discussion within a larger theoretical context, suggesting ways by which systems approaches can enrich the mainstream descriptive and explanatory frameworks of negotiation *and* how negotiation concepts and theories can stimulate continued methodological research on systems support.

This issue brings together, for the first time, critical evaluations of major methodological approaches targeted at negotiation support and challenges their proponents to examine a common set of issues confronting practical implementation that can be compared systematically. The concluding chapters synthesize the findings, begin the needed process of dialogue between the methodologist and research communities, and provide a blueprint for future research and application based upon practical and conceptual considerations.

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DECISION ANALYSIS FOR PRACTICAL NEGOTIATION APPLICATION

ABSTRACT. The family of decision analysis techniques can be applied effectively to support practical negotiators in international settings. These techniques are most appropriate in support of the prenegotiation phase, when parties are diagnosing the situation, assessing their own plans and strategies, and evaluating likely reactions and outcomes. The paper identifies how these approaches have and can be used to assist negotiation practitioners, offers a rationale for the application of decision analytic approaches in terms of the particular analytical requirements of the prenegotiation period, suggests how these process-oriented tools can be integrated with substantive tools, and discusses ways in which these tools can be presented and delivered to practitioners in a practical and confidence-building manner.

Keywords: Decision analysis, prenegotiation, multi-attribute utility analysis.

1. INFORMATION AND ANALYTICAL REQUIREMENTS OF INTERNATIONAL NEGOTIATION

International negotiation is a process which inherently depends on information. For example, negotiators require information about their own country's goals and resistance points. They need reciprocal information about their counterparts. They require sufficient information to develop tactical and strategic approaches to joint problem solving, that is, effective ways of persuading other interested parties to come to the table and reach a mutually acceptable accord. Negotiators also need to have adequate knowledge to design innovative, but realistic options for solution and the ability to evaluate the costs and benefits involved in striving for each. That means that they need to understand in detail the substantive issues which they are debating; in this age, that often means a sophisticated knowledge of science, technology, and economics.

Negotiators and their staffs need the tools to adequately analyze this information to produce assessments that will help them make good decisions. For example, they need the analytical resources and skills to

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diagnose the situation, evaluate the cost-benefit of their own strategy options, assess the impact of other party strategies, and trade off the efficacy of alternative negotiated outcomes.

Despite these information dependencies and analytical requirements, international negotiators usually confront their counterparts only with their wits, instructions from their home government, and minimal background information developed by their staffs. International negotiation is still viewed by practitioners as an art form, not a science. Unfortunately, much of the information required is either unavailable when needed or costly to obtain. Moreover, most nations can little afford the in depth analyses of issues, strategies, and outcomes that are required to understand the implications of one negotiation proposal over another. It is often the case that delegations arrive at complicated multilateral negotiations having performed minimal assessments of their own interests and positions, let alone that of other key nations and coalitions. In addition, negotiators lack the tools and techniques for effective joint problem-solving that have been developed in the management sciences and are already being widely used in industry. International negotiation has clearly not entered the modern information era.

If the power of information and analysis can be harnessed to support international negotiation, will it help and how? More significant, perhaps, is the answer to the question, 'What will it take to be used?' This paper focuses on one family of analytical methodologies, decision analytic techniques, which is central to understanding, and possibly recommending, the decision structure and logic employed by negotiators. The discussion examines the type of information needed to implement these techniques and what they can do to support the negotiation process, the prenegotiation phase, in particular.

2. DECISION ANALYSIS: KEY ASSUMPTIONS AND APPLICATIONS

Decision analysis is a methodology typically used to support decision makers actively in assessing alternative courses of action. Generated from statistical decision theory, decision analysis was developed in the field of business administration as a practical approach to assist

corporate managers in weighing their options and designing logical solutions in a systematic fashion. It is usually applied in a consultative, prescriptive mode with decision makers, helping them work through immediate decision problems (Ulvila and Brown, 1982).

Decision analysis tools have been applied along these same lines with negotiators and policy makers to assist, for example, in pre-negotiation strategy development over U.S. military bases in the Philippines (1978), the Panama Canal (1974), and international oil tanker standards (1978) (Raiffa, 1982; Ulvila and Snider, 1980; Ulvila, 1990). In these cases, decision analysts supported negotiating teams by eliciting practitioner preferences and values, generating models based on these subjective judgments, calculating the decision analytic results, and feeding these results back to the negotiators to help them evaluate alternative strategies.

Decision analysis targets one critical element in the decision making process that is a key driver in making and understanding effective choices, *personal preferences*. The decision maker's subjective judgment is incorporated into decision analysis models along with objective inputs. If these personal preferences can be defined and elicited directly from involved negotiators concerning particular negotiating interests, then the technique can be applied prescriptively as a supportive tool.

These models, applied to the negotiation process, can be most helpful in understanding strategy and outcome. The methodology is geared to evaluating alternate strategy options based on tradeoff analyses that take into account the expected value of the projected outcomes. Evaluation of strategy decisions is accomplished in decision analysis primarily in terms of negotiator preferences.

Decision analytic models offer the capability of disaggregating the decision rationale for selecting one strategy over another by evaluating negotiator preferences, criterion by criterion. In doing so, it is possible to understand not only the genesis of a country's bargaining interests and why certain outcomes are seen as attractive, but also the genesis of compromise solutions that provide a better distribution of benefits to all parties.

Two of the most commonly used forms of decision analytic models are decision tree analysis and multi-attribute utility (MAU) analysis;

other variants in the decision analysis family are described later in this paper. In *decision tree analysis*, the decision options and calculations can be displayed graphically as a network, indicating sequentially the decision choices that can be made, the actions of other negotiating parties, and the occurrence of uncontrollable and situational events. This network can be designed in an iterative offer–counteroffer pattern between negotiating parties. It can present a dynamic picture of the probable future progress of the negotiation process. Along with the specification of this network, decision trees also present the probability of occurrence of future events, the value of the alternate final outcomes, and intermediate expected values at each node in the tree. Overall, decision tree analysis offers an assessment of probable outcomes given choices made and the probabilities of occurrence of other party actions or events.

While person variables (negotiator preferences) are clearly central to this decision analysis methodology, situation variables also play an important role in the approach. Nodes in the decision tree can represent changes in the negotiation situation – changes in the other side's position or strategy, changes in home government instructions, changes in deadlines, introduction of new issues – with associated probabilities of occurrence and revisions to the expected outcomes.

Multi-attribute utility analysis provides a structure to tradeoff multiple decision objectives across alternate decision options, resulting in a prioritization of those options. It requires the development of a model that replicates the decision maker's set of evaluation criteria applied to the decision problem. This model includes not only the criteria, but also the relative importance of each criterion. Decision options are rated against each criterion and calculations performed. MAU usually results in a prioritization of strategy choices, one party at a time. Unlike decision tree analysis, MAU provides a static snapshot of the negotiation process.

Ulvila's (1990) Philippine base negotiations case is a good example of the use of decision analysis to support strategy development in the prenegotiation phase of a bilateral situation. The U.S. negotiating team used a facilitator to elicit their own preferences as well as the likely preferences of the other side's negotiators. Two MAU models were developed – one for each actor – by weighing the multiple issues

in the negotiation and rating the perceived attractiveness of actor positions on each issue. A compromise position that fell within the range of negotiating positions was also rated in terms of relative attractiveness. Using these quantified models, Ulvila was able to do the following.

- Identify the attractiveness of alternative packages of agreements across all of the key negotiating issues for each negotiating party. Many alternate packages were simulated across the issue areas and attempts were made to analyze their overall attractiveness to each party.
- Identify an agreement space in which both sides could maximize their gains in the negotiation. The points along the optimal frontier were explainable in terms of the actors' issue weights and position preferences.

Raiffa (1982) describes a very similar application of decision analysis concerning the bilateral Panama Canal negotiations. Spector (1991a) applies MAU models to analyze two multilateral negotiations – the Uruguay Round of the GATT talks and the Single Europe Act of the European Communities. Using sensitivity testing, he conducts a *preference adjustment* analysis to determine the extent of divergence in national interests and the degree of modification required by all parties to achieve a compromise agreement.

Ulvila and Snider (1980) provide an interesting case of the use of decision analytic models not only to support a particular negotiating team in an upcoming multilateral negotiation, but also to explain some elements of process. They used a MAU model in consultative mode with the U.S. negotiating team to the 1978 International Conference on Tanker Safety and Pollution Prevention to prepare alternate strategies and consider tradeoffs among them during the prenegotiation phase. In building the decision analytic model, U.S. negotiation interests had to be compared in relation to the interests of the other countries that would participate in the conference. This was accomplished by having the U.S. team role play their counterpart teams in 21 other countries.

A common set of criteria and negotiation proposals was identified

for the MAU model structure and a common set of scores was elicited from the U.S. team to rate each proposal package against each criterion. In building the model, the authors assumed that this basic structure of the negotiations was essentially equivalent across participants. However, the relative importances given to the various criteria were conceived as different across participants; that is, each country's interests, while comprised of the same set of issues, are prioritized differently.

By analyzing the model and examining its component elements, the researchers and U.S. negotiating team were able to highlight some issues which were likely to be contentious in the negotiations and develop compromise solutions. They were able to explain, in terms of the differential interests of various countries on particular issues, why a specific U.S. strategy would not likely be successful in yielding agreement in the upcoming multilateral conference.

As illustrated by the Ulvila and Snider case described above, multiple decision analytic models can be built in the context of multilateral negotiations, each attempting to replicate the perspective of each negotiating party. One can assume that the model structures (the inventory of interests and outcomes) are the same, but actor preferences and priorities for the interests vary across participants. Players that are closely aligned with each other – with high interest commonality – have very similar interest preferences. That is, they perceive and address the negotiating problem in a very similar manner and their model weights are highly correlated. On the other hand, players with strong interest divergence likely have very different perspectives on the criteria weights and hierarchy by which courses of action are evaluated; their decision calculus is very different and thus is represented very differently when modeled.

When model structures are very similar, it is possible to compare directly *both* the assumptions of the analysis (i.e. weights, scores, and probabilities) and the decision results directly. When model structures are dissimilar, it is still possible to compare the results of the decision analysis, that is, the prioritization of decision alternatives across actors.

Negotiation processes are dynamic, meaning that many decisions are made and modified by each negotiating party over time on multiple issues. For each issue area, different decision analysis models may be

required. However, if countries practice a consistent policy concerning their national objectives and interests within a particular negotiation, one may assume that the evaluation criteria and weighting schemes will be similar across decision episodes.

While decision analytic models have been applied successfully in a limited number of instances, the methodology has come under some criticism. First, the mathematics of the technique assume that the evaluation criteria are mutually exclusive and independent. This assumption is very difficult to satisfy in application, especially when attempting to model the logic of negotiators and policy makers. It essentially rests with the good judgment of the model developer to assess that the independence assumption is approximated as well as possible. Second, it is very difficult to avoid cultural biases when estimating the preferences of the other side, thus yielding possibly misleading results. Third, the calculus of decision analysis models is linear and additive; this is usually an inappropriate assumption when dealing with decision makers whose reasoning processes often incorporate extensive feedback.

All of these technical criticisms can be refuted by the argument that decision analysis was never intended to yield precise, engineering results; after all, the technique attempts to model a subjective region of human behavior. Although the method does produce quantitative results concerning the priorities of possible strategies for outcomes, these should be treated in a relative, not an absolute manner, given the admitted imprecision of the model's inputs, decision maker preferences. Hopple (1986) categorizes the decision analytic family under the rubric of 'structured *qualitative*', thus downplaying its quantitative aspects. Based on the model's calculations, it is sufficient for the decision analyst to present the negotiator with a rank ordering of options.

One of the greatest benefits of decision analysis is its capacity to present decision makers with a systematic way of structuring and restructuring a problem; the model-building exercise sometimes provides more insight to the decision makers than the model's calculations. It is the process of logically thinking through, representing, and reevaluating relationships and preferences that decision makers often find most valuable in the method.

3. APPLYING DECISION ANALYSIS TO THE PRENEGOTIATION PROCESS

The application of decision analytic techniques to the prenegotiation process is particularly appropriate. This is the phase of negotiation in which the need for information, planning, and tradeoff assessment is instrumental in determining whether conflicting parties will in fact decide to come to the negotiating table or settle their disputes by unilateral means. It is a suitable time for each party to conduct a diagnosis of the situation: generating alternate formulas, defining its own interests clearly, inferring the motives and interests of the other parties, identifying opportunities for tradeoffs and compromises between opposing perspectives, and developing expectations for the final outcome of the negotiations. Decision analysis methods are relevant to supporting these activities.

3.1. Satisfying User Needs in the Prenegotiation

Saunders (1985) describes the prenegotiation process as one of defining the problem both unilaterally and with the other parties to the conflict. It is a testing or experimental phase before commitments are made to use the negotiation table as the accepted venue to resolve the dispute. Zartman (1989) expands upon this description by specifying the functions served by the prenegotiation process in transforming conflictual into mixed-motive perceptions. Performance of each of these functions serves a purpose in the transition from unilateral to multilateral perspectives on solution options. They include:

1. *Risks*. Prenegotiation helps nations identify and assess the risks involved in future negotiation within a low risk environment.
2. *Costs and Benefits*. In the prenegotiation phase, nations can estimate the costs and benefits of concessions and agreement, thereby sorting out their motives for negotiating.
3. *Requitement*. This is the period during which each side can persuade the other that concessions will be responded to in a positive manner.
4. *Domestic Support*. Prenegotiation can serve to build and consolidate domestic support for a negotiated outcome.

5. *Problem Solving*. This phase offers the opportunity to define the problem and search for options – ways out of the conflict. The identification of negotiable issues begins and parameters are defined that help evaluate and eliminate alternatives.
6. *Coalition Building*. The prenegotiation period presents the opportunity to evaluate the benefits of building minimum winning or blocking coalitions.
7. *Confidence Building*. This is the phase in which trust-building measures can be evaluated and implemented to develop bridges from conflict to cooperation.

Each of these prenegotiation functions has its informational counterpart – information and analysis are required to conduct them effectively. As an experimental or testing period, prenegotiation is particularly useful if it helps parties evaluate, estimate, and simulate 'what would happen if' scenarios. The analytical requirements implied by each function and the specific types of decision analytic approaches that can provide meaningful support to each function are described in Table I.

This table suggests that the family of decision analytic tools are likely to be useful to negotiation practitioners in managing prenegotiation functions. Each of these tools has similar methodological foundations in decision theory, but provides different results that are tailored to prenegotiation analytical requirements. Specifically,

1. *Cost-Benefit Analysis* models (Raiffa, 1982) evaluate tradeoffs in cost-benefit terms of alternative proposal packages. They are appropriate, therefore, to aid in the assessment of alternative negotiation formulas, each comprised of different combinations of approaches and principles to achieve a mutually acceptable outcome.
2. *Cross-Impact Analysis* (Institute for the Future, 1983) is a methodology that facilitates the modeling of complex situations with the purpose of simulating the impact of particular policy decisions that may affect that situation. It is appropriate to conduct a risk analysis, examining the many internal and external factors that can impact upon achieving a convergence of interests.
3. *Decision Tree Analysis* (Raiffa, 1968), as described earlier in this

TABLE I

Prenegotiation functions, analytical requirements, and decision analytic approaches.

Prenegotiation Functions	Analytical Requirements	Decision Analysis Techniques
Risks	Examine range of national interests; evaluate extent of preference adjustment required; evaluate impacts of reaching a negotiated agreement	Cross-Impact Analysis
Costs and Benefits	Tradeoff costs and benefits of potential concessions	Multi-Attribute Utility Analysis
Requitement	Evaluate likely external responses to concessions	Decision Tree Analysis
Domestic Support	Evaluate likely reactions of internal interest groups to alternate outcomes	Stakeholder Analysis
Problem Solving	Generate alternative formulas; evaluate alternatives	Cost-Benefit Analysis
Coalition Building	Tradeoff costs and benefits of alternate coalitions; evaluate extent of preference adjustment required to form coalitions	Multi-Attribute Utility Analysis
Confidence Building	Generate alternate trust-building measures; tradeoff costs and benefits of alternatives	Multi-Attribute Utility Analysis

paper, creates a sequential network of events and decision points, with probabilities attached to each node, that can help in an assessment of response behavior to earlier concessions.

4. *Multi-Attribute Utility Analysis* models (Raiffa, 1982) structure decision problems so as to facilitate selection among alternate decision options based on multiple criteria and objectives. It is an appropriate technique to assess tradeoffs and examine the extent of adjustment required in preferences to achieve compromise solutions.
5. *Stakeholder Analysis* (Weiner and Brown, 1986) uses information on the positions, interests, priorities and preferences of various stakeholders on a particular issue to facilitate analysis of the range

of differences among stakeholders and the potential for coalition formation.

Frei and Ruloff (1989) and Mitchell *et al.* (1977) provide good explanations, illustrations, and step-by-step guidance on how to apply most of these decision analytic methods. One illustration of the use of decision analytic methods to support ongoing prenegotiations can be found in Spector (1991b), who describes the application of multiple MAU models to evaluate coalition building and preference adjustment in the context of the United Nations Conference on Environment and Development (UNCED). Two central negotiation issues were addressed by the modeling effort: developing a viable funding mechanism for future environment-development projects and agreeing on acceptable funding target levels. Two months before the formal negotiation conference was held, a handful of proposals had been tabled on these two issues; these were defined as options in the MAU model. A content analysis of statements presented by most of the key national participants on financial issues yielded a hierarchy of criteria upon which policy decisions would be made affecting negotiation choices and strategies. These criteria formed the basis of the MAU model (see Figure 1). The relative importance of each decision criterion for the three nations/coalitions of interest (the United States, the European Community, and the Group of 77) were coded on the basis of their public statements on a five-point scale and transformed into numerical values. Finally, an assessment of how well each option satisfied each lowest level criterion was also conducted and quantified into scores based on the national statements and proposal descriptions.

Exercise of the models revealed the comparative preferences of the

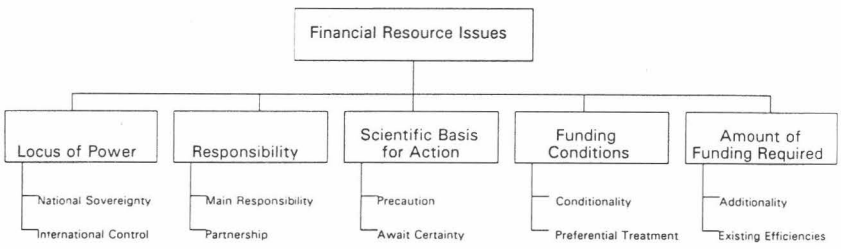

Fig. 1. Criteria for financial resource decisions at UNCED.

three actors for each option. As a mirror of reality in the prenegotiation period, the preference space across the parties for the available options was rather large. Sensitivity analysis was conducted to assess the extent of adjustment required of each actor to achieve a compromise proposal. This sensitivity analysis identified the specific preferences, in terms of decision criteria, that must be modified by each negotiator to make a compromise proposal feasible.

The model structuring itself yielded useful insight for the UNCED Secretariat at a point when it was developing the content for a proposed global action plan for future environment-development activities. The sensitivity analysis results were highly suggestive of the feasibility of various compromises. Although the analysis was conducted after the actual negotiation was completed, it could have served as an important decision support tool during the course of the prenegotiation to identify where the gaps in preference lie and the extent of flexibility required to achieve compromise. In particular, the results indicated that the United States position on financial issues required the greatest modification to achieve a compromise formula; movement in the bargaining space appeared much less stressful for the Group of 77. The United States had to give way on some of its key interests and demands in the negotiation, in particular, the demand to postpone serious negotiation until there is greater scientific certainty on the issues. For the Group of 77, the strong demand for preferential treatment and concessions on future financial and technological assistance had to be dispensed with somewhat. Overall, the preference adjustments required of all parties, when viewed together, suggested the precarious balance of negotiating tradeoffs to achieve compromise outcomes.

A toolkit comprising the entire methodological family of decision analytic techniques could enhance the effectiveness of early negotiation phases by supporting the array of prenegotiation functions described earlier.

3.2. Presentation and Confidence-Building in the Approach

How can these techniques best be incorporated into the prenegotiation process? Software packages are now available to make the design and

exercise of this family of models extremely accessible. However, without formal training and dedicated staff analysts, it is unlikely that such decision analytic modeling packages can become integrated fully in supporting prenegotiation diagnoses. Moreover, the use of decision analytic models involves more than just operating computer-based software; the meaningfulness and validity of such models depends largely on the way in which the models are structured, and preferences, priorities, and values of the negotiators and policy makers are elicited. In this regard, the use of independent facilitators of group workshops involving the key decision makers has proved to be effective (as described in Raiffa, 1982; and Ulvila and Snider, 1980).

Facilitated group policy exercises enable participants to analyze, evaluate, and explore important decision opportunities in a controlled environment (Spector, 1990). Trained external facilitators help participants work their way through the systematic processes of assessing likely scenarios, effective decisions, and the logical implications of these futures using decision analytic methodologies.

Structured policy exercises seek to identify key issues, uncover problem areas, define opportunities for important breakthroughs, generate alternate solution paths, evaluate options, and project future implications. A successful policy exercise may sometimes be measured by the consensus that is achieved on key issues by the participants. Success, though, can also be measured merely by the degree to which the group facilitator helps to open communication channels among various parties within the session.

It is the facilitator's responsibility to create a situation in which participants can freely communicate their preferences and points of view. The facilitator must foster and focus discussion to uncover points of difference and disagreement, determine the range of positions, and find opportunities for convergence of opinions. During the course of the exercise, the facilitator will use several approaches to elicit valid preferences, priorities, and judgments from the participants. Facilitation techniques such as paired comparisons (for example, do the probabilities assigned to Events X and Y appear proper in relation to one another?), option anchoring (given Event X has a probability of n, how are Events Y and Z likely to fare?), and in-context assessments (given a described negotiation environment, how would you assess the

probability of Event X?) will be used to ensure logical and consistent data collection.

The facilitator uses decision analytic models to structure the policy exercise. These models provide the systematic and logical basis for representing the decision environment and help the participants to test the implications of alternate decisions before they are selected. As an experienced methodologist, the facilitator seeks to satisfy the technical assumptions of decision analysis described earlier. Exercises are often preceded by in depth interviews of key participants that result in strawman models to get the exercise off to a fast start.

Ultimately, the policy exercise provides a forum that allows participants to debate issues, communicate preferences, and find common ground. There are two principal products of a facilitated policy exercise. First, decision analytic models are built, values and preferences elicited, the models exercised, results presented, and sensitivity analyses conducted. Second, improved communication among the participating decision makers yields a mutually developed, examined, and understood conclusion in which all share ownership.

3.3. Integrating Process and Substance

The family of decision analytic models discussed in this paper are process-oriented models, focused on enhancing the process by which prenegotiation is conducted. Policy maker preferences, priorities, and values on substantive issues constitute the content of these models. But these judgments are not resident in the models to begin with; they must be elicited for the models to be applied. In one sense, this substance-free state makes decision analysis models highly mobile and independent – capable of being applied to almost any negotiation issue. On the other hand, it handicaps their application; other, more substantive, approaches are required prior to their use to identify the issue parameters and limitations and generate alternative formulas for possible negotiated agreement.

Integration of these process and substance models should yield effective support to prenegotiation teams. Perhaps the linkage can be fostered in the following way. Substantive models can help identify alternate formulas of the outcome and can simulate their implications.

Based on these parameters, decision analytic process models can be structured to reflect on and examine the political acceptability of the components of specific formulas that are viewed as reasonable and negotiable.

Attempts to foster such a collaboration between substance and process has been made at the International Institute for Applied Systems Analysis (IIASA) in connection with its project in support of the UNCED secretariat. One research team was focused on developing a systems model that explained the substantive linkages between the issues, in this case, among economic development, agricultural production, lifestyle, population dynamics, and environmental issues (Shaw *et al.*, 1991). The results of exercising this model point to the factors that need to be modified for environmental constraints and developmental drives to be in harmony. Together, these factors suggest alternative solutions that are the subject of negotiation. Such packages were presented to a second research team focused on supporting the negotiation process. As indicated earlier, decision analytic methods were used to evaluate the policy implications and the political feasibility of these packages given the interaction of a range of national interests and objectives in the negotiation (Spector, 1991b).

4. CONCLUSIONS

Decision analytic methods are suitable for practical implementation in international negotiation settings. This methodological family can be engineered to satisfy the four challenges to application posed in the introductory paper of this issue.

- Conceived of as a practitioner's tool from the outset, decision analysis is designed inherently to provide normative and prescriptive advice.
- While innately a highly transportable process tool, decision analysis can be integrated with substantive models. The range of possible negotiation outcomes, often produced by subtantive models, can be fed into decision analytic models to assess tradeoffs on political feasibility.
- From an end-users' perspective, the need for diagnosis, analysis and

planning for negotiation is significant in the prenegotiation period. This is when the capabilities of decision analytic methodologies appear most suitable.

- The presentation and delivery of decision analytic tools for use by practical negotiators is best accomplished through the assistance of a facilitator who can serve both as a methodologist, ensuring a valid model development process, and as an effective independent third party, stimulating communication, understanding, and group acceptance of the structural and logical, if not quantitative, results of the modeling exercise.

Several issues still need to be addressed in preparing decision analytic methods for practical implementation.

- Alternate data collection methods to calibrate the other parties' preferences should be developed to cross-check for possible cultural and perceptual biases that might be introduced by the first party.
- Alternate facilitation protocols should be generated and tested to design an effective third party interface.
- Fuzzy measurement approaches, such as those designed by White and Eldeib (1986) and others at the Systems Engineering Department of the University of Virginia, should be examined to reduce the criticism of false precision in decision analytic findings.

Overall, decision analytic approaches can make a practical contribution in supporting negotiators and their staffs at points in the process when the assessment of options and tradeoffs is significant.

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THE ROLE OF MULTI-OBJECTIVE OPTIMIZATION IN NEGOTIATION AND MEDIATION SUPPORT

ABSTRACT. The paper reviews the methodology of multi-objective modeling and optimization used in decision support based on computerized analytical models (as opposed to logical models used in expert systems) that represent expert knowledge in a given field. The essential aspects of this methodology relate to its flexibility: modeling and optimization methods are treated not as goals in themselves but as tools that help a sovereign user (an analyst or a decision maker) to interact with the model, to generate and analyze various decision options, to learn about possible outcomes of these decisions. Although the applications of such methods in negotiation and mediation support is scarce yet, their flexibility increases essentially the chances of such applications. Various aspects of negotiation and mediation methods related to multi-objective optimization and game theory are also reviewed. A possible application of the MCBARG system for supporting negotiation related to the acid rain problem is briefly summarized.

Keywords: Negotiation, multi-objective modeling, optimization, mediation.

There are various approaches to the theme of how to use analytical techniques in negotiation and mediation support. In the 'off the shelf' approach, established techniques such as result from multi-attribute utility (MAU) analysis, simulation modeling, optimization, or game theory are examined to see show they might support some aspect of the international negotiation process. Another, which is highlighted in this paper, is a more deliberate approach to match methodological capabilities to the difficult analytical requirements of real negotiation situations. For example, how might a simulation model that represents the key decisions and outcomes of a negotiation be applied to support an actual negotiation? Is an optimization of an aggregated objective function useful? Should this function be related to the relevant outcomes simulated by the model or to the decisions? Is it possible to represent the interests of all parties in the negotiation by one aggregated function? There are no easy answers to such questions.

Multi-objective modeling and optimization approaches possess unique methodological characteristics that are likely to be extremely

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meaningful in satisfying the analytical needs of practical negotiators. These approaches integrate the benefits of *substantive models* that represent knowledge concerning actual negotiation issues and *procedural models* that highlight process dynamics. While models that focus on the interests of the negotiation actors, *preference models*, are important, substantive and procedural models are more likely to stimulate the creativity of practical negotiators by offering new perspectives and ways of testing alternative solutions.

1. INTRODUCTION

A decision support system should never *replace* a human decision maker. Even in operational, repetitive decision situations, computerized decision support can at most relieve decision makers from standard calculation and fill in the details of a suggested decision. In strategic decision situations, typical for negotiations, decision support systems can play a different role: they can represent the knowledge of specialized analysts about the substantive aspects of a decision situation and thus provide a laboratory ground, a proxy of the real world, for studying various impacts of selected decisions as well as possible developments in the negotiation process. The value of these systems depends crucially on the validity of their knowledge representation, as logical, analytical or procedural models.

However, models that represent knowledge in a given field have two important limitations. One of them is that the model always must be simplified to some extent and can never represent all pertinent aspects of a given decision situation. Such models cannot be made more adequate by increasing their complexity, because this might increase their sensitivity, make parameter estimation less reliable, or introduce unintended chaotic effects. In strategic decision situations, the intuition of a human decision maker is irreplaceable and knowledge representation in a computerized model can help to enhance this intuition by allowing the decision maker to learn about possible consequences of various hypothetical actions.

Another important limitation of computerized models is, paradoxically, that they are constructed by experts in a given substantive field of knowledge. Such experts often understand the art and science of

model building, but seldom the relatively new methodology of using such models in decision support, which in turn influences significantly the way the models should be formulated, validated, and used. A cooperative team of substantive and decision support modelers is necessary to construct good decision support systems. Even such cooperation may not be sufficient: the ultimate value of a decision support system is in the eyes of its users. Thus, the ultimate user must also cooperate in the development of the system.

With the above reservations, this paper concentrates on decision support using models of an analytical and procedural type. When using models of an analytical type, optimization techniques can often be exploited for selecting decision options. However, attempts to model the preferences of individual decision makers by a single objective function (value or utility function) are never fully adequate and must be treated as rough approximations only. The flexibility of optimization techniques can be increased considerably through multi-objective formulation. This paper describes in simple terms the basic concepts of multi-objective optimization, some selected results from the corresponding mathematical theory, their relations to representing knowledge by analytical modeling and to decision support, and the possibilities of analyzing multi-objective games, negotiation, and mediation processes.

2. MULTI-OBJECTIVE MODELING AND SIMULATION

While single-objective mathematical optimization models are, in a sense, closed and distinct from simulation models that are typically used for analytical representations of knowledge in a given substantive field, multi-objective optimization models can be formulated as a natural, open extension of simulation models. If we accept that a decision maker can have multiple objectives and we simulate a part of the decision maker's world in a model, we can represent these objectives as variables in the model, and allow the user to modify and test the implications of these objectives. The model might not be complete in the sense that it does not represent *all* concerns of the user, but then it must be either reformulated for simulation purposes

or its incompleteness must be overtly admitted and accounted for in the analysis.

An analytical model of the substantive aspects of a decision situation typically contains:

- actions or decisions represented by decision variables;
- potential objectives represented by outcome variables;
- various intermediate variables (state variables, balance variables, etc.) that are essential for flexible model formulation;
- parametric variables or parameters that might remain constant during model simulations but are essential for model validation and alternative model variants;
- constraining relations (inequalities, equations, etc.) that determine the set or admissible decisions and are usually divided into direct decision constraints that involve decision variables and indirect constraints that involve outcome and intermediate variables;
- outcome relations that determine how outcome variables depend on decision variables (with the help of intermediate variables and state equations in dynamic models, and often with the help of recursive or even implicit formulae);
- a representation of model uncertainty (in probabilistic, fuzzy set or set-valued terms); if such a representation is not explicit, we often call such a model 'deterministic' and assume that it represents average situations.

While typical models for single-objective optimization specify only one optimized outcome (*the* objective function) and treat all constraints inflexibly, multi-objective modeling and optimization allow a flexible choice of objective variables between the outcome variables (if necessary, also between decision variables) and a much more elastic interpretation of constraints.

Indirect constraints that are represented in single-objective optimization with a standard form, say, of an inequality, model two quite different classes of phenomena of the real world. One of these classes contains balances that must be satisfied, such as the balance of energy in a physical model; these are so-called 'hard' constraints. The other class contains balances that we would like to satisfy, such as the

balance in a budget sheet; these constraints can be violated (at an appropriate cost) and are called 'soft' constraints. Soft constraints can be modeled even in single-objective optimization by appropriate penalty terms in the objective function; but then the question of their permissible violation calls for additional judgment. In multi-objective modeling and optimization, soft constraints are most naturally interpreted as additional objectives and their evaluation is thus included in the overall evaluation of a multi-objective solution.

Having formulated a multi-objective model, one has to estimate its parameters and validate it; that is, check whether the model represents adequately not only the formal, but also the intuitive, side of expert knowledge in a given substantive field. While there are many methods of parameter estimation and formal model validation, intuitive model validation usually relies on repetitive simulation: the model must be run many times by experts in the field of knowledge under changing assumptions about decisions (or their scenarios, in the case of dynamic models) or parameters, and the obtained outcomes (or their trajectories, in the dynamic case) must be compared against the formal knowledge and the intuition of the experts.

The way that various constraints are treated during the simulation of a model is also essential for its validation. Typical approaches to simulation and existing simulation languages usually allow only for direct decision constraints that can be represented by admissible ranges of decision variables; they do not allow for the inclusion of indirect constraints nor do they distinguish between hard and soft constraints. In addition, expert users of simulation models are often interested in inverse simulation, in which desirable trajectories of model outcomes are specified by the user and decision variables are chosen during the simulation that result in model outcomes close to the specified trajectories. Inverse simulation is particularly useful in scenario generation. Moreover, good simulation techniques should make it possible to perform sensitivity analysis of simulated solutions along with simulation runs. All these issues of simulation under constraints, inverse simulation, scenario generation, and sensitivity analysis can be included in sufficiently sophisticated methods of simulation that use optimization techniques and multi-objective approaches as tools of simulation support. The International Institute for Applied Systems

Analysis (IIASA) has contributed considerably to the development of such methods, see e.g. Kallio *et al.* (1980), Grauer *et al.* (1982), Kurzhanski (1986), and Makowski and Sosnowski (1989).

Multi-objective analysis and optimization also can be performed to help understand the model itself and selection of decision options that are interesting for the user. The basic concepts of multi-objective optimization are well described in several monographs (Sawaragi *et al.* 1985; Yu, 1985; Steuer, 1986; Seo and Sakawa, 1988). For multi-objective scenario generation and option selection, the methodology of reference point optimization, or resulting from it, the aspiration-led approach to multicriteria decision support, is especially useful (Lewandowski and Wierzbicki, 1989). A short review of these concepts in relation to negotiation and mediation support is presented by Wierzbicki and Makowski (1992).

3. MULTI-OBJECTIVE GAMES AND BARGAINING: SIMULATING MULTI-OBJECTIVE NEGOTIATION PROCESSES

It is well known (Rapoport, 1989) that normative game theory, while well developed theoretically both for noncooperative and cooperative solution concepts, does not represent sufficiently the complexity of practical observed behavior of decision makers in gaming, bargaining or negotiation situations. This has stimulated research on modifications and extensions of game theory to obtain more practical tools for studying decision situations in which multiple decision makers might have conflicting interests. Especially interesting results in this direction, useful for understanding negotiating behavior, are connected to the concept of the evolution of cooperation (Axelrod, 1984).

However, the practical use of computerized models of substantive aspects of a decision situation with conflicting interests has been until now restricted almost entirely to simulated gaming. Users (students, analysts, decision makers) participating in such gaming exercises can play the roles of decision makers by entering their decisions in the simulation model and then observing the simulated results of these decisions. While very valuable as a learning exercise, such simulated gaming has one essential drawback: users must rely on their individual intuition only and are usually denied more advanced decision support; in real life, any important strategic decision is based on support

provided by analysts or by discussions at executive boards, for example. This creates the challenge of introducing decision support tools into simulated gaming (Wierzbicki, 1989). Similarly, as more advanced model simulation should include multi-objective optimization tools, simulated gaming should include game-theoretical tools. However, such tools must not be treated as normative prescriptions; they should help only in analyzing the simulated game. They must also take into account possible multi-objective formulations of the game. Unfortunately, while game theory from its very beginning admitted multiple objectives of the players, it almost always assumed the possibility of aggregating them by value or utility functions. The basic solution concepts in game theory – starting with the Nash noncooperative equilibrium concept – were not sufficiently analyzed after generalization to the multi-objective case; only recently (Wierzbicki, 1990) have such extensions been attempted.

Multi-objective equilibria in a game are necessarily not uniquely defined; there may be many of them. Unilateral selections of such equilibria by players can lead to conflict escalation. If one player selects an equilibrium that seems rational to him, but another player a different equilibrium, and both pursue strategies that should lead to the outcomes desired by each, it usually results in non-equilibrium outcomes that are much worse – even disastrous – for both the players. This fact is well known even in single-objective game theory for cases with multiple equilibria, as for example the so-called game of chicken (Axelrod, 1984). However, since conflict escalation processes occur in real life, the multi-objective formulation of a game can help in understanding such processes. For example, during a gaming simulation, appropriate conflict coefficients can be computed to inform the participants how far they are from a noncooperative or even cooperative equilibrium.

Together with game theory, bargaining theory (Roth, 1979) has concentrated on certain cooperative solutions to bargaining games which could be useful in supporting negotiations, mediation, and arbitration. Studies on multi-objective aspects of bargaining have led to the development of a prototype multi-objective mediation support system, MCBARG. A possible application of MCBARG is briefly presented in the next section of this paper.

Although there are notable methodological reflections on the art and

science of negotiations (Raiffa, 1982), the development of multi-objective methodologies in multi-actor decision situations to support negotiations, mediation and arbitration is still in the beginning stages. Some applications are known – see for example, the multi-objective analysis of multilateral gas trade by Messner (1985) – and some conclusions can be drawn.

(a) Analytical models, combined with role-playing and gaming simulation, preferably in multi-objective formulation and supplemented with various decision support tools, can be used by each team preparing for negotiations. While such preparation can be valuable, extreme caution should be exercised when preparing the substantive analytical model and when playing the role of the opposite side. The experts and analysts of one side are apt to misperceive the concerns and objectives of the opposite side; thus, the substantive model prepared by them might not include objective outcomes of the opposite side and might not be adequate for gaming simulation. When role playing, ideological indoctrination of one side can lead to serious misrepresentation of the behavior of the opposite side.

(b) Analytical models representing internationally accepted knowledge in a given field, validated by experts from various sides, can be very useful in supporting both the preparation for and the actual conduct of negotiations. This, however, assumes that all parties to the conflict are prepared for 'getting to yes' (Fisher and Ury, 1981), accept a mediating role of an impartial institution (in terms of gathering relevant knowledge and information), participate in validating the model, and are prepared to take seriously the outcomes simulated by the model. If these prerequisites are met, then the resulting model can have a profound impact on the course of negotiations, as it did in the case of negotiating the Law of the Sea agreements. Even more profound in terms of influencing the attitudes of high-level decision makers was the more generally formulated model of nuclear winter accepted by both American and Soviet experts.

(c) Future generations of negotiators, more exposed to concepts and techniques of the information society than the contemporary generation of negotiators, may accept further extensions of the procedural role of knowledge formalized in models and decision support systems in negotiations and mediation.

To achieve this, the following conditions must be satisfied.

(a) The principle of user sovereignty should be particularly stressed and strictly observed when constructing decision support for negotiations. Diplomats quite rightly stress the role of their intuition and negotiating skills. Thus, a decision support system must only augment and enhance these skills.

(b) Prototype negotiation and mediation support systems – including various procedural variants, such as support for unilateral decisions and support for multilateral role-playing should be introduced as a part of training for young negotiators.

(c) The methodology for developing and using analytical models that represent substantive aspects of multi-actor decision situations with conflicting interests should be further advanced, along with appropriate developments of multi-objective, multi-actor decision support.

4. THE MCBARG SYSTEM

MCBARG is an experimental multi-objective optimization system that illustrates the issues of supporting the mediation process in bargaining situations. In the following example, MCBARG is used to deal with international negotiations concerning acid rain. Several countries are engaged in developing a mutually acceptable formula to reduce sulfur emissions. For each country, the expected emission level of sulfur is assumed. Also given is a cost function describing the minimal required expenditures for emission control as a function of the emission reduction in the country. Sulfur depositions in particular countries are described by linear equations of the emission levels with coefficients of atmospheric transportation. This simple example was inspired by the RAINS model (Alcamo *et al.*, 1990) and is presented in detail in Kruś and Bronisz (1991).

Each country can, of course, act independently by enforcing its own reduction program and covering its own costs. However, this runs contrary to international cooperation, especially if the countries have agreed jointly to coordinate their reduction programs and reap mutually beneficial results. In fact, results of simulation runs of the RAINS model have shown that cooperation is truly effective, saving

both costs and effort. Each country has two objectives to be minimized, namely: the monetary share they pay to obtain the joint results and the resulting sulfur deposition. The nature of the reduction programs in particular countries and the costs of the programs covered from a joint fund are the decision variables.

How can a model such as MCBARG be used to support preparation of international agreements where selection of a cooperative solution is sought? Certainly, no mathematical model can incorporate all variables of importance at the level of detail required, but such models can, in a simplified way, stimulate the creativity of negotiators by providing varied perspectives on their complex problem. In the acid rain negotiation application, MCBARG uses more modest models than in the RAINS model to illustrate how multiple objectives can be incorporated and benefit the exploration for solutions.

The set of outcomes that are beneficial to all negotiating countries (agreement set) in comparison to the noncooperation case (described by a disagreement point) can be arrayed on a continuum; however, it is not simple to specify which outcome should be selected as the solution. The bargaining problem consists of looking for an efficient solution in the agreement set. The solution should be selected according to the preferences of the countries and should be unanimously accepted. Roughly speaking, the problem consists of allocating the benefits resulting from cooperation in a mutually beneficial fashion to all parties.

MCBARG offers decision support in the form of an interactive mediation procedure. This support is framed using a single negotiation text procedure described by Raiffa (1982) and the principle of limited confidence proposed by Fandel and Wierzbicki (1985). MCBARG is used iteratively across a number of rounds. Each round starts from the current status quo point. The system supports players in unilateral interactive analysis of the problem with an emphasis on learning. Each player can independently scan the possible outcome variants according to the rules of the aspiration-led approach of multicriteria decision support, as well as different assumptions for the counterplayer's preferences or decisions and different assumptions about the possible improvements of counterplayer outcomes due to the limited confidence principle. After scanning, each player is asked to select a preferred outcome.

The preferred outcomes of all the players are the basis for calculation of the result of a round. The result is calculated following the limited confidence principle, improving outcomes of all the players in terms of the outcomes specified as preferred ones according to a common confidence coefficient. The result of a round can be considered as a single negotiation text proposed by the mediator and to the players, and as a status quo point forming a basis for the next round of negotiations. The process terminates when the Pareto optimal solution in the agreement set is reached.

Formulation of this interactive process is based on theoretical research by Kruś and Bronisz (1991). To assure fairness of the solutions, axioms such as independence of linear transformations of objectives, anonymity of players and criteria, monotonicity, and player rationality have been considered (Nash, 1950; Roth, 1979; Kalai and Smorodinsky, 1975; Thomson, 1986). Different solution concepts have been analyzed and a generalization of the Raiffa–Kalai–Smorodinsky solution is used based on the concept of utopia point related to player aspirations. The generalized solution is calculated according to the preferences of the players. This solution has some useful properties. It is resistant to the manipulations of the players. In particular, the players cannot benefit from changing scales in their particular objectives, from making decisions during the process that do not truly reflect their preferences, and from proposing dummy objectives. Uniqueness and convergence of the negotiation process has been demonstrated, assuming conditions of player rationality, which are not very strong assumptions. In future versions of the MCBARG system, several solution concepts satisfying different sets of axioms will be proposed for user selection.

A more detailed description of the MCBARG system can be found in Kruś, Bronisz, and Lopuch (1990). The system has been tested in experiments with various users for the simplified model presented above. A discussion of the experiments can be found in Kruś and Bronisz (1992).

The system enables players to learn, analyze, and modify their bargaining positions. In this way, it assists in the structuring of the negotiation process. The system also supports a mediator role that calculates single negotiation texts to be analyzed, modified and remodified by the users representing various negotiating parties.

5. CONCLUSIONS

A major challenge to modelers is to combine human expertise and intuition with more formalized knowledge, while preserving the strengths of both parts. Can multi-objective modelling, optimization, and decision support be useful in this regard for negotiation and mediation? The answer is positive in principle, though more practical experience is needed. The use of multi-objective model formulation, optimization, and game theory treated not as goals or normative prescriptions, but as flexible instruments is especially promising. Using this methodology, one can design and implement decision support systems (DSS) that can be tailored to specific needs. However, to successfully implement a DSS, many conditions must be met. We list below only a few essential ones (Makowski, 1991).

- A DSS must support fast, but reliable analysis of large amounts of data and logical relations to provide results for experts or decision makers. However, such an analysis is problem-specific and usually deals with only a few of the issues involved in a complex negotiation or mediation. A careful study must be conducted for each case to identify and scope the proper design of a DSS.
- A DSS clearly should be only a supportive tool. The user should be aware of its limitations and of the underlying mathematical model. Users must be convinced that a DSS is not aimed at replacing the decision maker's knowledge or experience, but is just a tool for performing sophisticated or cumbersome calculations and analysis that is specified jointly with the user. The DSS frees the decision maker to concentrate on tactical and strategic issues in the negotiation process.
- Claims of DSS usefulness must be modest. However, DSS effectiveness, particularly in the negotiation field, can be improved only through real-life applications and feedback.
- The analytical team which develops a DSS should work in close cooperation with future users. Potential applications of DSS must be carefully chosen. They should contain a subproblem that is complicated enough to justify development of a DSS but that is simple enough to be implementable.

Why have such negotiation support applications not been more widespread? First, the proposed methodology is fairly new. Many applications of multi-objective optimization employ techniques that have many drawbacks (Wierzbicki and Makowski, 1992), thus spreading a misleading judgment that such techniques are not useful. Second, serious applications of modeling approaches used to be restricted to specialists well trained in computer systems. This second argument is now vanishing (see Andriole in this issue). Development of user friendly software, together with powerful but relatively cheap hardware, is resulting in the proliferation of computers to many new areas and applications. However, it should be stressed that specification, estimation, and verification of mathematical models must be left to specialists who work together with future users.

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STATISTICAL ANALYSIS FOR NEGOTIATION SUPPORT

ABSTRACT. In this paper we provide an overview of the issues involved in using statistical analysis to support the process of international negotiation. We will illustrate how the approach can contribute to a negotiator's understanding and control of the interactions that occur during the course of a negotiation. The techniques are suited to the analysis of data collected from ongoing discussions and moves made by the parties. The analyses are used to illuminate influences and processes as they operate in particular cases or in negotiations in general. They do not identify a 'best' strategy or outcome from among alternatives suggested either from theoretical assumptions about rationality and information-processing (see Munier and Rullière's paper in this issue), from personal preference structures (see Spector's paper in this issue), or from a rule-based modeling system (see Kersten's paper in this issue). This distinction should be evident in the discussion to follow, organized into several sections: From Empirical to Normative Analysis; Statistical Analysis for Situational Diagnosis; Time-Series Analysis of Cases, and Knowledge as 'Leverage' Over the Negotiation Process. In a final section, we consider the challenge posed by attempts to implement these techniques with practitioners.

Keywords: Statistical analysis, situational diagnosis, time-series analysis.

1. FROM EMPIRICAL TO NORMATIVE ANALYSIS

The use of statistical analysis of data for decision support turns on the issue of how general knowledge can be used in giving advice about specific (time and space-limited) problems. For most problems, statistical techniques are used to discover or describe relationships between scaled variables sampled from defined populations. Obtained relationships are evaluated in terms of probabilities of occurrence. Stronger relationships (or correlations) between variables are those less likely to have occurred by chance alone: For example, a correlation of 0.5 is likely to occur by chance in only 5 of 100 samples of size 10 drawn from the same population. The most important contribution of probability theory is the idea of statistical inference, namely, determining the extent to which relationships obtained for a given sample apply

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also to other samples that can be drawn from the same population. The inference process is based on the theoretical concept of the sampling distribution of a statistic. Simply stated, this is a probability distribution of the values of a statistic, such as a *t*-ratio or an *F*-ratio, computed from all samples of a given size drawn from the same population; it is the basis for the tabled values associated with probabilities of occurrence found in the back of most statistics texts, and permits statements such as a *t*-ratio of 1.96 is likely to occur in only 5 of 100 samples by chance alone.

Statistical analysis is most appropriate for testing hypothesized relationships derived from theory. It provides tools for evaluating the strength of relationships obtained from sampled situations. Whether confirmed or rejected, the result of the analysis is stated in general terms, as applying to a wide range of situations and samples. Less attention is paid to the contextual (or case specific) contingencies that would qualify the generality of the findings. For this reason, advice based on statistical analysis is likely to be largely independent of those contextual details that often seem essential to practitioners. How then might we bridge the gap between the general, theory-based knowledge accumulated through statistical analysis of data and the specific information sought about cases by practitioners and policy makers? One way to do this is to place the case in a dimensionalized space based on a wide sampling of situations. Another strategy is to perform time-series analyses of the specific case. The former involves extrapolating from knowledge about a range of known situations to situations about which less is known ('extrapolating in space'); it will be illustrated with the problem of situational diagnosis. The latter involves extrapolating from a known past to an unknown future along a time trajectory ('extrapolating in time'). This will be illustrated with examples from work on the content analysis of specific negotiations.

Both of these analytical strategies are descriptive. Each deals with the issue of extrapolating from a set of relationships found in one situation or time period to another where similar relationships are assumed to exist. The transfer of knowledge is problematic for processes that are sensitive to context and culture: contextual influences militate against the development of propositions that apply across a wide range of situations. The literature on negotiation is

dominated by case studies and by conceptualizations that emphasize an intertwining of process and context (see Druckman and Hopmann, 1989). Like facial expressions, negotiating behavior can be understood in terms of both 'universal' and context-specific elements. For expressions, the facial configurations elicited by the primary emotions (happiness, surprise, sadness, anger, disgust-contempt, fear, and interest) are universal while the conditions that evoke those emotions are culture specific (Ekman *et al.*, 1987). Similarly, for negotiating behavior, convergence processes occur in virtually all cases; when, how, and on which issues these processes occur depend on the parties, issue-areas, and the broad context surrounding the talks. Thus, extrapolation is problematic in developing knowledge about negotiation. It is addressed directly by statistical analysis, particularly those aspects of statistics that deal with sampling designs. The strategy presented in the next section illustrates an approach to extrapolation based on principles of representative sampling of situations.

The ability to extrapolate knowledge from one situation to another does not, however, prescribe actions. Neither analytical strategy suggests how to use the information obtained about relationships among variables for advice on negotiating tactics. While each strategy may alert a negotiator to what happened in *other* situations and at *other* times, it does not tell him or her what to do in *this* situation. In a later section, we discuss the relevance of descriptive information for making prescriptions about negotiating tactics.

2. STATISTICAL ANALYSIS FOR SITUATIONAL DIAGNOSIS

A situational diagnosis is an assessment of the negotiating situation in terms of the presence (or absence) of those elements hypothesized to influence outcomes. Such an assessment is based on knowledge of relationships among situational and process or outcome variables. Just how to develop this knowledge and how to apply it to particular negotiating situations of interest are challenging research issues. In this section, we discuss the theoretical underpinnings for the concept of situational diagnosis and propose an analytical strategy in several parts.

The idea of a situational diagnosis derives from a research tradition

that places emphasis on understanding the negotiation process in terms of the way aspects of the situation influence negotiators' behavior. Developed largely by social psychologists, this approach contrasts to perspectives that focus on persons, structures, or the systems surrounding the negotiation. It assumes that much of the variation observed in negotiating behavior from one case to another is due to the differences in situational attributes that characterize those cases. Just *how* the behavioral variables relate to the situational attributes is an empirical issue that can be addressed by statistical analysis of experimental or case-study data. Implications of the analyses are, however, limited to the variables chosen for study. Thus, the way these variables are defined is critical.

The definition of situational attributes has been guided by conceptual frameworks and by theory. Frameworks are developed to organize the parts of a negotiation, often taking the form of flowcharts that depict an interplay among influences and processes through time (Sawyer and Guetzkow, 1965; Randolph, 1966; Druckman, 1973, 1977). Among the variables highlighted by the frameworks are preconditions (relationships, preparation), issues (size and complexity), structure of the parties (presidential interest, bureaucratic agencies, third-parties), and the immediate situation (deadlines, other parties' concessions and tactics). Other variables are suggested by part-theories developed in related areas. Examples are prenegotiation strategizing or studying the issues, developing BATNAs, linking or delinking values from negotiating positions, and salient solutions. Corresponding 'theories' are the effects of effort on commitment to positions (Lewis, 1965), comparison of rewards derived from current versus alternative social interactions (Thibaut and Kelley, 1959), the way values or ideologies interact with interests (Coser, 1967), and the role of coordination points in solving problems (Schelling, 1960).

Progress has also been made in defining behavioral variables. Many of the indicators refer to negotiating flexibility as manifest in concessions, verbal statements, perceptions, or outcomes. *Concessions* are measured as changes in proposals that occur during the course of bargaining in laboratory (e.g., Bartos, 1974) and real-world settings (e.g., Jensen, 1988). *Verbal statements* are coded for tough and soft postures and for tactics used to persuade an opponent to alter his or

her positions (e.g., Hopmann and Walcott, 1977). *Perceptions* are assessed as views of the opponents (as tough or soft bargainers) and the situation (as win–lose or problem solving), and are often analyzed as variables that intervene between the situation and outcomes (e.g., Druckman *et al.*, 1988). *Outcomes* could be stalemates or agreements and are often evaluated in terms of costs incurred or benefits obtained by the parties. These measurements have been used in a variety of studies designed to discover relationships between situational and process or outcome variables. How to use the results in making diagnoses of flexible behavior and outcomes in particular cases raises the issue of *extrapolation*. The strategy proposed here addresses this issue. It illustrates the way that statistical analysis can be used to bring research results to bear on case diagnoses.

The first task consists of developing a knowledge base for inferring relationships among the variables of interest. Since relationships cannot be discovered from analysis of single cases, the knowledge base must be established from analyses of many cases or from replications of experimental sessions where variation occurs on both the situational and process or outcome variables. This entails sampling widely across a range of negotiating situations in which the key variables can be observed and coded. The coded variables are the data that capture variation in both situation and process among the sampled cases. They provide the information needed to distinguish the cases in terms of similarities and differences, a task that can be performed with multidimensional scaling techniques.

The second task consists of reducing the variation among cases to a smaller set of types of cases grouped according to dimensions of similarity and dissimilarity. The groupings are discovered through the use of statistical scaling techniques that serve to define a dimensionalized space based on the coded data. (See Kruskel and Wish, 1990, for a discussion of multidimensional scaling; computations can be done by such statistical packages as SYSTAT, now available for use on personal computers.) This task provides an empirical basis for a taxonomy of negotiating situations. It is similar in many respects to the approach taken by Frederiksen (1971) for categorizing diverse situations in terms of their similarity in eliciting behaviors. However, while this task is useful for generating types of negotiation situations, the

categories that emerge apply to the sampled situations and to the range of variation characteristic of *those* situations. They do not encompass *other* situations about which less is known. Another task is needed to take into account situations or cases that were not part of the original data base used to discover dimensions. The 'new' cases can be located within the dimensionalized space (clusters of coded cases) by matching aspects of the new situation with the aspects of the analyzed situation which were part of the data base: accurate matching depends on whether the new situations or cases elicit the same negotiating behaviors as those matched situations already analyzed. Having accomplished this task, we are ready to perform a situational diagnosis.

The analyses completed to this point provide the information needed for diagnosing the likelihood that particular negotiations would result in agreement. By assessing a negotiating situation in terms of whether the key elements (found in the analyses above to relate to negotiating behavior) are present, it should be possible to estimate the extent to which parties are willing to move from their initial positions to get an agreement or to produce a stalemate. This task is a step between the empirical analyses described above and the prescriptive advice to be described below. It consists, first, of describing the situation or case in terms of the variables found in the above analyses to influence negotiating behavior; then, the relationships are represented by deriving the behavior of interest, such as negotiating flexibility, from the situational variables such as whether the negotiator is constrained by instructions from his or her home office. For example, a judgment that the chief negotiator representing one of the parties in this case is constrained by instructions results in a 'score' of low flexibility for this variable; judgments on each of the other variables are similarly shown to lead to flexible or inflexible behavior, culminating in an aggregated 'score' for each of the negotiating parties. Missing from such a diagnosis, however, is an evaluation of the relative importance of the variables as influences on negotiating behavior. This can be determined by using another analytical procedure, experimentation. Reactions of negotiators (or experimental subjects playing roles of negotiators) to alternative scenarios can be used to establish weights for the variables. The scenarios can be altered to define different experimental conditions, each condition reflecting a particular combi-

nation of the situational variables. The reactions would be analyzed for effect sizes (see, for example, Hedges and Olkin, 1985, or Wolf, 1986) or for scale position resulting from such techniques as pair comparisons (see Guilford, 1954). These techniques can be illustrated.

Two recent analyses demonstrate how experimental data can be used to derive weights. One was a meta-analysis of published bargaining experiments. The other was a simulation-experiment designed to elicit decisions about bargaining moves in reaction to alternative scenarios. The experiments used in the meta-analysis were organized into eight independent-variable (IV) categories. Using procedures for converting statistical ratios (F-ratio, t-test) into effect sizes (correlations), average effect sizes were calculated for studies in each IV category. Arranged in order of effect size, the variables are as follows: type of prenegotiation preparation, negotiator's orientation toward the negotiation, distance between initial positions, time pressure (with or without deadlines), type of opponent's concession strategy, the visibility of the negotiation to others, accountability of the negotiating representative, and whether the issues were 'large' or 'small.' The effect sizes calculated for these variables can then be used as empirically-derived weights in the situational diagnosis, distinguishing relatively strong from weak relationships between the variable and negotiating behavior. Several of these variables were included in the example of a diagnosis described below.

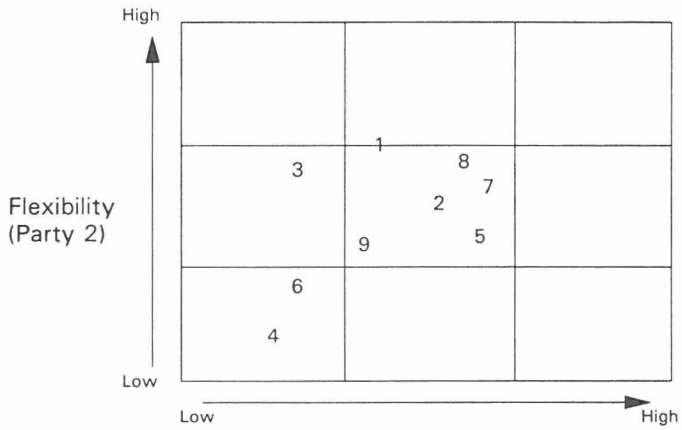
The simulation results also provide weights for relevant variables. Role players responded to alternative scenarios containing 'packages' of situational variables – for example, scenarios hypothesized to produce flexible or inflexible decisions about position movement. Using a pair-comparison procedure, they compared the variables in terms of their relative impact on flexibility in the negotiation. The judgments were converted to scaled weights indicating the relative importance of each of the variables: Particularly strong weights were obtained for visibility of the negotiation (wide versus limited media coverage), type of prenegotiation preparation (studying the issues or strategizing), and type of negotiating representative (head-of-delegation or advisor to the delegation). These weightings can then be used in a diagnosis that includes those particular variables. (See Druckman, 1992, for the details.)

Once determined, the weighted variables provide opportunities to

influence the negotiation process. They are the aspects of the environment that can be manipulated for impact in particular cases. By using general results about relationships between variables as a framework for making situation-specific judgments, this information would help a negotiator who attempts to gauge the flexibility of his or her opponent; it would aid a mediator who tries to determine how much flexibility exists in a particular situation, and, it would contribute to an analysts' understanding of the negotiation process. The negotiator uses the diagnosis for strategic purposes; the mediator uses it to ascertain where leverage can be applied to get a mutually-acceptable agreement, and the analyst can evaluate the correspondence between the diagnostic evaluation and actual negotiating behavior.

Preliminary diagnoses of nine cases illustrate the analytical value of the exercise. Each case was construed as a bilateral negotiation and coded, for each party, by analysts familiar with the negotiation. Coding decisions were made for 17 variables organized in the categories of background factors (e.g., relationship between parties), issues (e.g., number and complexity), structure of parties (e.g., negotiator accountability to agencies), and situation (e.g., deadline pressures). Weightings for the variables were not derived empirically for this illustrative application; they were determined by judgments made by scholars with substantial knowledge about the cases. A computer program aggregated the codes for each party, sorting them into a two-dimensional 'flexibility' grid divided into thirds. The intersection of the parties' flexibility, indicated by a point in one of the nine cells, is converted into a likely outcome as either the most desired outcome for both parties, a fair agreement, a capitulation of one party to the other, to continue negotiating without an agreement, or a stalemate.

Results are shown in Figure 1. Interestingly, the two cases that actually resulted in an impasse – MBFR (case 4) and the regime-insurgent talks in the Philippines (case 6) – are located in the lower-left cell whose outcome is judged to be a stalemate. Similarly, for cases 1 (Panama Canal), 3 (INF), 7 (test-ban in the endgame), 8 (ECE air pollution in the endgame), and 9 (US-Canada talks on acid rain) the diagnosed outcome of a fair agreement is close to the actual outcome. And, for the Spain base-rights talks (case 3), the diagnosed outcome of



Cases
1. Panama Canal, 1974
2. Panama Canal, 1977
3. Spain military base rights, 1985-86
4. MBFR, 1974-77
5. INF, 1985-87
6. Philippine's regime vs. National Democratic Front, 1987
7. Test ban, 1962-63
8. ECE on air pollution
9. U.S.-Canada on acid rain

Fig. 1. Location of cases in a flexibility grid.

continuing the talks without an agreement would have occurred if not for the critical event of Franco's death after ten rounds of negotiation (Druckman, 1986). The validity of these results attests to the experts' understanding of these particular negotiating situations as reflected in their coding decisions. The program provided a framework for relating these decisions to possible outcomes, going from diagnosis to prognosis.

3. TIME-SERIES ANALYSIS OF CASES

Analysis of the specific case of interest would seem to translate more directly into advice than the results of the situational analysis described above. A focus on the particular rather than the general renders the approach idiographic and 'clinical'. This approach has the *advantage* of penetrating more deeply into internal case dynamics as well as the historical context that determines how the issues are defined, how they

are approached by the parties, and the evolution of national policies relevant to the negotiations. It has the *disadvantage* of neglecting theory-based knowledge about negotiation that would expand the range of insights beyond those available from close analysis of a particular case, as well as place the case in the context of other cases both past and present.

Statistical analysis can contribute to an understanding of a negotiation as it unfolds through time. Content-analysis coding of moves made in earlier rounds can be used to project trends of moves to be made in later rounds. This is a form of linear statistical extrapolation done with regression analysis. It has been illustrated with moves made during the course of an ongoing negotiation such as the Mutual and Balanced Force Reduction (MBFR) talks (Druckman and Hopmann, 1979); it has also been done as a retrospective case analysis by Hopmann and King (1976) on the partial test-ban talks and by Druckman (1986) on the military base-rights talks between Spain and the United States. The on-line consultation provided for the MBFR delegation enabled the negotiators to use the analysis to influence the process – or, at least, to give them a sense of control over the near-future course of events. The retrospective analyses provided an opportunity for validation by comparing the regression-based forecasts with the actual moves made and the outcomes obtained.

The time series was created for these cases by content coding of statements made by the negotiators during the round-by-round discussions. The codes were aggregated by session to form indices of hard and soft bargaining following the bargaining process analysis system devised originally by Walcott and Hopmann (1975). The trends in these indices across rounds provided a data base for addressing questions posed by members of the support staff for the negotiations: Can critical events such as impasses or proposals be predicted from negotiating behavior occurring prior to those events? Can we forecast moves made by other delegates in the next round of the talks? On which issues are the other delegates likely to be flexible or inflexible? Answers to these questions were provided from the results of correlational and regression analyses of the time-series data.

In the base-rights case, impasses were predicted from the difference between the teams' hard behavior in the *previous* round: The larger

the difference, the more likely an impasse would occur in the *next* round (Druckman, 1986). In MBFR, the tabling of a proposal occurred following a trend of increasing soft statements through several sessions *prior* to the event, followed by a trend of increasing hard statements in the sessions *following* the event (Druckman and Hopmann, 1991). Also in the MBFR talks, the percentage of hard statements to be made by the other delegates in the next round was projected reliably from regression equations based on correlations between the round-by-round hard behavior coded for pairs of teams, referred to as patterns of responsiveness; information about past *patterns of interaction* among members of different delegations was more useful than extrapolations of trends in a party's own past behavior. Using the indices, it was possible to distinguish between the MBFR issues where delegates were relatively flexible and those where they were inflexible, leading to a definition of a bargaining space within which agreements could occur. In fact, the particular trade-off suggested by this analysis was recognized by the delegates as a potential basis for agreement. For other examples of practical uses of time-series analysis in negotiation, the reader is referred to the chapter by Druckman and Hopmann (1991).

If done correctly, a statistical time-series of a single case can uncover patterns that project reliably into the future, and may even be duplicated in other cases. One such pattern is the way negotiators respond to their opposite numbers through the course of the talks (Druckman and Harris, 1990). Another pattern is the relative impact of external events and internal moves as influences on negotiating postures coded from verbal statements (Hopmann and Smith, 1977). Certain requirements must however be met in order to do the analysis correctly. One is that there be sufficient data points to be able to use the most powerful techniques to detect relationships, as well as prevent distortion of results due to extreme or isolated events, i.e., the degrees-of-freedom problem (Campbell, 1975). Another is to correct for interdependencies among variables caused by factors that are either internal or external to the stream of moves taken by the parties through time. An internal factor is autocorrelation or correlations among successive time-dependent moves which extend to points more distant in time and disturb the direction of relationships. An external

factor is multicollinearity which refers to correlations among independent variables which may jointly or singly influence the process; the problem here is one of detecting which variables have the largest impacts. Fortunately, statistical tests have been devised for detecting these problems and adjustments can be made to reduce their impact on the results. (See Ostrom, 1982, for a discussion of the advantages and limitations of time-series analysis.)

While the technical problems involved in time-series analysis can be solved, other problems are more fundamental and may undermine the purpose of the analysis. One problem is the assumption of linearity. For many negotiations it may be that processes move along trajectories not captured well by linear models. They may be depicted as stochastic processes captured by such statistical techniques as Markov chains or Bayesian analysis: The former would be sensitive to state changes from one stage of a negotiation to another; the latter would revise probabilities of events in response to new information during the course of an unfolding negotiation process. (See Job and Duncan, 1982, for an illustration of the way these techniques are used to monitor changes in the international system.) This is largely a problem of theory – of the ways by which we conceptualize processes of negotiation. Another problem is that longitudinal analysis is not suited for hypothesis testing. This requires that the case, rather than the time period, serve as the unit of analysis. By gathering a data base of cases, it would be possible to test hypotheses about relationships among variables as they operate across a spectrum of cases. The statistical techniques described above in conjunction with situational diagnoses would be relevant to these comparative analyses.

4. KNOWLEDGE AS 'LEVERAGE' OVER THE NEGOTIATION PROCESS

Statistical analysis can play an important role in the application of knowledge about negotiating behavior. Its main contribution perhaps is to call attention to the adequacy of the data bases which guide decisions. A large number of cases, replicated experiments, reliable codings, and similarity between the analyzed situations and the case about which advice is sought are some of the considerations en-

tertained in judging 'adequacy'. More often than not, these considerations will highlight the limitations of advice based on personal experience (e.g., Lall, 1966), on 'accumulated wisdom' (e.g., Fisher and Ury, 1981), or on case studies (e.g., Walton and McKersie, 1965; Bendahmane and McDonald, 1986). They also provide standards against which to evaluate nostrums derived from a 'few experiments' (e.g., Karrass, 1974). The conclusion often reached is that many writers, and some scholars, offer advice without a solid foundation, extrapolating beyond the available data bases or out of context.

The critical function served by statistical analysis can also be constructive. The approach encourages the analyst or consultant to articulate the dimensions of similarity or dissimilarity among cases in order to know the limits of knowledge transfer from one set of cases (e.g., those in the 'data base') to another (e.g., those not in the 'data base'). It reminds the analyst that even the strongest relationships obtained in a particular study are probabilistic and could conceivably be due to sampling error; thus, the need for replication, large samples, and diverse contexts in which relationships are explored. It leads one to develop a critical eye for advice offered by 'experts'. Yet even 'bad advice' may well be taken seriously by practitioners, leading them to make decisions that influence the process or outcome of a negotiation. This too can be evaluated by statistical techniques.

The analytical strategies discussed above can enhance a negotiator's leverage over the process. The situational diagnosis alerts a negotiator to factors in the situation that may influence the process. He or she is likely to have control over, or be able to manipulate, many of these factors: for example, the way a delegation prepares for a negotiation, BATNAs, perceptions of the size of issues, rate of concession making, deadlines. Other factors may be more difficult to control but can be monitored and taken into account in devising negotiating strategies: for example, the extent to which negotiators are accountable to government agencies, the broader relationship between the nations, types of third party interests. The time-series analysis provides warnings about possible future developments, especially if past trends are repeated. Most interesting perhaps is the way the 'other' team responds to 'our' moves or to events that occur during the negotiation. Knowing the other's pattern of response to our moves enables a

negotiator to alter his or her own concessions or rhetoric to produce desired effects.

Enhanced leverage over the process would result from using the two analytical strategies together. The influences discovered by the situational diagnosis may impact on the process primarily during certain stages. By combining the strategies it should be possible to develop a more differentiated conception of negotiating behavior. The time-series analysis could identify points or stages during the process where the influences have their strongest (or weakest) impact on negotiating behavior: For example, the effects of prenegotiation preparation strategies on negotiating postures are likely to be strongest early in the talks, dissipating in later stages as the talks proceed through the give-and-take discussions. Such refined knowledge about relationships and dynamics would contribute to an understanding of the popular notion of 'points of leverage'. It would call attention to 'moments' during the process when certain tactics are likely to be effective.

5. COMMUNICATING WITH THE END-USER

Many tools developed for negotiators are used primarily by analysts whose backgrounds are similar to the developers. Implementing the tools for use by negotiators or their support staffs has been difficult; few of the analytical techniques discussed in the articles of this issue are used on a regular basis to support actual negotiations. Reasons for this may have to do with the 'two cultures' problem discussed by Druckman and Hopmann (1989) and by Winham (1979). Several dimensions of difference between the research and practitioner communities have made communication difficult: for example, the one is oriented toward explanation, the other toward prescription; the one concentrates on general principles while the other focuses on case-specific details; an emphasis on the process and on strategic interactions contrasts with an emphasis on the context for policy formulation and problems of bureaucratic management. Bridging these gaps requires a transition from the role of research analyst to that of analytical consultant, a role whose function is to adapt knowledge to the expressed needs of the 'client'. How best to make this transition is a challenge to the ingenuity of the researcher. But, it can be aided by some general guidelines.

First, rather than attempting to educate practitioners in theory or research methodology, the analytical consultant should be educated by practitioners to understand their problems, accepting the reality in which they operate as one that is crisis-ridden, uncertain, complex, and changing in unpredictable ways. Confronting this environment, the practitioner views his or her craft as an art; the consultant can accept this view, making evident some of the advantages to be gained by informing that 'art' with advances in scientific theory and research. Second, the tools should be designed to provide practical solutions to problems that arise in specific cases. The results should be judged by the practitioner as solutions to his or her problems as these emerge in the context of the negotiations. Third, the tool should be user friendly. The language used to address the problems should be familiar and the questions asked easy to answer. The answers are 'processed' by computations done by the computer software; the algorithms do not need to be transparent to users. Better yet, the user would benefit from a program that also permits him or her to explore alternative options or futures, aiding the job of contingency planning engaged in by most agencies that support negotiations. Statistical analysis can contribute in important ways to the development of useful tools, such as those discussed in this paper. Whether these tools are actually used, however, is likely to depend more on judgments of practitioners that "they work" than on an understanding by them of *how they work*.

Implications for application can be illustrated. The intent of a diagnosis is to identify those aspects of a complex negotiating situation that can be altered to facilitate the search for agreements. Recent research suggests the possibility of differentiating more precisely in the sense of highlighting just those variables that operate in particular phases of a negotiation; for example, prenegotiating, stage-setting, the give-and-take discussions, the endgame. One set of findings from the simulation-experiment, discussed above, was trajectories of variables, based on the pair-comparison weights, leading either toward agreement or toward a stalemate. For example, the following trajectory toward agreement was developed from the findings:

> Being a delegate-advisor and studying the issues (stage 1)→ holding the talks at a peripheral location and being at a power disadvantage (stage 2)→

exposing the talks to only limited media attention and having salient outcome options (stage 3)→
exposing the talks to limited media attention and having unattractive alternatives to a negotiated agreement (stage 4)

Similarly, a trajectory toward stalemate took the following form:
Preparing strategies (stage 1)→
having a power advantage over other delegations (stage 2)→
wide media coverage and few concessions from the other delegations (stage 3)→
having attractive alternatives to a negotiating agreement (stage 4).

These are some aspects of the negotiating situation that can be altered for effect. They serve as guides to the third-party practitioner in his or her efforts to create environments that would be conducive to the kind of problem solving needed for agreements to emerge. This type of information augments the communication and persuasion functions performed by mediators during negotiation.

6. CONCLUSION

Statistical analysis provides techniques that can be used to support the negotiation process. Two approaches are illustrated in this paper. One, referred to as a situational diagnosis, provides advice based on information obtained from empirical studies designed to discover relationships among aspects of negotiating situations, the behavior of negotiators during the process, and the outcome. The other, consisting of time-series analysis, results in forecasts of likely moves or outcomes based on information about past behavior of the negotiating parties in particular cases. The value of each approach turns on the issue of whether results obtained in other settings (situational diagnosis) or in earlier time periods (time-series analysis) are relevant or can be extrapolated to new situations. Relevance can be judged in terms of statistical criteria of sampling design and data quality. An adequate basis for extrapolation can increase a negotiator's leverage over the

process, especially when the two approaches are used together. But, relevance does not insure implementation of the tools in an actual negotiation. The analyst must also confront possible problems of communicating with the practitioners who will use the techniques. An overview of these problems and some guidelines for dealing with them are discussed in a final section.

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ARE GAME THEORETIC CONCEPTS SUITABLE NEGOTIATION SUPPORT TOOLS? FROM NASH EQUILIBRIUM REFINEMENTS TOWARD A COGNITIVE CONCEPT OF RATIONALITY

ABSTRACT. If game theory is to be used as a negotiation support tool, it should be able to provide unambiguous recommendations for a target to aim at and for actions to reach this target. This need cannot be satisfied with the Nash equilibrium concept, based on the standard instrumental concept of rationality. These equilibria, as is well known, are generally multiple in a game. The concept of substantive or instrumental rationality has proved to be so pregnant, however, that researchers, instead of re-evaluating its use in game theory, have simply tried to design concepts related to the Nash equilibrium, but with the property of being unique in a game – i.e., they have devised ways of *selecting* among Nash equilibria. These concepts have been labeled *refined Nash equilibria*.

The purpose of this paper is to show the following.

(a) The different types of refined Nash equilibria, based on the principle of backward induction, can lead to severe contradictions within the framework itself. This makes these concepts utterly unsatisfactory and calls for a new appraisal of the reasoning process of the players.

(b) The degree of confidence in the principle of backward induction depends upon the evaluation of potential deviations with respect to the extended Nash equilibrium concept used and upon the possible interpretations of such deviations by the different players. Our goal is to show that the nature of these possible interpretations reinforces the argument that a serious conceptual reappraisal is necessary.

(c) Some form of forward induction should then become the real yardstick of rationality, extending Simonian *procedural rationality* towards the concept of *cognitive rationality*. This could open the way to a renewed game theoretic approach to negotiation support systems. Such a research program, which would be a revision of the basic game theoretic concepts, is dealt with in the end of the paper.

Keywords: Game theory, Nash equilibrium, perfect equilibrium, trembling hand procedure, backward induction, common knowledge, strategic deviation, forward induction, dynamic rationality, cognitive rationality.

1. INTRODUCTION

The question of whether game theory could serve as a decision aid has

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been debated for many years. When it comes to negotiation, the favored solution calls for a concept of basically noncooperative behavior, allowing for some possibility of cooperation or strategy coordination.

For example, disarmament negotiations have followed such a path. Typically, one chief of state announces a (sometimes unilateral) move, others announce their response to the move, and so on, without formal bargaining sessions. Similar observations can be drawn from developments in the recent conflict between Serbia, Croatia, Slovenia and other members of the former Yugoslavian Federation.

The closest available concept is the Nash equilibrium, which leaves possibilities for a certain amount of cooperation between players. Such possibilities have implicitly been modeled in the *refinements* of the concept, but it can be shown that this modeling is consistent with the backward induction principle on which these *refinements* rest. As an example, take the idea of perfect equilibrium. The idea is that the rationality of a player's strategy should be evaluated not only at the beginning of play, but also at *any* node of the game, including the response to an opponent's unexpected deviation from equilibrium, and that all players implicitly agree on the rationale behind the ensuing selection of Nash equilibria. This is but one particular way to model *noncooperative behavior with coordination of moves*! Alas, using the backward induction principle to model the idea leads to two possible consequences: first, to discarding the most interesting coordination between the moves of the players; second, and worse, to dominated outcomes.

If one wants to keep the rationality concept which underlies the Nash equilibrium point (i.e., the concept of instrumental backward maximization of some objective function, assuming implicitly that what we hold to be true about the others' behavior is not to be questioned), the design of a strategic concept which would have the property of being unique in a game can certainly be regarded as the design of *techniques of selection* among Nash equilibria. But the trouble has been that these techniques have themselves become the objective of research, probably because keeping the backward induction concept has turned out to be a difficult constraint to meet.

As J. C. Harsanyi (1984) once explicitly pointed out:

We need a theory which selects one specific equilibrium as the solution of the game. In fact, Selten and myself have as a main objective to establish a mathematical criterion which always will select a particular equilibrium point as the solution. This fundamental objective boils down to overcoming the multiplicity problem.

Section 2 shows that this research program has led to fundamental inconsistencies within the framework of backward induction reasoning. Section 3 deals with what should be viewed as the real challenge to game theory, if one wants to use the concepts it offers in negotiation support systems. Section 4 contains some concluding remarks and suggestions on the design of the research program.

2. SOME SEVERE LIMITATIONS IN BACKWARD INDUCTION MODELS OF NASH EQUILIBRIA SELECTION

2.1. Perfect Equilibrium and Trembling Hand Reasoning

The models dealt with in this section have been developed under the extensive form of games and are linked to the seminal work of Kuhn (1953) on behavioral strategies. They include the 'perfect equilibrium' concept of Selten (1975), as well as the 'sequential equilibrium' of Kreps and Wilson (1982a). These concepts look for good reasons for every player to select given equilibria, and possibly one given equilibrium. If they are successful in doing it, the players will indeed abide by these good reasons, not only because they find them convincing, but also because they think that the other players will share this opinion and thus also abide by these good reasons. These good reasons are like the recommendations of a chessbook: smart players will follow them only if the book convinces them that the opponents will do the same. In other words, the good reasons given by backward induction models of selection, like the recommendations of the chessbook, have to be common knowledge among the players to be of any value. Let's recall, as the epitome of this kind of model, the perfect equilibrium and the 'trembling hand' perfect equilibrium of Selten.

2.1.1. Perfect equilibrium. In a two-player game, the good reason behind the selection of some perfect equilibrium, say (B, Y), is as follows: in *every* subgame of the game-tree (even if it is outside the

equilibrium path, and thus has zero probability of ever being reached), let us demand that the decisions of the players implied by (B, Y) constitute a Nash equilibrium for the subgame. Thus, between two Nash equilibria, say (A, X) and (B, Y), let us select the one in which the strategy of the second player would be played at any node of the game, if the first player would *effectively* drive the play to that node by choosing his strategy – i.e., A in the first case and B in the second.

Using this rule, one can easily look at terminal subgames and then maximize backward. If, however, a game displays several perfect equilibria – which is often the case – the rational foundation of this reasoning of a credible threat can be questioned. However, difficulties increase considerably when imperfect information games are considered.

2.1.2. Trembling hand. The limits of Bayesian inference procedures are encountered in imperfect information games. To select an equilibrium, a player has to evaluate and re-evaluate its probability of occurring with respect to the out-of-equilibrium context. By definition, however, we do not know anything about the beliefs regarding out-of-equilibrium matters. Mere intuition tells us that this makes Bayesian inference methods and backward induction inappropriate for solving the problem.

Let us briefly recall the extension of the perfect equilibrium concept by taking into account potential deviations with respect to the equilibrium path, which is discussed by Harsanyi (1973) and Selten (1975). It assumes that all players i, $i = 1, \ldots, n$, select totally mixed strategies in the following sense:

$$\forall i,\ i = 1, 2, \ldots, \ldots, n$$

$$\forall i,\ x_i \in X_i \text{ (set of available strategies of player } i)$$

$$\forall \epsilon,\ \epsilon > 0,\ \exists \epsilon_i,\ \epsilon_i > 0, \text{ such that } \epsilon > \epsilon_i = p(x_i) > 0$$

where $p\ (x_i)$ is the probability that player i plays x_i.

A game giving rise to such behavioral schemes is called an ϵ-perturbed game. An n-tuple $(x_1^*, \ldots, \ldots, x_i^*, \ldots, \ldots, x_n^*) = (x_i^*)_i$ is an ϵ-equilibrium if and only if:

(a) $\forall i, i = 1, \ldots, n, \forall x_i \in X_i, \forall \epsilon, \epsilon > 0, \exists \epsilon_i, \epsilon_i > 0,$
such that $\epsilon > \epsilon_i = p(x_i) > 0$

(b) $\forall i, i = 1, \ldots, \ldots, \ldots, n, (x_i^*)_i = (x_i^*, x_{-i}^*) = \text{Arg} \underset{x_i \in X_i}{\text{Max}} E(U_i(x_i, x_{-i}^*))$

Then a Trembling Hand equilibrium $(x_i^*)_i$ is such that

(a) $\forall \epsilon$, $\epsilon > 0$, $(x_i^*)_i$ is an ϵ-equilibrium.
(b) When ϵ goes to 0, $(x_i^*)_i$ is a Nash equilibrium.

Such an equilibrium may be shown to exist (Selten, 1975).[1] An interesting feature of the concept of the Trembling Hand equilibrium is precisely that, in games with imperfect information, Bayes' theorem is applied everywhere, on equilibrium paths as well as on off-equilibrium paths.

2.2. Internal Inconsistency of the Concepts

The perfect equilibrium concept and the trembling hand perfect equilibrium concept, as well as all other concepts aimed at selecting Nash equilibria on similar grounds and by backward induction, raise different types of problems.

As Kreps and Wilson (1982) have shown, a trembling-hand procedure is not very selective unless particular conditions on the game structure are imposed. This leaves the problem of recommendation in the negotiation process unsolved.

On the other hand, experimental studies over the last 35 years have raised many doubts on expected utility behavior among individuals. More particularly, the certainty effect (Allais, 1953, 1979, 1988) and the overweighting of small probabilities effect (Kahneman and Tversky, 1979; Allais, 1988) entail either discontinuities in the anticipated payoffs of the players, or, at least, strong nonlinearities of these payoffs either for small probabilities or for probabilities close to one. Anticipated utility models, for instance, take such behavior patterns into account (Munier, 1989), for example.

If there are discontinuities, Selten's theorem (1975) is not sufficient to ensure the existence of an ϵ-perfect equilibrium. Neither is Dasgupta and Muskin's theorem (1986) for it assumes that ϵ-probabilities make payoffs negligible, which is true only if the players' behavior can

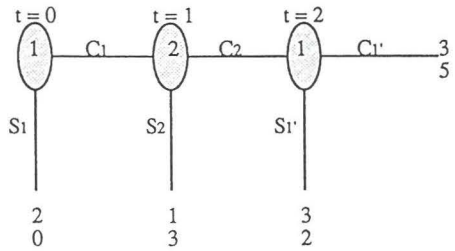
be represented by a preference functional which is linear in the probabilities, i.e., by some expected utility pattern of behavior. It is not true if they follow an anticipated utility behavior. In this case, existence of an ϵ-equilibrium is not ensured when payoff functions exhibit some discontinuity in pure strategies. Existence of an ϵ-perfect equilibrium is thus ensured only under restrictive conditions.

But we shall not overemphasize these difficulties, for three other problems are more fundamental. They show that using the perfectness criterion and the Trembling Hand procedure leads to potential contradictions and that these techniques are either inappropriate or of a limited applicability.

2.2.1. How consistent are cooperation and backward induction? Consider the following example of an alternated two-person game with complete information and finite horizon ($T = 3$), the extensive and normal forms of which are displayed in Figure 1. A first contradiction appears as soon as it is observed that the only perfect equilibrium corresponds to $(S_1, S_2, S_{1'})$ with an associated payoff vector of $(2, 0)$, while this payoff is strictly dominated by the imperfect equilibrium $(C_1, C_2, C_{1'})$. Decomposing the game according to the backward induction principle leads to precluding every possible cooperative behavior between players. Such a cooperative behavior could lead to a dominating outcome, but would require the players to conceive of time in the commonsense meaning of the word, i.e. to think in terms of forward induction.

This conclusion leads to either rejecting the backward induction as a necessary and *sufficient* principle of rationality, when confronted with the problem of equilibrium selection, or accepting it under the restrictive proviso that it is common knowledge among the players (Binmore, 1990, Ch. 4), while Bicchieri (1990) unconvincingly attempts to weaken this common knowledge condition. As we will see, however, the latter possibility leads in turn to a contradiction.

2.2.2. Is a trembling hand equilibrium path common knowledge? If common knowledge is modeled as a probabilistic structure (Tan and Werlang, 1988; Brandenburger and Dekel, 1987), it can be shown that a trembling hand perfect equilibrium cannot be common knowledge among the players (see appendix). But, if it is not common knowledge, all the reasoning crumbles and the concept cannot logically hold; if I am not sure that my opponent is playing trembling hand, nothing will assure me that my interest is to play trembling hand.



Player 2 \ Player 1	S1 S1'	S1 C1'	C1 S1'	C1 C1'
S2	2 ; 0	2 ; 0	1 ; 3	1 ; 3
C2	2 ; 0	2 ; 0	3 ; 2	3 ; 5

Fig. 1.

among the players (see appendix). But, if it is not common knowledge, all the reasoning crumbles and the concept cannot logically hold; if I am not sure that my opponent is playing trembling hand, nothing will assure me that my interest is to play trembling hand.

Here the difficulty of the simple Nash equilibrium concept is apparent: if my opponent deviates, why should I continue to play the Nash equilibrium and not deviate myself?

2.2.3. Are deviations necessarily errors? Using the same example, we find that the nature of a possible deviation constitutes a second inconsistency within the concept of perfect equilibrium. Let us consider the perfect equilibrium $(S_1, S_2, S_{1'})$.

Selten's reasoning (1975) holds that, if one observes an unanticipated deviation with respect to an equilibrium path, one will interpret it as an involuntary mistake of the deviating player, without any link to the other period moves of this player. Time independence of the mistakes is related to the agent's normal form representation of the

game, where every player is divided into as many independent subplayers as there are possible moves for him in the game.

In this view, for each player, ϵ-trembling at each one of his moves in the game does not depend on ϵ-trembling at the other moves. Quite consistently, every deviation with respect to an equilibrium path is seen as a simple mistake.

But, if one regards the agent's normal form as an ad hoc representation of the game, the hypothesis of a statistical dependence between the ϵ-tremblings of a given player during a play appears to be quite plausible and indeed very likely.

In the above example of a game, $(C_1, S_{1'})$ constitutes a deviation for player 1 with respect to the imperfect equilibrium $(C_1, C_2, C_{1'})$. Let $p(C_1, S_{1'}) = \epsilon$, with $0 < \epsilon < 1$. With this probability in mind, player 2 selects the imperfect equilibrium strategy C_2 by taking the limit – as the Trembling Hand procedure recommends – of the following computation:

$$\begin{aligned} p(C_{1'}) &= \frac{p(C_1, C_{1'})}{p(C_1, C_{1'}) + p(C_1, S_{1'})} \\ &= \frac{1 - p(S_1, S_{1'}) - p(S_1, C_{1'}) - p(C_1, S_{1'})}{1 - p(S_1, S_{1'}) - p(S_1, C_{1'})} \\ &= 1 - \frac{p(C_1, S_{1'})}{1 - p(S_1)} . \end{aligned}$$

Thus, for every given value of the probability that player 1 deviates at his first move, $p(S_1)$, one computes:

$$\lim_{\epsilon \to 0} p(C_{1'}) = \lim_{\epsilon \to 0} 1 - \frac{\epsilon}{1 - p(S_1)} = 1 .$$

It then becomes clear that player 2, when observing C_1 as a deviation of the perfect equilibrium of the game, will not interpret it as a simple mistake. He will base the selection of move C_2 on this observation, following the above probability computation. C_1 represents a relevant informational signal, to which a meaning has to be attached before player 2 selects his own move.

Let us briefly summarize. Problems of existence, as well as problems

to reduce the number of possible equilibria to 1, have the same consequence as the impossibility for the equilibrium path of being common knowledge: *Players will not trust the Trembling Hand procedure as a safe decision aid.* Each player will not be certain that an equilibrium will obtain (existence problems); he will doubt whether the equilibrium he is working on will necessarily be the same (capacity of selection problems) as the one(s) other players are aiming at (and thus upon the fact that his strategy could be a best reply to theirs); he will not trust that the other players will follow the same rules of conduct for they cannot be common knowledge; and he will then expect them to deviate from the equilibrium path (from the same observation).

It appears therefore that deviations from equilibrium paths, far from being necessarily irrational, may represents signals which, if they could be interpreted, would constitute the most interesting inputs into a negotiation support system.

3. NECESSARY AND DIFFICULT INTERPRETATION OF DEVIATIONS: THE REAL CHALLENGE TO GAME THEORY

In a game theoretic framework, a strategy is not a mere plan of action, as was the common definition used until the late 1970s. Let us quote Rubinstein (1991) in an article which was brought to our attention only after we wrote an earlier version of this paper:

> Could we not narrow the formal definition of a 'strategy' to specify an action only at the decision nodes which are not excluded from being reached by the strategy? If we were only investigating Nash equilibria of extensive games, then the game-theoretic definition would indeed be unnecessarily broad . . . Player 1's strategy at . . . [some node of the game out of the equilibrium path] must be interpreted as what would be player 2's (as opposed to player 1's) belief regarding player 1's future play, should player 1 decide to deviate from what was believed to be his original plan of action. Thus, a strategy encompasses not only the player's plan, but also his opponent's beliefs in the event that he does not follow that plan.

This is an elegant and very clear statement of the necessity of interpreting the deviations of other players from their Nash equilibrium path and thus the very nature of a strategy. Meaningful deviations from any equilibrium path can very well occur and it would thus be of great interest to infer the rationality underlying such deviations.

This would then advise the negotiator on where to move according to the retained interpretations of observed deviations. The nature and content of such interpretations is thus a central question. Solving it would amount to selecting a new subgame target; when a player deviates from a given equilibrium path, he informs the other players by aiming at a different outcome than the one attached to the former equilibrium path.

In this general perspective, one of the most frequently used selection criteria is the one of Cho and Kreps (1987). This criterion rest on the two following rules:

- Every deviation should be interpreted with respect to an equilibrium path.
- An equilibrium will be discarded if a deviation can be interpreted without ambiguity for all players and if this deviation ensures the deviating player of a higher payoff than the equilibrium payoff.

In Section 3.1 we evaluate the extent to which this criterion is insufficient to interpret deviations and in Section 3.2 we suggest directions for a research program.

3.1. The Challenge to the Cho–Kreps Criterion

Figure 2 illustrates an example of the possible use of this criterion (see Ponssard, 1990). In the figure, x is some payoff for player 2 when player 1 plays A. By deviating from the equilibrium pair $(A, \bullet)$ to $(B, \bullet)$ player 1 clearly shows that he wants to gain more than 3; therefore, he wants to play T to obtain a payoff of 4. He thus unambiguously suggests that player 2 plays L. Therefore, (B, T, L) is a more stable equilibrium than $(A, \bullet)$, which should therefore be disregarded on the basis of the information provided by the deviation.

The strength of this proposition lies in the fact that the two players admit it, i.e., that it constitutes a common knowledge among them.

The fact that player 1 will play T if he deviates from $(A, \bullet)$ by playing B is clearly interpreted by player 2. Player 1 will guess that interpretation by player 2 but nevertheless maintain his deviation.

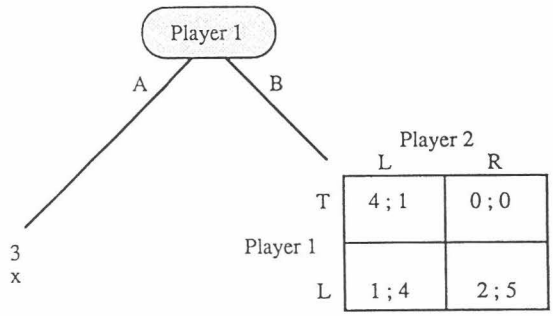


Fig. 2.

Thus, all levels of interpretation of the deviation come to the same conclusion: there is no ambiguity on the meaning of the deviation.

Unfortunately, this result is not always true. An unambiguous deviation of a given order of interpretation can become an ambiguous one at a higher order. To show this, let us consider the example of the 'Chain-Store Paradox' given by Selten (1978).

Let a monopolist M, in a given market, be confronted to two successive potential entrants E_1 and E_2. For every entrant, the game is as follows: either he does not enter the market, and the monopoly is maintained, or he does enter the market. In the latter case, the monopolist can either accept to share the market or stage a retaliation campaign which proves to be very costly to him and to his competitor.

To deter his potential competitors from entering the market, the monopolist has to make them believe that retaliations would not be costly to him. He thus has to acquire the reputation of being a *hard* monopolist, whereas he in fact is a *soft* monopolist. To model this (Figure 3), two possible versions of the game are created: one with a *hard* monopolist (version H) and one with a *soft* monopolist (version S). If the potential entrants believe the monopolist is playing version H, whereas he is really playing version S, the monopolist will have succeeded in acquiring the desired reputation.

Let us now assume that the two potential entrants play sequentially. On the extensive form of the game, let us denote the following moves:

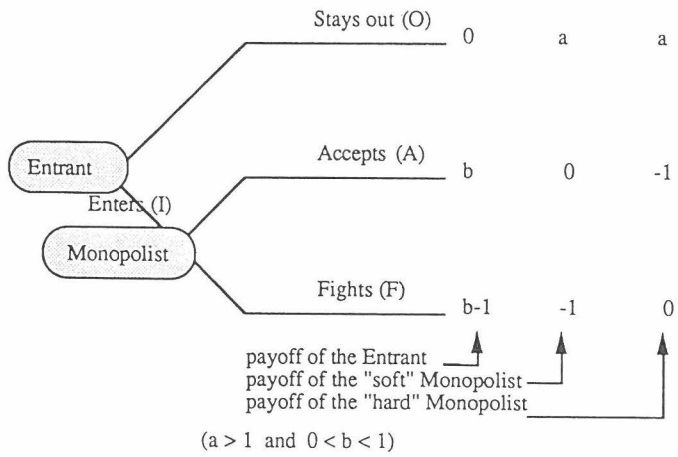


Fig. 3.

O_1: Potential entrant E_1 stays out of the market.
I_1: Potential entrant E_1 enters the market.
F_1: The monopolist stages a retaliation campaign.
A_1: The monopolist agrees to share the market.

The only interesting case in this game appears when E_1 enters the market and the monopolist decides to fight back. What should E_2 conclude about the nature (hard or soft) of the monopolist and what moves will this entail from E_2 as well as from the monopolist?

Let us apply the Cho–Kreps criterion to determine moves by E_2 and M:

(1) E_2 should enter if he thinks that M is soft, and otherwise stay out.
(2) If E_2 enters, M fights back if he is *hard* and accepts if he is *soft*, even though he regrets that E_2 was not convinced of a *hard* reputation.

Let us consider the following deviation: M, being soft, fights E_1 in order to impress E_2. This strategy is a deviation from the acceptance to share the market, because the retaliations are costly to M. This deviation indeed allows the monopolist to get, at best, a payoff of

$(a-1)$ instead of (a) if he had not deviated. Thus, according to the Cho–Kreps criterion, one has to conclude that if M fights E_1, this is because M actually is of the hard type. This reasoning will make E_2 feel confident as to the true nature of M. Cho–Kreps would argue that, for M to fight E_1, if he himself is soft, is not a Nash equilibrium strategy.

This conclusion can be challenged, however, on the basis of an argument in common knowledge. Let us look at the successive orders of interpretation of the Cho–Kreps criterion:

Order 1. This level of reasoning of the Cho-Kreps criterion is the following:

> either M retaliates against E_1, then he is hard.
> *or* M accepts the entry of E_1, then he is soft.

This proposition is known by M and E_2.

Order 2. But one can immediately see that the monopolist M can make use of E_2's expectation, i.e., of the former proposition. In this case, M will fight E_1 to acquire a hard reputation in E_2's view. His expectation being thus manipulated by M, E_2 will not enter the market.

Order 3. We can go one step further. E_2 might anticipate that M will follow Order 2 reasoning and thus guess that M has fought E_1 only to impress him. Having realized this, he then will enter the market.

This infinite regression of the different orders of reasoning shows clearly that E_2's interpretation of the deviation F_1 of the monopolist is ambiguous. This ambiguity arises from the fact that the interpretation is not common knowledge among the players (which would imply an identity of the interpretations of all orders). Put in other words, the Cho–Kreps criterion does not take into account that every player can try to manipulate the expectation and rationality of his opponent(s). This could mean that a non-manipulable rationality should be of a different kind than the usual Nash rationality.

3.2. A Research Agenda for Game Theoretic Negotiation Aids

First we should emphasize that the very problem raised here had been considered by the founders of game theory who, however, felt that deviations should be interpreted as 'irrational'. Von Neumann and Morgenstern (1947, 2nd ed.) explicitly stated:

> The rules of rational behavior must provide definitely for the possibility of irrational conduct on the part of others. In other words: Imagine that we have discovered a set of rules for all participants – to be termed as 'optimal' or 'rational' – each of which is indeed optimal provided that the other participants conform. Then the question remains as to what will happen if some of the participants do not conform . . . . If the superiority of 'rational behavior' over any other kind is to be established, then its description must include rules of conduct for all conceivable situations including those where 'the others' behave irrationally, in the sense of the standards which the theory will set for them.

We have shown that such an interpretation of deviation does not help our problem and, more importantly, is erroneous. We have also suggested that it is difficult to find any other interpretation of such deviations to the backward induction principle. We thus suggest using some type of forward induction reasoning scheme.

More precisely, one could consider first the reasonable extent of common knowledge elements within the negotiation situation. This extent usually depends directly on the content of the prenegotiation phase and could be regarded as embedding some scenarios of the negotiation session (Ponssard, 1990). Which scenarios would qualify for reasonableness could be regarded as some form of convention between the players.

The question would then be how to interpret a deviation from such a reasonable scenario. We believe that no universal scheme of rationality should be devised toward this end. We think that the *memory* of each player in the game can offer some *history* of deviations, the regularities of which should bring some comprehension of the local and contingent scheme of rationality used. Experiments could help in testing some of the preliminary conclusions reached. Interpretations could then be offered and would help the negotiator make his own local but strategic choices.

Such a research program borrows from game theory and the theory of comprehension (Schank, 1985) and from the newer concepts of

strategic information systems (Tardeu and Theys, 1987). The concept of strategy derived from the theory of games and the one derived from strategic management theory, previously viewed as very different, now appear to be converging, thus providing negotiators support in their difficult task. Such a research program must obviously be conducted on an interdisciplinary basis.

4. CONCLUDING REMARKS

Nash equilibrium refinements both restrict and extend the original concept. They restrict the concept to the extent that they define the more severe conditions one can encounter when selecting from the multiple Nash equilibria. But they also stretch it, for they want it to apply to games in extensive form, i.e., to a context where time is somehow modeled, at least with a sequential character. What we have shown here, we think, is that *both* types of efforts raise more problems than they can presently solve.

Although the backward induction principle represents an interesting attempt toward an appraisal of intertemporal rationality, our analysis shows that it crucially raises the problem of the nature and the significance of potential deviations and of their successive levels of interpretation. Bayesian backward induction models rest on the possibility of a deviation but do not admit that the interpretation of such deviations could be ambiguous. Presently, available models consider exclusively such deviations as mistakes.

Deviations from the standards which the theory will set can be mistakes, but also *strategic signals*. In every case, they are required to be first analyzed and then interpreted; the theory should tell us an appropriate response for all connected situations. This, in turn, calls for a group decision support system which could help *interpreting* deviations. The relevant concept of rationality is thus the concept of *cognitive rationality*, emerging from the comparison of what the others think of the situation and what we think of it. Rationality is not, in this view the traditional contingent and static maximization rule we have been used to, but a treatment of information in a dynamic and interactive process.

This completes the argument that game theory, if we want it to provide guidance to the negotiator in real negotiation processes, has to change the basic concept of rationality it has used until now.

APPENDIX

In Selten's 'Trembling hand' procedure, all out-of-equilibrium paths receive an equal probability ϵ/m if ϵ is the degree of error with which the other players deviate. But where does this 'trembling hand' way of modeling the problem come from? There are two possible answers:

- an exogenous answer: The modeler dictates the rule and imposes it, acting as a 'benevolent umpire'. This answer can be relevant in the case of arbitration schemes, but not in the case of a negotiation aid.
- an endogenous answer: the rule of analysis emerges from a convention (Lewis, Schotter) between the players. This could be relevant to negotiation aids, but requires, to be effective, that the convention is common knowledge. It can be shown, *ad absurdum*, that this is impossible.

To show it, let us define common knowledge as a probabilistic structure. Let:

E	be the set of events assumed to be observable by all agents.
$P(.)$	be the set of probability measures on some subset (.) of E.
$t_i^1(.)$	be the belief of order 1 of player i, on some subset (.) of E.
$t_i^2(.\ ,.)$	be the belief of order 2 of player i, i.e., the belief on some subset of the set $B_i^1(.)$ of all possible beliefs of order 1 on the subset (.) of E of the other players, on the one hand, and on this subset (.) of E, on the other hand.
$t_i^3(.\ ,.\ ,.)$	be the belief of order 3 of player i, etc.

For any given player i, the set T_i of all possible beliefs is a set of infinite sequences of beliefs:

$$t_i = (t_i^1, t_i^2, \ldots, t_i^\infty) \qquad t_i \in T_i .$$

Common Knowledge Conditions

$\forall A \subset E$, A is common knowledge if, from every player i's point of view, two conditions hold:

(1) *Certainty condition*: i knows that A is certain, i.e.:

$$t_i = (t_i^1, t_i^2, \ldots) \text{ is such that } t_i^1(A) = 1 .$$

Let $B_i^{1^*}(A)$ be the set of all possible such t_i :

$$B_i^{1^*}(A) = \{(t_i^1, t_i^2, \ldots)\} \epsilon\ T_i \text{ with } t_i^1(A) = 1 .$$

(2) *Reciprocity condition*: i knows that the beliefs of *every order* of all the other players j $(j \neq i)$ regarding A superimpose with his own belief.

Let $B_i^{1^{**}}(A)$ be the set of all beliefs of order 1 for which (1) and (2) are met.

$$t_i \in B_i^{1^{**}}(A) \Leftrightarrow t_i \in B_i^{1^*}(A) \text{ and } \forall j,\ j \neq i,\ t_j \in B_j^{1^*}(A) .$$

For higher orders of beliefs $(k > 1)$:

$$t_i \in B_i^{k^{**}}(A) = t_i,\ t_i \in B_i^{k-1^*}(A) \text{ and } \forall j,\ j \neq i,\ t_j \in B_j^{k-1^*}(A) .$$

Definition. A is Common Knowledge if and only if $\forall i$, $B_i^{\infty^{**}} = 1$.

IMPOSSIBILITY PROPOSITION. Let S^0 be the equilibrium strategy to be a Trembling Hand-type of procedure. S^0 will be common knowledge if and only if $B_i^{\infty^{**}}(S^0) = 1$. But assigning non-null probabilities to strategies other than S^0, in compliance with the procedure, means that

$$B_i^{\infty^{**}}(S^0) < 1 , \quad \text{a contradiction} .$$

Q.E.D.

NOTE

[1] Other concepts of Nash-refined equilibrium also rest on the idea of an ϵ-perturbed game, although they use either a different definition of an ϵ-perturbation or a different

process of convergence. Such are the equilibrium concepts suggested by Myerson (1978), the 'Sequential Equilibrium' of Kreps and Wilson (1982), and the 'Stable Equilibrium' of Kohlberg and Mertens (1986).

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COGNITIVE MAPPING AS A TECHNIQUE FOR SUPPORTING INTERNATIONAL NEGOTIATION

ABSTRACT. This article explores the use of cognitive mapping as a tool for supporting international negotiation. Cognitive mapping was developed from the research tradition in cognitive psychology that was pioneered by Heider, congruity theory and attribution theory. Applied to political analysis, the technique can be used to represent causal and quasi-causal thinking about a specific policy area. Cognitive maps can be hand-drawn, or, in the case of maps consisting of more than 25 concepts, machine-generated for detailed and systematic analysis. Regardless of the format, cognitive maps can be examined to determine the most central concepts, the explanation of a problem in terms of its root causes and potential consequences, the use of evidence, such as historical analogies, internal consistency, and perceived consequences of policy proposals. Although the technique was designed to represent the views of individuals, cognitive maps can be aggregated to study collective decision-making. Applied to international negotiation, the technique can be employed as a substance-focused tool to represent and integrate knowledge about a specific policy area for use by negotiators. As a process-oriented tool, the technique can be used to help negotiators understand better their own assumptions about a problem, the viewpoints of other parties to the negotiations, and the ways others see their own position. In this mode, the technique has promise for promoting convergence of views and negotiated agreements.

Keywords: Cognitive mapping, cognitive psychology, international negotiation, collective decision-making, knowledge representation.

1. INTRODUCTION

Negotiators may find that cognitive mapping is a useful tool for helping them to prepare and engage in negotiation. At the pre-negotiation stage they can prepare for the talks by mapping out their own assumptions to explore the costs and benefits of alternative proposals, and they can construct cognitive maps of the other parties to the negotiation to anticipate their initial positions. Once the negotiations have begun, cognitive mapping can be used by negotiators to gain a better understanding of the statements and arguments of the other parties, as well as to provide a template for seeing how others comprehend their own position. Finally, the technique can be em-

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ployed to help combine the positions of the various parties to the negotiation and create a package deal that can be described in a single text.

This article will introduce cognitive mapping by situating the technique within its research tradition and providing a brief outline of the technical underpinnings, along with its assumptions, inputs, and outputs. The article will also describe the transformation of cognitive mapping into a 'hands-on' tool that can be used by negotiators throughout the negotiation process. Because cognitive mapping is intuitively understandable, the technique can be used by diplomats, themselves, to assess differences in assumptions and positions as they strive to reach cognitive convergence and concrete agreements.

2. THE TECHNIQUE OF COGNITIVE MAPPING

2.1. Research Tradition

Cognitive mapping is an outgrowth of the research tradition in cognitive psychology that was pioneered by Heider (1946), who developed the concept of 'congruity' in human cognition, and Cartwright and Harary (1956), who generalized Heider's theory to a greater range of empirical cases and used the mathematical model of linear graphs to build a theory of cognitive balance (Harary 1959). Further contributions were made by Osgood *et al.* (1957), whose concept of *semantic space*, "a region of some unknown dimensionality and Euclidian in character" (p. 25) was used to construct a measure of connotative meaning. Kelly's (1955) approach to the measurement of personality, although developed independently of Heider and Osgood *et al.*, is similar in that a person's cognitive system is arranged in the form of an interrelated set of subordinate and superordinate constructs, which he or she relies on to anticipate events and classify experience.

Another contribution of Heider (1958) to cognitive psychology led to an interest in the process of "causal attribution in the perception of others," and the development of attribution theory. Attribution theorists have studied the efforts of people to explain and draw inferences from behavior – their own behavior and the behavior of

others. According to attribution theory, people are 'constructive thinkers' or 'naive scientists' who search for the causes of events and draw conclusions about people and their circumstances as a basis for action. The 'naive scientist' framework, however, is not the only way of thinking about attribution. Attributions serve other functions, in addition to cognitive mastery, such as the need to protect or enhance self-esteem (Miller 1976), to create a favorable impression to others (Bradley 1978), and believe in a just world (Lerner and Miller 1978). In the field of international relations, Jervis (1976) has applied attribution theory to foreign policy decision-making, Heradstveit (1979) has studied how Arabs and Israelis attributed the causes of the Middle East conflict, and Larson (1985) has tested attribution theory as an explanation of the containment policies of the cold war.[1]

2.2. Cognitive Mapping

The term 'cognitive mapping' was first used in the psychological literature by Tolman (1948) to describe the field map that becomes established in a rat's brain while running a maze. Generalizing to human beings, Tolman distinguished between 'narrow cognitive maps', which lead to aggression, and 'truly comprehensive maps', which result in rational behavior (p. 208).

Twenty five years later the term was used by Shapiro and Bonham (1973), and Axelrod (1976) to denote a pictorial representation, consisting of points (nodes) and arrows (links), of a person's political beliefs and values:

> The concepts a person uses are represented as points, and the causal links between the concepts are represented as arrows between these points. This gives a pictorial representation of the causal assertions of a person as a graph of points and arrows. This kind of representation of assertions as a graph will be called a cognitive map. The policy alternatives, all of the various causes and effects, the goals and the ultimate utility of the decision-maker can all be thought of as concept variables, and represented as points in the cognitive map (Axelrod, 1976, p. 5).

Small cognitive maps, such as the one shown in Figure 1, can be drawn by hand, and, with a little practice, the direct and indirect connections of any single concept to other concepts in a cognitive map

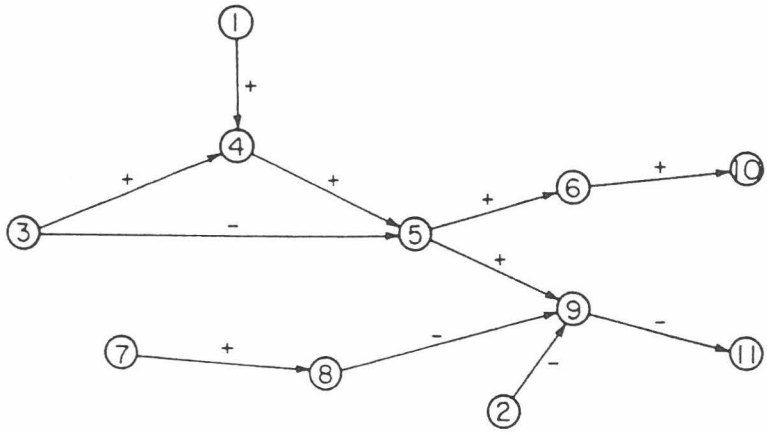

Fig. 1.

can be calculated in one's head. For example, in Figure 1, Concept 7 has a positive effect on Concept 11, because the path between the two concepts has an even number of negative arrows, while Concept 4 has a negative effect on Concept 11, because its path contains an odd number of negative arrows. For large cognitive maps, however, the calculations are more easily performed by a computer. First, a hand-drawn cognitive map is converted into a valency matrix, V, a square matrix of size $n \times n$, where n is the total number of concepts in the corresponding cognitive map (see example in Figure 2). From the valency matrix, the computer can construct a reachability matrix, computed as $R = V + V^2 + V^3 + V^{n-1}$, since the longest possible path in a cognitive map with n concepts is of length $n - 1$. The reachability matrix for the cognitive map shown in Figure 1, is displayed in Figure 3. A nonzero entry in this matrix shows the concepts that are connected, either directly or indirectly, to other concepts in the cognitive map. From the reachability matrix, it is easy to see the overall structure of the whole set of beliefs and values in the cognitive map; for example, a reachability matrix with many non-zero entries suggests a relatively complex cognitive system (Levi and Tetlock, 1980).

The flexibility of the cognitive mapping approach across different levels of abstraction has enabled investigators to apply the approach to

	1	2	3	4	5	6	7	8	9	10	11	Row abs. sums
1	0	0	0	1	0	0	0	0	0	0	0	1
2	0	0	0	0	0	0	0	0	−1	0	0	1
3	0	0	0	1	−1	0	0	0	0	0	0	2
4	0	0	0	0	1	0	0	0	0	0	0	1
5	0	0	0	0	0	1	0	0	1	0	0	2
6	0	0	0	0	0	0	0	0	0	1	0	1
7	0	0	0	0	0	0	0	1	0	0	0	1
8	0	0	0	0	0	0	0	0	−1	0	0	1
9	0	0	0	0	0	0	0	0	0	0	−1	1
10	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0
Column abs. sums	0	0	0	2	2	1	0	1	3	1	1	11

Fig. 2.

	1	2	3	4	5	6	7	8	9	10	11	Row sums
1	0	0	0	1	1	1	0	0	1	1	1	6
2	0	0	0	0	0	0	0	0	1	0	1	2
3	0	0	0	1	1	1	0	0	1	1	1	6
4	0	0	0	0	1	1	0	0	1	1	1	5
5	0	0	0	0	0	1	0	0	1	1	1	4
6	0	0	0	0	0	0	0	0	0	1	0	1
7	0	0	0	0	0	0	0	1	1	0	1	3
8	0	0	0	0	0	0	0	0	1	0	1	2
9	0	0	0	0	0	0	0	0	0	0	1	1
10	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0
Column sums	0	0	0	2	3	4	0	1	7	5	8	30

Fig. 3.

a wide variety of policy situations, ranging from the political thinking of President Kennedy in the Cuban Missile Crisis (Sergeev *et al.*, 1990) to juror decision-making (Pennington and Hastie, 1991). Cognitive mapping has also been employed to study international negotiation. Axelrod (1977), in his research on argumentation in foreign policy settings, compared cognitive maps constructed from the 1938 Munich

negotiations to deliberations that took place within a single nation. He found relatively less disagreement over causal relationships in the Munich negotiations than in collegial and bureaucratic groups. Bonham *et al.* (1987), used cognitive mapping to compare two sets of negotiations, the 1905 negotiations between Sweden and Norway over the dissolution of the Union between these countries, and the discussions at the Paris Peace Conference in 1919 over the future of the Saar Basin. This research demonstrated the utility of cognitive mapping as an organizing device for representing the beliefs and values of the negotiators. For example, when an aggregate cognitive map of the Saar Basin discussions was analyzed, the shared meanings, as well as the conflicting understandings, emerged as well-defined cognitive paths (Bonham and Shapiro 1988a).

2.3. Assumptions

Rather than concentrating on structural or organizational effects on international negotiation, the cognitive mapping approach focuses on the thinking processes of the negotiators. To the extent that other kinds and levels of effects on negotiation are involved, their impact is assumed to be mediated through their effects on the perceptions and interpretations of the negotiators.

By applying a cognitive mapping approach to international negotiation, one incorporates an epistemological assumption that is the dominant view in cognitive psychology today. The assumption is that there exists no 'event' or 'situation' that has meaning apart from the constitution and interpretation of events and situations by the active cognizing of persons. As this assumption applies to international negotiation, it implies that no event can become part of the negotiating context until a negotiator constitutes the event by selecting out aspects of the experiential environment for special attention. This selecting out process is therefore to be considered as being as much a part of negotiation as is the process of selecting among alternative proposals on the negotiating table, which is more familiarly recognized as part of negotiation.

Having assumed that negotiators bring an interpretive framework to the table, this approach posits a set of cognitive operations that are

presumed to be related to each other both in a particular structure and sequence. The details of this 'cognitive process model' are described elsewhere.[2] What is important to note in identifying the cognitive mapping approach is its empirical base. The approach is more empirically based than, for example, a rational choice approach to negotiation, for it is built upon what is known about thinking rather than on a reconstruction of how one might think if one adhered to certain logical rules for processing information.

The cognitive mapping approach also avoids the limitation inherent in rational choice approaches with respect to the problems of what information is. To the extent that one cannot find a situation in which it is obvious as to what 'information' is, one is not justified in speaking about the rationality of the choices involved. Complex negotiations such as those involved in arms control and disarmament are clearly situations where it is problematic as to what information is relevant. The cognitive mapping approach provides an alternative for studying negotiating situations where one must include the constitution of the situation and thus what valid information is as part of the process.

2.4. Coding Cognitive Maps[3]

A cognitive map consists of two elements, concepts and causal (or quasi-causal) beliefs. Concepts refer to a person's mental images or ideas of a class of objects. In the illustration of President Wilson's cognitive map, described below (see Figure 4), 'excessive demands', 'impression of injustice', and 'reasons for seeking revenge', would be

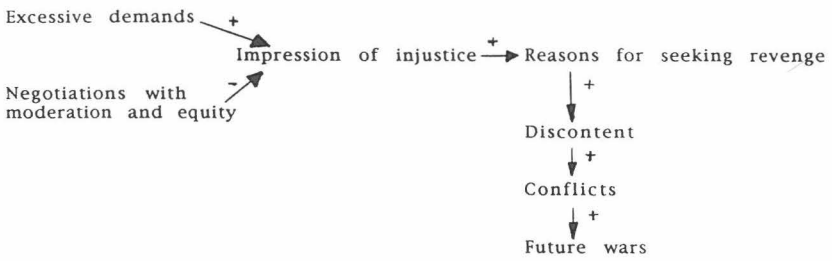

Fig. 4.

examples of such mental images. As Axelrod (1976) points out, different types of concepts can be represented in a cognitive map:

> They may be continuous variables, such as an amount of something; they may be ordinal variables, such as more or less of something, or they may be dichotomous variables, such as the existence or non-existence of something (p. 59).

The other basic element in a cognitive map is the causal belief – a presumed causal or quasi-causal linkage between two concepts. Beliefs reflect both the congealed experiences of a person and his or her expectations about the future environment. In a cognitive map causal or quasi-causal beliefs are represented as signed arrows, with the tail of the arrow denoting the 'cause' and the head of the arrow the 'effect'. The signs on the arrows identify the nature of the causal relationship; a positive sign indicates that a concept is perceived to increase or promote another concept, while a negative sign is used to represent an inverse relationship. Taken together, the concepts and causal linkages between concepts form the cognitive map.

Cognitive maps can be coded directly from a text of a document, speech, interview, or transcript of a meeting. The process begins by marking the text with circles and arrows to identify the concepts and links between them that are expressed by the author. Some of the linkages are easy to find, while others must be inferred from the context and structure of the argument. A plus sign + can be used to indicate a positive relationship (increases, promotes, leads to, contributes to, a condition of, etc.), and a minus sign (−) to indicate a negative relationship (decreases, detracts, diminishes, does not depend on, etc.).

After the text has been coded, the next step is to begin drawing the cognitive map. As a convention, concepts which refer to proposals or policy options are placed on the left-hand side of the map, while concepts that denote goals or values are placed on the right-hand side. In general, arrows should move across the page from left to right; that is, from proposals to values. Experience shows that it is advantageous to position the most central concepts in the middle of the map, if possible, and the least central and most unconnected concepts on the edge of the map. The arrows can be tagged with information about the

author and the position in the text and/or transcript. If the resulting cognitive map is small, that is, consists of fewer than 25 or 30 concepts (typical of a five-page text), it can be analyzed directly by the use of paper and pencil. Larger maps are more efficiently analyzed by computer, after conversion to an adjacency matrix (see above).

The presence of *cycles* in a cognitive map may create problems for the analyst. A cycle is a path that has an arrow from the last point to its first point (Axelrod, 1976, p. 66). In Figure 1, for example, a cycle could be created by adding an arrow from Concept 6 to Concept 1. If the arrow is positive, it is no problem, because it simply amplifies the initial concept. On the other hand, an arrow with a negative sign would counteract the initial concept. As a general rule, a cycle with positive arrows or an even number of negative signs is *deviation-amplifying*, and a cycle with an odd number of negative signs is *deviation-counteracting* (Axelrod, 1976, pp. 67–68).

Cycles are interesting because they either reinforce or neutralize perceived relationships between concepts, depending on the sign of the cycle. In the absence of other information, such as a reference by the author to time, cycles can be handled by *chunking* them to create more abstract constructs that describe the underlying relationship (Culter, 1982, p. 96). Alternatively, the cycle can be represented as a separate submap that can be isolated for further analysis.

2.5. Outputs

The analysis of a cognitive map is straightforward, regardless of whether it is hand-drawn or has been machine-processed. Maps of individual political actors can easily be examined to determine the most and least central concepts, their explanation of a problem in terms of root causes and future consequences, their use of evidence, such as historical analogies to support arguments, internal consistency, and perceived consequences of various policy options or proposals.

Examples of such outputs can be found in a case study of a 'foreign policy advisor' who participated in a gaming exercise on the Middle East (Bonham and Shapiro, 1976b). The cognitive map, which was coded by the authors from a transcript of the discussions in the gaming exercise, consisted of 73 concepts and 115 arrows for the foreign policy

advisor. Inspection of the hand-drawn map reveals that three concepts are very central to the advisor's beliefs about the Middle East: 'Friendly relations between Arabs and the United States', 'moderate Arab regimes', and 'stability in the Middle East' (pp. 126–27). Centrality can be determined by counting the number of arrows (perceived 'causes' and 'effects' of a concept) coming into and leading from each point in the cognitive map.

The *explanation* of a problem in a cognitive map consists of all paths leading to a concept (or concepts) that describes the problem, the *antecedents*, as well as all paths leading from that concept, the *consequences*. In the case of the foreign policy specialist, 'Syria's intervention in Jordan' had its roots in 'the occupation of Arab territory by Israel', and 'alienation of the Arabs from the United States', while the consequences of the crisis would likely be 'instability' and 'increased Soviet presence in the region' (pp. 129–135). The evidence for this explanation, which was also tagged on the arrows of the cognitive map, consisted largely of the foreign policy specialist's analysis of events surrounding the 1967 war in the Middle East (p. 130). Furthermore, in this cognitive map, like most maps of individuals, the explanation was 'balanced', that is, there were no internal inconsistencies (Axelrod 1976, p. 90).

Inspection of a cognitive map also enables the analyst to determine, with respect to an individual's explanation of a problem, the impact of various policy proposals or options on his or her policy goals. Such calculations can be made using either a hand-drawn cognitive map or by a computer-generated reachability matrix. In the case of the foreign policy specialist who participated in the Middle East gaming exercise, a package deal of two proposals, 'reassuring the Arabs that the United States is not hostile to them' and 'convincing the Israelis that their security cannot be achieved by occupation', emerged as the most preferred policy options, while 'the use of U.S. military forces' was the least preferred option (pp. 135–137).

The thinking of collectives, such as small groups, can also be represented in a cognitive map. One way to study a collective is simply to combine the cognitive maps of individuals into one large cognitive map. An alternative to a mechanical combination of beliefs is to 'let the collectivity speak for itself' and code the documents that are

produced by collectives such as committees (Axelrod, 1976, p. 239–243). Both approaches were used in a study of 23 oil policy decision-makers in Norway. Oil policy officials were interviewed to produce individual cognitive maps. The individual maps were aggregated to form a collective cognitive map consisting of 175 unique concepts and 1065 perceived causal relationships. This aggregate map was analyzed and compared to a parliamentary debate in Norway on a proposal to extract oil in a northern region of the country (Shapiro *et al.*, 1988).

In a follow-up study, a sample of policy makers participated in an oil policy gaming exercise, and the resulting game transcript was coded and analyzed to study collective decision-making processes, including the argumentation and policy choice of high-level officials (Bonham *et al.*, 1988b). In the cognitive map of a group or committee, the focus of the analysis becomes the conflicting viewpoints of the members, and the resolution of such conflicts "through interpersonal interaction which establishes predominant discursive practices or 'explanations' of the situation prior to the selection of policy choices" (Shapiro *et al.*, 1988, p. 401). In the study of Norwegian oil policy that was based on an aggregation of individual cognitive maps, there were 30 instances of 'direct' conflict; that is, where individuals disagreed about the sign of an arrow, and over 300 instances of 'indirect' conflict that involved more than two concepts and longer chains of reasoning (Shapiro *et al.*, 1988, p. 417). For the study that used the game transcript as a collective document, 24.6% of the explanatory paths were incongruent with other paths (Bonham *et al.*, 1988b, p. 406). In such instances of cognitive conflict, the analyst can examine how the collective attempted to resolve its differences and come to an agreement. In the study based on the aggregated cognitive map, the conflict was resolved by a vote of 76 to 26 in the Norwegian *Storting* (Parliament), while the game participants were unable to reach a consensus.

Regardless of the type of cognitive map (individual, aggregate, or collective), the technique is valuable for studying changes in beliefs and argumentation over time. Two studies have made use of actual events to observe adjustments that policy officials make in their thinking to accommodate new information. In one study, oil policy officials were interviewed before and after an oil pollution accident. An analysis of the cognitive maps showed that the environmentalists in

the sample became much less sanguine about the consequences of oil pollution accidents, and argued for stronger anti-pollution measures, while the other officials viewed the consequences of oil pollution much the same way as they did before the accident (Bonham *et al.*, 1978). The other research that compared cognitive maps of individuals over time was conducted before and after the 1973 war in the Middle East. A comparison of pre-war and post-war cognitive maps of U.S. officials from the State Department, National Security Council, and Department of Defense, showed almost no restructuring of beliefs as a result of the conflict. The 1973 war reinforced the views of some officials while it led others to perceive certain concepts as having a negative rather than positive effect on their values (Bonham *et al.*, 1979).

3. USES OF COGNITIVE MAPPING BY NEGOTIATORS

3.1. A Substance-Focused Tool

Although cognitive mapping has not been used extensively to represent knowledge about policy issues, the technique has been applied and tested in a wide range of policy areas (Bonham *et al.*, 1986a). These studies suggest that cognitive mapping is a powerful way to represent and integrate information of a causal or quasi-causal nature. Unlike many artificial intelligence approaches to knowledge representation, cognitive mapping assumes that language is constitutive of knowledge rather than simply a transparent medium for representing it (see Assumptions). From this perspective 'knowledge representation' becomes more than merely finding the appropriate language within which to capture the inference process for speaking with semantic and syntactic exactitude about causation. It involves, rather, the development of a system for legitimating appropriate *questions* which are always presupposed within any problematic, that can give rise to an explanatory account. Cognitive mapping distinguishes itself precisely in this area because it is oriented toward the problem of what frame of reference is appropriate to understanding a given situation (Shapiro *et al.*, 1988).

To use cognitive mapping as a tool for representing and integrating

substantive knowledge about an issue being debated in an international forum, negotiators and their staffs would collect information, either in the form of published literature or interviews with experts, and code the material into cognitive maps. Because this task is quite time-consuming, it would, most likely, have to be done at the pre-negotiation stage. Individual cognitive maps, which reflect the knowledge contained in a specific journal article, book chapter, or expert interview, would be aggregated into a single large cognitive map for each issue area, following the procedure for aggregating maps that was utilized in the oil policy study (Shapiro *et al.*, 1988). Before achieving a synthesis of knowledge about an issue area, the concepts in the map would be checked for synonyms, and it might be necessary to redefine local and global terms into structurally equivalent constructs. Finally, the causal or quasi-causal linkages would be analyzed for instances of conflicting knowledge, and the conflicts would have to be resolved, perhaps by further research or the use of expert panels. The resulting cognitive map can be treated by negotiators as a structural representation of knowledge within a particular issue area in the form of concepts and causal relationships between concepts.

To test the feasibility of using cognitive mapping to represent knowledge about an international problem area, the technique outlined above was applied to the negotiations on Mutual Balanced Force Reduction (MBFR), which were conducted in Vienna in the 1970s. As a step toward the achievement of an integrated conceptual framework for the MBFR talks, Guetzkow (1978) constructed a cognitive map of the major issues based on information supplied by the MBFR Task Force. This cognitive map was enriched by integrating it with concepts and propositions from the international relations literature, particularly the literature on fear and trust.

The MBFR exercise illustrates the feasibility and promise of cognitive mapping as a technique for representing knowledge about an issue domain at the pre-negotiation stage. This use of the technique, however, depends upon the availability of a comprehensive and systematic collection of documentary material and the efforts of negotiators and staff members to code the information and create an integrated cognitive map that can be used in the actual negotiations.

3.2. A Process-Focused Tool

Cognitive mapping can also be used to great advantage as a process-focused tool to promote the convergence of perspective and the achievement of agreement in international negotiation. At the pre-negotiation stage, negotiators can use the technique to map out their own assumptions and explore perceived effects of various proposals on their policy goals. Other applications of the technique can also be useful at this stage. The statements of other parties to the negotiation can also be mapped and analyzed to anticipate their arguments and proposals. On the basis of this analysis, counter-arguments and alternative proposals might be prepared.

Once the negotiations have begun, negotiators can promote convergence by mapping the statements and positions taken around the table. Here, simple hand-drawn maps, which do not require machine processing, would help to pinpoint areas of conflict, not only with respect to policy goals, but also the underlying assumptions that lie behind the argumentation. Compared over time during the course of the negotiations, hand-drawn cognitive maps might enable negotiators to determine areas of convergence and the underlying conceptual structure that supports the convergence.

The utility of cognitive mapping as a tool for helping to promote convergence and agreement in negotiation is demonstrated in a study of the 1919 Paris Peace Conference (Bonham *et al.*, 1991a). Using the transcripts from the conference, aggregate cognitive maps for the Big Four were constructed and compared over time for the negotiations over the Saar Basin. These maps were analyzed to describe how Wilson, Lloyd-George, Clemenceau, and Orlando developed a shared understanding of the problem and arrived at an agreement on the future of the region.

Cognitive maps of the initial discussions over the Saar Basin revealed major differences between the negotiators over the future of Germany. For example, in a meeting between President Wilson, Mr. Lloyd-George, and M. Clemenceau in Paris on 27 March 1919, Wilson argued that moderation should be shown toward Germany. Wilson's cognitive map begins with the concept, 'excessive demands', and is linked to other concepts by causal connections, which can be repre-

sented by the signed arrows (see Figure 4). According to Wilson's reasoning, excessive demands create the impression of injustice, thus fermenting discontent among the German people and providing Germany with reasons for seeking revenge. Discontent leads to conflict and sows the seeds of future war. Wilson argued that these consequences can be avoided by 'negotiation with moderation and equity', a concept that reduces the impression of injustice.

M. Clemenceau's reply produces a reality that differs from that of Wilson's by using a national character discourse to explain the behavior of Germany (see Figure 5). The 'German spirit' creates the desire to impose force on others and leads to aggression. This can be avoided, according to Clemenceau, by imposing sanctions on Germany to assure the fruits of victory.

As the process of negotiation unfolded, its degree of success seemed to be related to the degree to which negotiators constructed shared cognitive maps, which amounted to their building of a shared 'reality'.[4] More specifically, as each proposal was offered, there occurred a within-nation information processing in which the proposal is first connotatively amplified and then valued within the receiving nation's cognitive map. If not, it was followed by a counter proposal. Moreover, as the negotiation proceeded, each proposal offered was selected not only to the extent that it spoke to the goals of the nation making the proposal, but also because it had some chance within the joint cognitive map, i.e., it was intelligible and coherent within each negotiator's cognitive map.

For example, in the 1919 negotiations when Wilson proposed his idea of justice as the avoidance of 'excessive demands' on Germany, Clemenceau proposed, instead, multiple interpretations of 'justice'. He argued that "what we regard as just here in this room will not necessarily be accepted as such by the Germans," and he offered some evidence for differentiation of the term: "Note that no one in

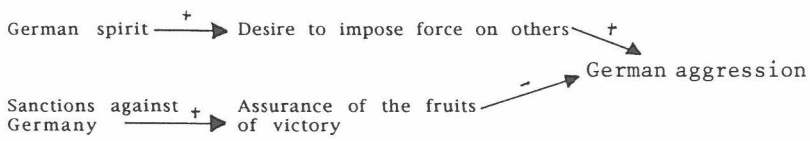

Fig. 5.

Germany draws a distinction between just and unjust demands of the Allies." Later, in an attempt to build support for his position, he proposed another concept of justice:

> There is a sense of injustice as between allies which must be satisfied. If this feeling were violently thwarted, either in France or in England, grave danger might follow. Clemency toward the conquered is good; but let us not lose sight of the victors.

By introducing a new notion of justice and playing on the fears of 'grave danger' (i.e., revolutionary movements), Clemenceau attempted to construct a strategy that would evoke a cognitive map he shared with Wilson and Lloyd-George.

4. CONCLUSIONS

While the cognitive mapping is no panacea for negotiators, it represents an improvement over intuitive analysis, which is often unsystematic. The output of the approach is concrete and it can therefore be applied to specific policy problems. Furthermore, the output is congruent with the way in which negotiators themselves use concepts and justify policy positions. The approach shows the kind of thinking that will take place when negotiators confront a problem, and it traces the implications of this thinking for policy choice.

The cognitive mapping approach also reveals the structure of thinking about a problem, a structure which is often much less complex than practitioners realize. It shows which factors actually have an impact on judgement and singles out these factors which are relatively unimportant. Through the use of cognitive maps, either hand-drawn or machine-processed, negotiators might be able to construct richer, much complex cognitive structures as well as alternative ways of looking at a problem. In short, the cognitive mapping approach is flexible over a range of issue areas, and it is a heuristic device which can also be used to help promote negotiated agreements.

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NOTES

[1] For a recent review of social psychological approaches to the study of foreign policy decision-making, see Vertzberger (1990).
[2] See Bonham *et al.* (1976a), Bonham and Shapiro (1986), and Shapiro *et al.* (1988).
[3] Coding procedures for inferring and constructing cognitive maps can be found in Axelrod (1976), Bonham and Shapiro (1986b), and Ackerman *et al.* (1990).
[4] Although this proposition has not been tested, experimentally, it is suggested by the study of the 1919 negotiations, as well as Bonham *et al.* (1987), Bonham *et al.* (1988b) and Bonham *et al.* (1991b).

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ANALYSIS, MODELING, AND THE MANAGEMENT OF INTERNATIONAL NEGOTIATIONS

ABSTRACT. Negotiation management, a framework for practical implementation of computer-based support to negotiators and their staffs, is defined and described in this paper. In particular, three integrated tools and their underlying methodologies, are illustrated. The collaborative use of computers and information techniques in complex negotiation is framed in terms of a 'discovery and design' paradigm in which parties engage in dialogue, learn, and develop trust that can support the negotiation itself through a process of joint analysis and modeling.

Keywords: Negotiation modeling, simulation, fairness, consensus rules, statistical analysis, information systems.

0. INTRODUCTION

It has been observed that much work has been done to develop analytical techniques that can describe and explain processes of international negotiation after the fact, but that far less is known about how these techniques can be used to aid negotiators *during* their negotiations. There are good reasons for practitioners' reticence when it comes to the adoption of analytical methodologies as tools in negotiation, and the usually concomitant requirement that computers be used only makes matters worse. The reasons for practitioner's lack of enthusiasm are many (Nyhart and Samarasan, 1990) and include:

1. a perception that the costs of adoption – financial and otherwise – outweigh the expected benefits;
2. a distrust of the proffered tools, founded, ironically, on the readiness of *other* parties to use them; and
3. a lack of ownership over the tools, which leads to rejection on grounds that models and mathematics are not relevant to the negotiation process.

Each of these factors can usually be traced to failure of the meth-

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odologist/consultant to discover and communicate the benefits of analytical tools in a rigorous and convincing manner; a failure to present the joint use of tools as a simultaneous opportunity for all sides in a negotiation; and a failure to emphasize that analytical tools and computerized calculations are not meant primarily to predict or guarantee success but to enhance communication and the sharing of information in the intensely human process that is negotiation.

1. NEGOTIATION MANAGEMENT

Recent writers have approached the effective application of computer models in negotiation and group decision-making on three fronts:

1. general principles (Shakun, 1981; Straus and Bazerman, 1985; Straus, 1986; Samarasan, 1986);
2. specific computer methods and system architectures (Steeb and Johnston, 1981; Ezrol, 1987; Göltner, 1987; Stefik *et al.*, 1987; Göltner, 1988; Roe, 1988; Samarasan, 1988); and
3. practical guidelines for the use of specific modeling tools in particular negotiation contexts (Raker, 1987; Lando and Tong, 1988; Lee, 1988, Nyhart and Samarasan, 1988; Samarasan and Messina, 1988).

All three of these elements – principles, tools, and practical guidelines – are included in *negotiation management*, an emerging framework that emphasizes the important role of information and knowledge as resources in negotiation (Nyhart and Samarasan, 1989; Samarasan, 1987).

Negotiation management is a framework built around the use of generic software, designed to aid the processes of collaborative group decision-making in complex multi-party, multi-issue negotiation. By complex negotiation, I refer particularly to those where:

1. the points of dispute are technical and involve a high degree of uncertainty:
2. practical experimentation with solutions is too expensive or risky;

3. there is no unquestioned authority to whom the disputing parties all defer; and
4. prompt resolution and a return to friendly, or at least stable, relations are desired.

'Complex negotiations' are usually negotiations among several parties about numerous issues. The issues may be independent, but more commonly they are naturally coupled. They are 'technical' in the sense that they spring from specialized scientific or technological controversy. Contemporary examples of technical problems in international negotiation include arms reduction, the economic effect of restrictive tariffs and quotas, and the resolution of long-standing regional conflicts. When proposals are made in these negotiations, they cannot be tested clinically, and structural problems due to incomplete or inaccurate knowledge cannot be exposed immediately. When there is no obvious and constructive settlement, the absence of an *unquestioned authority* forces the parties to negotiate under uncertainty. And in most of these cases, *prompt resolution* is rare. The typical alternatives to negotiation are usually costly, lead to extended stalemate, and can be disastrous in the long run.

There are, of course, countless analytical methodologies on which one could base the design and development of tools for negotiators, including (Samarasan, 1988):

1. dynamic simulation of the process of negotiation;
2. dynamic simulation of the substance under negotiation;
3. analysis of similar precedential disputes and negotiations;
4. risk and decision analysis;
5. utility analysis; and
6. expert systems.

The following section elaborates on three negotiation tools that are based on practical utility and experience more so than on theoretical analysis. The three tools are:

1. SAM: a modeling tool designed to simulate the effect of various group decision-making norms in the process of negotiation;

2. ISES: an integrated simulation and evaluation system with which negotiators can assess the appropriateness of relative acceptability of incoming and outgoing settlement proposals; and
3. MATCH: a tool designed to help negotiators identify effective settlement strategies based on the analysis of precedent conflicts and negotiations.

These tools illustrate the kinds of capabilities that are important in the management of complex international negotiation.

2. TOOLS FOR NEGOTIATION MANAGEMENT

2.1. SAM: Simulating the Process of Negotiation

The synthesis of an agreement – the design and creation of a mutually acceptable solution through negotiation – appears to be at least as important and difficult a process as the analysis that helps parties shape their bargaining tactics and competitive strategies. One way of improving the chances that an agreement can be synthesized is to provide negotiators with a tool to simulate the effect of decision-making norms that govern the process of negotiation. In particular, the norm of fairness is powerful and of almost universal interest.

SAM is a computer program – actually, a suite of programs – that enables parties to design, simulate, and select fair negotiation and group decision-making processes (Samarasan, 1986; 1988; 1989; 1990a; Nyhart and Samarasan, 1989). The use of SAM encourages parties to explore diverse conceptions or norms of fairness in negotiation. An idealized vision of this process of exploration is as follows:

1. parties begin by each voicing their own conceptions or norms of fairness;
2. they then jointly build SAM models of these various norms:
3. the parties run each SAM model, thus simulating each of the modeled norms for group decision-making;
4. as different agreements emerge, the parties evaluate each one on the basis of its substantive impact on its interests.

5. finally, by iterating through the procedure, the parties jointly arrive at a mutually acceptable definition of a fair decision-making procedure whose substantive outcome is also acceptable.

At first glance, the idea may appear somewhat peculiar. On reflection, however, one sees that it is consistent with the need, in negotiation, to agree first on principles and group norms for decision-making before embarking on an emotionally charged bargaining process. Furthermore, it builds on a long tradition of applied mathematics in economics, political science, cognitive science, and general systems theory. Finally, I note that it offers a mechanism through which negotiators can synthesize process-related analysis with subject-specific assessment of alternate substantive options that might resolve the conflict they are negotiating.

To illustrate the use of SAM, consider the so-called 'rule of consensus'. This rule states that negotiation among n parties can only be settled when all have agreed to one solution. In other words, forcing a minority to capitulate is unfair. Next, consider a group of n negotiators wondering how to settle fairly on some unknown X^*, the numerical level at which a particular issue is to be ultimately settled. Assumed that X^* is defined on some closed interval $[X_{\min}, X_{\min}]$ which, by prior agreement, contains all conceivable settlements. Given a set of individual preferences p_n, a set of individual upper bounds on offers, U_n, and a set of individual lower bounds on offers, L_n, one party might argue in purely utilitarian grounds that the fairest consensus is the one which minimizes total group compromise, Ω. The imperative mathematical representation of this statement is:

$$(1) \qquad \text{Minimize } \Omega = \Sigma(|P_i - X^*|) \text{ such that } L_i \leqslant X^* \leqslant U_i \text{ for all } i \leqslant n$$

If no solution exists to this optimization problem, all n parties would have to reconsider their inputs P_n, U_n, and L_n and then restart the process. If there is exactly one solution, then it is trivially the 'fairest' solution. But if more than one solution exists – in other words, if distinct values of X^* result in the same value for Ω – then there is a positive and meaningful bargaining range. The choice of an ultimate

settlement from among the possibilities within this range, if it is still to be made on equitable terms, requires further analysis.

In order to further pursue fair solutions, the parties must probe deeper into what they each mean by fairness. For example, one party might argue that negotiators ought to be rewarded for being flexible. This assumption could be represented in Equation 2 by setting K_i directly proportional to flexibility, which might be defined as $(U_i - L_i)$:

$$(2) \qquad \text{Minimize } \Omega = \Sigma(K_i|P_i - X^*|) \text{ such that } L_i \leq X^* \leq U_i \text{ for all } i \leq n$$

In this case, K_i could be understood as a simple weight applied to the opinion or preference of party i. Alternatively, K_i could be set to increase non-linearly with MIN $[(U_i - P_i), (P_i - L_i)]$. This slightly more cynical condition implies that each negotiator values another's flexibility more when it is symmetric about a preference point than when it is skewed, because the symmetric form is less obviously self-serving or manipulative.

To take yet another example, one could argue that the fairest consensus settlement is one in which no party achieves its preferred level unless all parties do. Thus, another condition would be added to Equation 2: $X^* \neq P_i$ for all $i \leq n$, unless $P_i = C$ for all $i \leq n$, where C is some constant. Notice that these and other additional conditions can be added to the list of constraints in Equation 2 according to ordinary rules of logic. Properly formulated, each condition implies a group decision-making rule or norm. When these rules or norms are weighted and combined, the resulting set of constraints on solutions can be called a 'constitution' or, more grandly a 'social contract'. The former usage borrows from Arrow, and the latter from Rawls (1971) and thereby from Rousseau.

The 'consensus' example discussed above shows how and why one might translate given intuitive conceptions of fairness into mathematical models that are neither exclusively descriptive nor exclusively prescriptive. SAM enables negotiators to build models of this kind. The benefits of doing so are at least four-fold:

1. the intuitive basis for each suggested norm is made explicit and can then be communicated and shared;

2. norms can be combined in various ways to form 'constitutions';
3. the power of the computer can then be used to simulate multi-party, multi-issue decision-making norms; and
4. possibly, new principles or mutually acceptable norms can be discovered or developed.

Assuming that a fair negotiation process is more acceptable to parties than an unfair one, all of these benefits are consistent with a view of negotiation in which it is considered more effective if, among other things, each party perceives that the particular process of group decision-making is acceptable.

A slightly different use of SAM is in planning for negotiation. A negotiator or neutral mediator might use a comprehensive process simulation model to predict the course of on-going or future negotiations or, more usefully, to synthesize multi-dimensional settlement proposals that are designed to appeal to as many negotiating counterparts as possible. Yet another use of SAM is not directly in negotiation management but in research and theory-building. By fine-tuning a SAM process simulation model with empirical data, it is possible to specify and develop analytical models of negotiation that have obvious and intuitive correspondence to real-world negotiation phenomena, even when these phenomena involve subjective factors not susceptible to other modeling methodologies.

2.2. ISES: Integrated Simulation and Evaluation

ISES is a program that facilitates the evaluation of complex settlement proposals; to date, the program has been developed in the context of arms control negotiations (Göltner, 1988), but I choose to describe it here in the context of a different East–West interaction: the negotiation of a Western–Russian industrial joint venture.

This program combines a particular simulation model (or set of simulation models) and a rule-based evaluation procedure in an integrated, multi-user system. Parties exchange proposals, usually in the form of long and complicated sets of parameters stored and transferred electronically. The consequences of an agreement based on each of these proposals is determined through the use of the simulation model. Then, the evaluation system helps in flagging those proposals

that need special attention because they (or their consequences) fail to meet certain criteria pre-specified by the parties.

In the context of Western–Russian joint venture negotiations, ISES could be used to help negotiators evaluate the terms of proposed contracts in light of their interests. For example, consider a joint venture that will manufacture three different products out of seven produced elsewhere by the prospective Western partner. The Russian side might have an interest in modernizing the industrial base by obtaining access to advanced Western technology and management skills. This interest can be analyzed and formulated in terms of an equivalent rule, so that the underlying interest would be satisfied if, say, the proposed venture were to be such that, within five years, it could produce *A*, *B* and *C*; or could produce, within eight years, *M* units per year of *B* and *N* units per year of *G*, *etc*. Each part of the rule can be tested in a simulation model and the underlying interest checked in ISES.

The use of ISES helps negotiators to show clearly how their negotiating positions and underlying interests are related. The program's evaluation section requires users to be explicit about their interests. In order to use the evaluation feature, users have to specify various tests and rules. Tests are formulated in terms of comparisons among the many variables being negotiated or discussed: some of these variables may take on values that are assigned in the associated simulations. Rules then combine these tests as necessary to define broader interests. As settlement proposals are exchanged, the system automatically checks each proposal to see if these rules are violated.

2.3. MATCH: Analysis of Precedent Cases

Parties in a negotiation can use the computer to help them learn from precedent. For example, a negotiator might obtain answers to the following kinds of questions:

1. what cases are similar to a given case?
2. what is the probability that a given case can or will be settled?
3. what is the probability that a given case will be settled within some period?

4. what is the probability that a given case will be settled for less than some value?
5. what is the expected lifetime and cost of settling a given case?
6. what tactics have other negotiators tried in similar cases and with what result?
7. what is the expected result of using a given tactic in a given case?
8. how often is a given tactic associated with a given result in similar cases?

The computer can aid in the generation of descriptive statistical reports about prior cases, the calculation of probabilities of future events, and possibly in the modeling of the future progress of the current case, taking into account subjective estimates of the reliability and relative importance of the data (see Druckman, in this issue).

Negotiators can use statistical estimates to identify expedient courses of action as they plan their negotiating strategies. Once a set of cases has been identified that is similar in some relevant sense to the case at hand, negotiators might be able to estimate the likelihood that a particular action or decision will lead to a desired result. In political, military, and para-military conflicts, for example, negotiators and decision-makers have found it useful to know whether a particular proposal for action – whether conciliatory or belligerent – will lead the conflict towards or away from resolution. Bloomfield and Beattie (1971), for example, describe a program called CASCON, designed to aid in the resolution of small wars and local conflicts: before the program can be used, a standardized series of questions about a large number of similar conflictual situations is formulated to elicit information from experts; this information is stored in a knowledge base; users specify their particular conflict using some or all of the attributes coded for in the knowledge base; the program locates those cases that are most similar to the one at hand and present them together with some analysis. The imputation of strategic value to summaries of similar cases is based on the prescriptive interpretation that steps identified as having been correlated with preferred outcomes in the past will, if taken in the current case, again lead to similar preferred outcomes.

MATCH is a computer program designed to help negotiators and third parties understand the history and potential course of a negotia-

tion and to develop a strategy for resolving it (Samarasan, 1989; 1990a). The use of MATCH depends on the existence of a data base containing information about similar cases: the program provides the user with a customized window into the data base. The program itself is generic, and consists only of (i) a set of matching algorithms, (ii) data types and file formats that specify an input/output mechanism, and (iii) a user interface. All context-specific information is stored in *frame models*, which are separate documents built with MATCH. Results of a match are of two kinds: (i) a *MATCH set*, or list of matching cases selected from the data base, and (ii) *MATCH statistics*, or summary information in the form of pertinent expected values and probabilities. The program leads the user through an interview, asking for answers to the specific questions listed in the frame, and building a profile of a case. The profile is then compared with entries in the data base to generate a MATCH set and MATCH statistics for the user.

Once a MATCH set is obtained, several statistics can be derived from it, including:

1. the probability that a given conflict can or will be settled peacefully can be derived by computing the fraction of cases in the MATCH set that were in fact settled peacefully;
2. the probability that a given conflict will be settled within some period, or with the expenditure of less than some amount of resource, can be derived similarly; and
3. the expected lifetime and cost of a given case can be computed by taking a mean lifetime and cost over all members of the MATCH set.

These and other MATCH statistics provide summary information in the form of pertinent expected values and probabilities.

3. THEORETICAL CONSIDERATIONS: NEGOTIATION AS DISCOVERY AND DESIGN

Given the panoply of analytical methodologies and computer-based tools that are – or can be made – available, I believe that the use of computer models in the management of negotiation presents us with both a problem and an opportunity.

The problem is inherent in the way in which negotiations are often conducted. Typically, negotiators presented with computer tools ask first how the tools can help improve their own situation without giving anything away to others. Given this approach, the use of analysis and modeling is perceived to be inadequate because it is quickly co-opted into a 'create and claim' framework (Lax and Sebenius, 1986; Lewicki and Litterer, 1985). In this framework, joint analysis and modeling are perceived to be appropriate for the 'create' phase, whereas distributive bargaining is seen as somehow more practical in the 'claim' phase. Negotiators are supposed to watch carefully the tension between creating and claiming value, lest they create value and someone else makes off with it. An 'us-and-them' orientation is perceived to be necessary, and is built into the framework.

As long as we take literally the terms of the basic integrative-distributive paradigm, the use of complex tools can be little more than distractions in the effort to resolve complex disputes: parties often have too much at stake to gamble on 'creation' if the other side is going to do the 'claiming'. But, approached in a different way, the application of analysis and modeling offers us an invaluable opportunity to transform the processes of complex negotiation.

An alternative model of complex negotiation – or at least an alternative metaphor – can be conceived on the basis of the collaborative use of computers and other information tools (Samarasan, 1990b). Negotiators and facilitator come to the table, each surrounded by a private collection of information: assumptions, facts, interests, and positions. They are collectively surrounded by even more information that is available or retrievable in some sense. Computers and related technology can provide them with tools to help them evaluate and manipulate the available information. Instead of placing negotiators within a framework where their task is to 'create and claim' value, one could provide them with tools meant to help them 'discover and design' solutions or agreements. If complex negotiations can be reframed in this way, computer-based tools can engage the parties in dialogue and help develop trust through a process of joint analysis and modeling.

Analysts use the word 'discovery' to refer primarily to the exposure of objective facts about the world through painstaking observation of the world. This usage can be modified to include explicitly discovery

through introspection and communication. In all but the most simple negotiations, the parties discover things – they learn from their interactions with each other – over the course of their interactions, whether or not they finally reach an agreement. Discovery can take place when negotiators obtain insight into:

1. other parties' understanding of the agenda and negotiation process;
2. other parties' preferences;
3. other parties' understanding of substantive issues;
4. the interests underlying other parties' preferences; and
5. their own understanding of underlying substantive and process issues.

Thus, introspection, external observation, and communication are key to discovery.

The notion of 'design' covers, in its broadest sense, any deliberate attempt to fill a need or solve a problem. I suggest, however, a more specific engineering-oriented sense of the term: the specification and production of devices and systems that use available resources in the most effective manner possible to satisfy a set of non-independent needs or requirements. Elaborating on this definition, I suggest the following nine-phase model of the design process:

1. identify the client and the need;
2. define the design problem;
3. search for relevant information;
4. formulate criteria and constraints on acceptable solutions;
5. list alternative solutions;
6. perform analysis to specify, modify, and evaluate proposed solutions;
7. make a decision;
8. formalize the specification of the selected solution; and
9. communicate the solution to the client.

Once the design process is reduced to these terms, I believe that it serves as a provocative (if not necessarily useful) metaphor for negotiation management: analyst as designer and negotiators as clients.

When negotiation is viewed as a process of discovery and design, the interests of all members of the negotiating group are arguably more likely to be seen as co-equal by each negotiator – or designer – and these interests can be treated as constraints in a joint design problem. In design problems, constraints are often weighted, and weighted unequally, but they are all acknowledged to be valid – this is, in fact, why it is useful to talk about design in our metaphor: it reflects the *primus inter pares* character of an enlightened negotiator. This view of negotiation does not simplistically prohibit distributive bargaining, nor does it ignore the 'claim' phase of earlier models. It comprehends the whole of negotiation. And if there is an 'us' or 'them' in this picture, it is less intrusive: the process of 'discover and design' is an inherently collaborative one.

Given this outline of the 'discovery and design' model, it seems reasonable to ask about its potential prescriptive aspects. How can this model help us better understand and approach effective negotiation? Effectiveness is generally measured by the extent to which an objective is met. I suggest (i) that the objective of negotiation is to solve a set of underlying substantive problems as efficiently as possible while maintaining – if not improving – the relationship among the parties; (ii) that effective negotiation is characterized by three attributes: legitimacy, feasibility, and efficiency; and (iii) that both the process and outcome of negotiation can be evaluated in terms of each of these three attributes.

Legitimacy has to do with the parties feeling or perceiving that their rights have been respected. Parties have expectations about the legitimacy of both the process and outcome of negotiation: relevant attributes include fairness and a sense of ownership. By definition, legitimacy is a subjective characteristic and can only be evaluated by the parties themselves. Nevertheless, we believe that the use of computer models can contribute to a sense of legitimacy in at least two ways. The collaborative use of computer models generally in negotiation involves the parties in a joint learning process. If parties cooperate to build models and then use these models to investigate or develop settlements, they derive a better idea of each other's needs and a greater sense of ownership over the process of negotiation (Clements and Sossen, 1987; Kraemer, 1985). Legitimacy also requires that the means of arriving at a decision be acceptable to all parties. Fisher and

Ury (1981) emphasize the importance of agreeing on ground rules for negotiation. Susskind and Cruikshank (1987) argue that the choice of decision process should be made with regard to the concerns and attitudes of the parties. When a group can step back from the heat of negotiation and focus on process issues, the question of legitimacy can more easily be addressed if negotiators have access to a computer modeling tool – *e.g.* SAM – that simulates and thus allows them to jointly design and select mutually acceptable negotiation and group decision-making rules or norms before they begin negotiation in earnest (Samarasan, 1987).

Feasibility, the second attribute of effective negotiation, is a more practical concern, and has to do with the possibility of successful implementation. A feasible process is one that usually leads to settlement; whereas an infeasible process – using formal voting rules in a bilateral arms control negotiation, for example – is one that most often leads to stalemate. A feasible outcome or settlement is one that, when implemented, solves the underlying substantive problem without unravelling. How can the use of computer models contribute to feasibility? If negotiators have built valid computer simulation models pertaining to the substance of their negotiation, they can perform sensitivity analyses to test policies and settlements. Suggestions or proposals that do not produce the expected or desired effect when tested in the model will probably also fail if actually implemented. The negotiator's ability to make a judgment on this matter is what Wheeler (1987) refers to as 'prospective hindsight', and it is enhanced by the use of appropriately designed analytical tools; the use of both ISES and MATCH, for example, improves the chances that an agreement will endure over time. Clearly, the parties never actually know whether a negotiated outcome is going to turn out to be feasible or not, but they can approach feasibility by selecting outcomes that are *more likely* to be feasible. Enhancing negotiation in this way is particularly important when scientific or technological uncertainty threatens to dominate the agenda.

Efficiency, the third and final attribute of effective negotiation considered here, has to do with reducing waste. A process is efficient if it minimizes the transaction cost of negotiation, measured in units of cost or time, whereas an outcome is efficient if it approaches Pareto-

optimality. How can the use of computer models contribute to increasing the efficiency of negotiation? In complex negotiations, there are multiple sources of technical data that must be considered and managed. And because of changing technological and political options, many negotiations result in temporary solutions, and become continuous or periodic institutions. Information technologies have the potential to greatly improve the cost-effectiveness of such negotiations. Furthermore, these technologies also make it possible for parties to quickly share information about underlying interests and priorities with each other and with third parties, steps that Susskind and Cruikshank (1987) argue are necessary if Pareto-optimal solutions are to be obtained.

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NEGOTIATION SUPPORT: DEVELOPMENT OF REPRESENTATIONS AND REASONING

ABSTRACT. The general importance of negotiations and bargaining as means of decision making has given rise to considerable research within two broad paradigms. The behavioral paradigm has attempted to discover rationality in specific situations in order to generalize. The formal paradigm has assumed a general rationality which could be applied to specific problems. This strict dichotomy imposes unnecessary restrictions on the use of formal approaches to structure, represent, and support negotiators. Logic-based approaches, such as rule-based formalism, make it possible to blend unique and specific aspects of a problem, with general reasoning mechanisms and rationality postulates. This paper introduces rule-based formalism and discusses its advantages and disadvantages. It attempts to present its ability to represent complex decision processes and to reason using formal structures. The approach is illustrated with several simple examples.

Keywords: Negotiation modelling, rule-based formalism, logic, expert systems, structuring, knowledge representation, negotiation support.

1. INTRODUCTION

1.1. Toward a Qualitative Framework

Negotiation is characterized by argumentation, persuasion, and interaction involving the comparison of goals and alternatives. These activities may cause a change of focus or preferences, shifts in strategy or the revision of negotiators beliefs. In many quantitative approaches, the arguments, beliefs and interactions disappear into functional relationships between goals and alternatives and into the probability distribution of the consequences.

Until recently, formal approaches had focussed exclusively on the quantitative aspects of negotiation. Raiffa, in the first comprehensive qualitative interpretation of many quantitative aspects, underlined the need for formal qualitative analysis. As a scholar in game theory and decision theory who was heavily involved in negotiation, Raiffa (1982, p. 3) says that in negotiations:

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The concepts of decision analysis seemed to me much more applicable than those of game theory, but not in the way I had taught it. The qualitative framework of thought was repeatedly helpful — not its detailed, esoteric, quantitative aspects.

1.2. Quantitative and Qualitative Modelling

The quantitative view of human actions has an underlying assumption that very different phenomena may be represented in exactly the same manner, and thus different problems can be represented with the same model and solved with the same procedures. Application of a standard procedure to the problem representation produces the solution. The focus is then on the choice of a representation and the selection of a solution procedure, with the main effort directed toward the application of the procedure, that is, on numerical manipulations.

The qualitative viewpoint assumes that there are families of phenomena which may be different in some specifics but which have enough similarities that they can be described with the same generic representation. The difference is that in the quantitative approach the phenomena are similar if they can be represented with the same model. From the qualitative viewpoint similarity is determined by the intrinsic meaning of different phenomena and their relationship to a concept earlier chosen by the decision maker, or to an established generic representation. For example, if the decision maker utilizes a concept of fairness then it can be applied equally to a negotiation about purchase of a house and in the analysis of trade negotiation between two countries.

An important part of the problem solution process in the qualitative approach involves the successive reformulation of the representation which becomes more specific and appropriate to the particular problem. Often, such restructuring involves more effort than the application of a solution procedure, which is used not only to determine a decision alternative, but also to analyze the appropriateness of the representation (Mayer, 1989). Representation and solution are interactive processes and influence one another. A solution procedure may be applied to a small portion of a problem to provide information required to structure other parts of the problem. The structuring

process may even replace the solution process. The problem solution is obtained through manipulation of the problem representation such that it becomes very specific and from it one solution clearly follows (Mintzberg *et al.*, 1976).

The basis for a qualitative framework may be found in logic which provides a rigorous approach to problem structuring and inference mechanisms. In this paper the use of formal logic is applied to the structuring of negotiation and determination of valid chains of reasoning, that is inference, from the structures obtained. The negotiation problem is represented with *production rules* that are an element of *production systems* (Barr and Feigenbaum, 1981) also referred to as *rule-based systems* (Luger and Stubblefield, 1989).

1.3. Modelling and Negotiation Support

The focus of this paper is on the development of representations and making deductions or reasoning. The representations may describe human knowledge and expertise and thus, they may be used to provide support to problems where deductive inference is appropriate (see Andriole in this issue). The support can be provided for negotiation planning to analyze the negotiation situation and the opponents. It can be used to simulate the negotiation process and reaction of the opponent to different negotiation tactics. The ability to model different situations and behaviours makes it suitable for training purposes. Knowledge-based support may also be used in on-line interactive systems, especially when immediate access to knowledge of many experts is often required but difficult to obtain.

An important area of negotiation support is analysis and verification of text. We show that negotiation texts can be represented by rules and then manipulated and analyzed from different perspectives. This provides a new type of support. Different texts are compared, their consistency checked, and conclusions drawn based on available expertise. This feature makes it possible to analyze opponents' responses, and compromise proposals in terms of their direct meaning and their relevance to the opponent's profile, behavior, or tactics.

2. RULE-BASED SYSTEMS

2.1. Knowledge

Predicate calculus provides the basis for the rule-based representation of knowledge and problem structuring, and allows reasoning to be performed on the developed structures. Production rules are of the form IF (action/antecedent) THEN (reaction/consequent) often denoted as 'action→reaction'. Production rules are used to represent knowledge and a set of rules describing a particular domain, type of problem or action is referred to as a *knowledge base*. Consider the following discussion about negotiation tactics (Wall, 1985, p. 49):

> Within the rational category lie most of the negotiation tactics, which can be grouped into two subcategories: debate and bargaining tactics. Debate tactics are those in which the parties engage in discussions, explications, interpretations, syntheses, and proposals to decide jointly upon an agreement that is acceptable to both sides. Bargaining tactics, in contrast, encompass negotiator (opponent) behaviors that is intended to move, direct, or constrain the opponent (negotiator).
>
> The bargaining tactics can be further divided into aggressive, nonaggressive, and posturing tactics. The aggressive tactics include announced intentions to harm the opponent if he or she does not engage in the desired behavior (threat tactics) and the specific attempts to inflict such harm (coercive tactics). The nonaggressive tactics include those that are conciliatory . . . (and) those tactics that reward the opponent.

Wall's knowledge about negotiation tactics formulated in English can be represented with eight rules, that is:

```
P1  rational_tactic or other_tactic
      →negotiation_tactic,
P2  debate_tactic or bargaining_tactic
      →rational_tactic,
P3  joint_decision and engagement_in(Engmnt_
      Type)→debate_tactic,
P4  aggressive_tactic or nonaggressive_tactic
      or posturing_tactic→bargaining_tactics,
P5  coercive_tactic or threat_tactics→
      aggressive_tactic,
P6  conciliatory_tactic or attempt_to_reward→
      nonaggressive_tactic
```

P7 announced_intention_to_harm→coercive_tactic,

P8 attempts_to_harm→threat_tactic.

The above rules represent a hierarchical decomposition of negotiation tactics. It may be considered as a classification problem which is to determine if a particular action, attempt or tactic is a negotiation tactic. The top-down approach to the structuring of this problem can be easily seen in its graphical representation as the AND/OR tree given in Figure 1.

At the very top is the *principal goal* which is called `negotiation_tactic`. This goal is decomposed into two goals `rational_tactic` and `irrational_tactic` and to achieve the goal `negotiation_tactic`, that is to obtain the value *`true`* for it, it is sufficient to obtain the value *`true`* for one of these goals. Then, the goal `rational_tactic` is decomposed into two goals, and this decomposition is continued down to the lowest level which is often called the `fact-level`. The decomposition process is top-down, but the data-driven reasoning process is bottom-up. Thus, to prove the top-level goal, facts at the bottom must be established.

An important question is how rules are determined and verified. This is the domain of knowledge engineering and it is clearly a

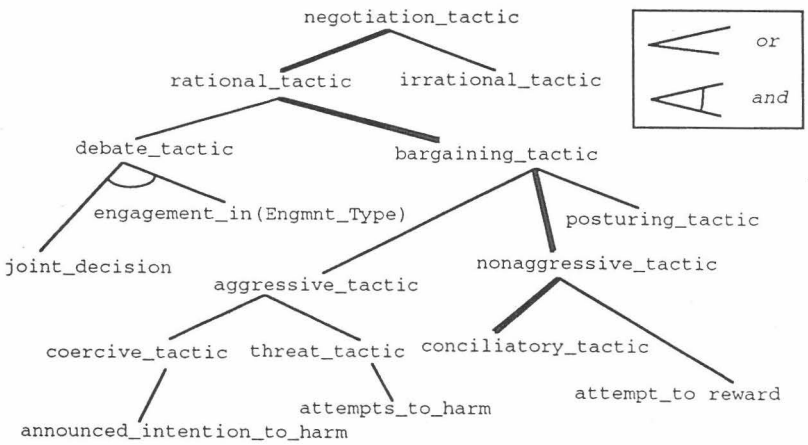

Fig. 1. Example of an and/or tree.

bottleneck in getting knowledge-based systems to their users. Because most human knowledge is not readily accessible and available for processing by a computer, it needs to be structured and appropriately presented. We presented here one example of how rules can be obtained – that is from analysis of texts. A complementary approach is to interview domain experts and researchers and present their thinking process using, for example, cognitive mapping (see Bonham in this issue).

Thus, obtained knowledge is fully portable and it can be used wherever it is applicable. If knowledge on environmental negotiation and possible negotiators' behavior is encoded then this knowledge can be used whenever a user conducts such negotiation. It is possible that multiple knowledge bases are accessed, for example a knowledge base describing international law and its interpretations may be used during environmental negotiations. Similarly, large quantitative models can be used to simulate possible consequences of compromise proposals determined with the use of 'environmental knowledge bases'. These consequences are then used to modify proposals and obtain new ones.

2.2. Reasoning

When a rule-based representation has been developed we may ask questions like: Is a request to make a decision jointly part of a negotiation tactic? Is a conciliatory approach a negotiation tactic? These questions can be answered by a repeated application of inference rules. For example, assume that we want to verify if a conciliatory approach is a negotiation tactic. We set

```
conciliatory_approach::= true
```
(where::= means 'is' or 'it is')

and having rule P6 and applying *modus ponens* we obtain

```
nonaggressive_tactic::= true.
```

Now, we can use rule P4 because it has `nonaggressive_tactic` as an antecedent, and by applying *modus ponens* we obtain

```
bargaining_tactic::=true.
```

Continuing this process we conclude that

```
negotiation_tactic::=true.
```

Hence, we proved that the conciliatory approach is indeed a negotiation tactic. This reasoning 'path' is depicted in Figure 1 in heavy lines.

3. APPLICATIONS

3.1. Expert Systems

A rule-based system is the knowledge representation system of choice for most expert systems which may be viewed as repositories of an expert's knowledge and from which the end user takes knowledge (Collins, 1990). An expert system consists of a knowledge base and a shell, which has an interpreter, interface, editor, and other parts used to enter, manipulate and use rules.

There are several important elements of expert systems which utilize rule-based formalism. Since the knowledge base is discrete, consists of separate rules, and the reasoning mechanisms are simple and link the rules in chains, it is possible to present the whole reasoning process to the user. Explanation is an important feature that distinguishes an expert system from a conventional computer-based system. While it is difficult to present how exactly a set of linear equations has been solved, it is easy to retract all the steps performed by the interpreter and present such a sequence to the user.

Such rule-based systems may be used in prediction to infer consequences in a given situation, for example, in determining the consequences of a compromise proposal. The power of such an expert system does not lie in its 'better-than-human' knowledge or reasoning capabilities, because the knowledge is obtained from specialists and experts. It is in the system's capability to access knowledge obtained from many experts, to access large databases in search of information, to verify the consistency of data and to reason on very large structures very rapidly. All these activities can be performed by humans, but in

many situations, the time and effort to do so is unavailable or prohibitive.

The simplicity of reasoning and natural representation is sometimes considered as a drawback. Some researchers and experts say that they perform these activities with 'pen and paper'. While this may be the case, expert systems may be used by non-experts and provide them with tools that can analyze and evaluate qualitative data, formulate hypothesis and/or provide recommendations.

Expert systems may be used to develop plans and scenarios, to monitor and evaluate the behavior of another system, to interpret and analyze data, and to train experts. From the negotiation perspective, they can be used in planning and verifying negotiation tactics, evaluating opponent's behavior, interpreting and evaluating the compromise proposals, their significance and impact, and in training negotiators.

3.2. Structuring and Simulation

Raiffa's comment about the usefulness of the decision analysis qualitative framework in conducting negotiations quoted at the beginning of this paper reflects the need "to think more systematically and consciously, and in a more conceptually integrated fashion, about the dynamics of negotiation" (Raiffa, 1982, pp. 358–359). This requires advance planning which involves defining goals, priorities and preferences, restrictions and uncertainties, as well as analysis of the opponent (Lewicki and Litterer, 1985). Systematic thinking and analysis leads to specifying the negotiation problem and the development of representations of the problem, the opponent(s), and possibly other entities that are involved in the negotiations. As we said, rule-based formalism may be considered a natural way to develop such representations.

There are several approaches to problem structuring and the development of representations which have their roots in system science (Eden, 1989; Checkland, 1988). The attempt to extract mental perceptions of a problem and present them in a formal manner. The focus is on the process during which the person clarifies his/her perception and obtains a map of entities and relationships.

Within artificial intelligence and expert systems, the development of

symbolic representations is often considered as the development of knowledge bases and it is known as *knowledge engineering*. It consists of the extraction of knowledge from sources of expertise, its formalization, and transfer to a knowledge base. This knowledge is then considered as a generic representation for a family of problems. It becomes part of an expert system and is used to develop a representation of a specific problem. The specific representation is often equivalent to a solution of this problem or a solution may be easily deduced from it. For example, the heavy lines in the AND/OR tree given in Figure 1 depict a specific representation of the problem 'What is a conciliatory approach to negotiation?' with the solution being a negotiation tactic.

The knowledge engineering approach is based on extensive interactions between a knowledge engineer and experts. Attempts have been made to develop systems which replace the knowledge engineer function and interact directly with expert decision makers. These systems aim "to help users to represent and manage the symbolic aspects of the decision making process – such as the alternatives being considered, the goals to satisfy, and the arguments evaluating alternatives with respect to the goals" (Lee, 1990, p. 105). Some of them utilize rule-based formalism to develop and manipulate problem representation. This approach, in addition to its simplicity and expressiveness, provides access to the analysis and reasoning mechanisms acting on the structures developed.

An important aspect of the structuring process is the analysis of the relationship between structures describing particular entities. In negotiation, for example, such analysis may include relationships between the representation of the negotiation problem and that of the opponent or the negotiator's constituency. This is an example of 'What-If' analysis extended from numerical to symbol manipulation. Kersten *et al.* (1991) propose restructurable modelling which uses rule-based formalism to build consecutive representations of a negotiation problem.

Restructurable modelling is based on the application of certain operators to rule based structures. The concept is based on the assumption that all 'chunks of knowledge' are known *a priori* and that the main difficulty is to gather these chunks together and build a

structure which represents the current problem and can be used to determine its solution.

To illustrate the restructurable modelling we consider a highly simplified example of labor-management negotiation described in Matwin *et al.* (1989). Assume that, we model and support a labor union which has developed a representation of its problem which is partially depicted in Figure 2.

The union also developed several other representations. One describes management's possible behavior in terms of simple reactions to particular offers. For example,

```
if      management: phase(bargaining) ::= true and
        management: overtime(150, percent, second_shift) ::= true and
        management: convert(overtime, timeoff) ::= false and
        union:      overtime(200, percent, second_shift) ::= true and
        union:      convert(overtime, timeoff) ::= false
then    management: overtime(200, percent, second_shift) ::= true .
```

This statement (meta-rule) describes a concession made by management during the bargaining phase, when the two sides agree on feasibility of conversion of the overtime into time off. More statements describing management's reactions may be prepared and then used to

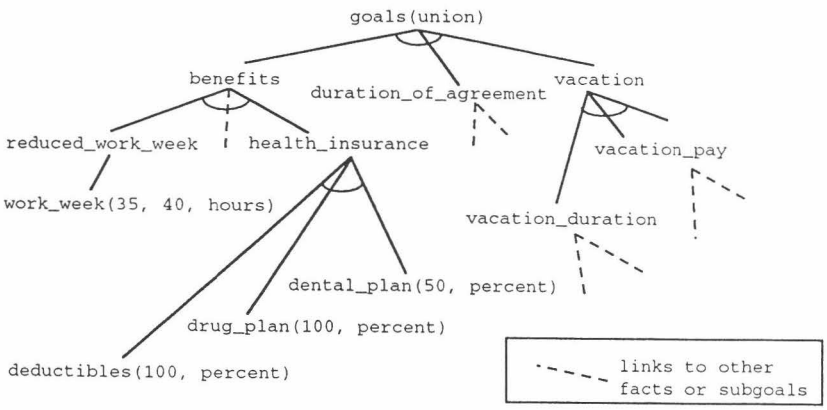

Fig. 2. Partial representation of union's negotiation problem.

obtain comprehensive management offers. One of these statements may describe a situation when, because of the union's very high demands, management walks away from the table. This may require a change in the problem representation, as depicted in Figure 2, to a new one given in Figure 3.

To move from the representation given in Figure 2 to the new one, rules with special operators are used. These operators modify representations. The new representation was obtained with the following modification rule:

```
if        management:  phase(stalemate) ::= true and
          union:       high_demands ::= true and
          management:  present_during_negotiation ::= false and
          union:       strike_mandate ::= true and
then  modify      (    initial_strike -> goals(union),
                       gatineau_on_strike   and   trois_riv_on_strike   ->
                       initial_strike ).
```

The above rule drastically modifies union's principal goals `goals(union)`. It replaces three sub-goals `benefits`, `vacation` and `duration_of_agreement` with one `initial_strike`, and introduces a definition of what the initial strike means.

Having prepared possible elementary reactions of management and rules that introduce changes into the union's problem representation we may simulate negotiation. The simulation process is a sequence of union's offers obtained from the AND/OR tree and management's counter-offers obtained from the management response meta-rules. When the situation changes so that the union is unable to prepare an offer, an attempt is made to develop new problem representation. For this purpose modification meta-rules are used.

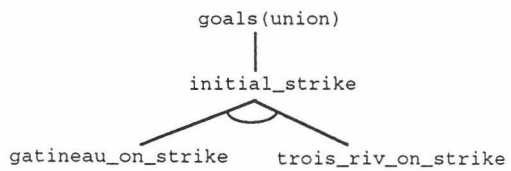

Fig. 3. New representation of the negotiation problem.

3.3. Examples

Rule-based formalism has been used to model hostage-taking incidents for the purpose of collecting and evaluating knowledge about these incidents and to support police negotiators. Vedder and Mason (1987) developed a Hostage-taking Information and Tactics (HIT) expert system which consists of a number of production rules describing stages of the negotiation and providing recommendations. The system has been verified and is considered as a valuable tool for training responding officers, on-scene commanders, SWAT commanders and hostage negotiation unit commanders. HIT poses questions to which the user enters the truth values. He/she may also respond that the answer is unknown.

An example of a dialog between the user and HIT is as follows (Vedder and Mason, 1987, p. 410) (user's answers are italicized):

PLEASE ANSWER THE FOLLOWING QUESTIONS WITH Y (YES), N (NO), U (UNKNOWN), OR W (WHY).
ARE YOU THE RESPONDING OFFICER? *N*
ARE YOU THE HOSTAGE NEGOTIATION UNIT COMMANDER? *Y*
HAVE YOU RECEIVED A FULL BRIEFING? *Y*
HAS THE NEGOTIATION POST BEEN ESTABLISHED? *Y*
HAS COMMUNICATION BEEN ESTABLISHED WITH THE HOSTAGE TAKER(S)? *Y*
...
IS THERE A DEMAND TO EXCHANGE HOSTAGES? *Y*
ACTION: REFUSE EXCHANGE
1. DEMAND SHOULD BE PUT OFF
2. ULTIMATUM SHOULD BE REFUSED
3. ...

The response unknown means that that particular rule cannot be used so the system attempts to use another rule. An important feature of HIT, which is present in most expert systems, is its ability to respond

when a user asks for the purpose of a particular question. When the user enters 'Why?', the system responds that the question is asked because it is a premise in a given rule which is being used in an attempt to provide a given conclusion. The explanation may involve not only the rule which at this point is being used, but also rules which lead to this rule. That is, the system may respond that 'Because you entered yes to question . . . and no to question . . . it has been proven that . . . Then, because you entered . . . (etc.)'.

Other examples of the use of rule-based formalism to model and support negotiations are given in Roman and Ahamed (1984) for labor–management negotiations, Kersten and Michalowski (1989) for hostage-taking incidents, and Kersten *et al.* (1990) for contract negotiations. There are also approaches which explicitly do not use the rule-based formalism, but incorporate production and logical reasoning. Sycara (1990, 1991) introduces case-based reasoning to negotiation planning and support. The focus of her research is on the development of formal representations of past cases of labor negotiations, for example, and then manipulating and merging case elements to obtain a representation of a given negotiation problem. The cases are also used to obtain argumentation for particular proposals, to determine interrelationships between elements of representations, and options for problem restructuring.

An example of the use of rule-based formalism and restructurable modelling to international negotiation is given in Kersten *et al.* (1988). The case considered is the 1978 Israeli–Egyptian negotiation at Camp David from the point of view of Israeli negotiators. A part of the initial problem representation is given in Figure 4.

With the use of meta-rules describing both Israeli and Egyptian responses such as:

```
if    egypt:     recognition (israel, plo) ::= true
then  israel:    withdrawal (israel, sinai) ::= false
```

and

```
if    israel:    withdrawal (israel, sinai) ::= false and
      egypt:     establish_dipl_relations (israel, soviet_union) ::= any
then  israel:    establish_dipl_relations (israel, soviet_union) ::=
                 false
and   israel:    set_up (united_nation_buffer, sinai) ::= true,
```

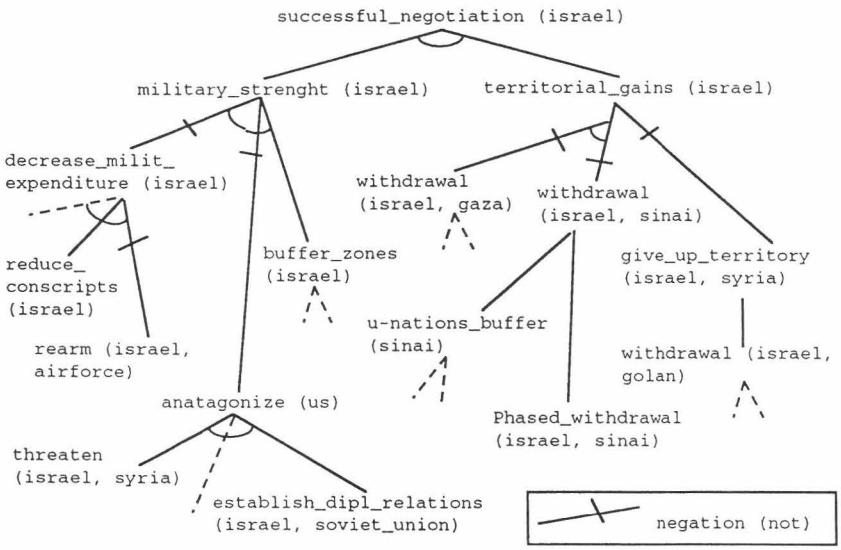

Fig. 4. Partial representation of Israel's negotiation problem at Camp David. (Adapted from Kersten *et al.*, 'Representing the negotiation process with a rule-based formalism', *Theory and Decision* **25**, 1988, p. 231.)

and modification meta-rules such as

```
if    egypt:      withdrawal (israel, west_bank) ::= true and
      israel:     rearm (israel, air_force) ::= true
then  modify      { not withdrawal (israel, gaza) and not
                    withdrawal (israel, sinai) and not
                    territorial_gains (israel, gaza) }.
```

a sequence of Israel's negotiating positions was obtained. Each position was determined on the basis of a particular set of demands of the two negotiating parties. The sequence of positions represented one possible scenario for the Camp David negotiations.

4. CONCLUSIONS

4.1. Advantages and Disadvantages

Rule-based modelling is a powerful and expressive approach to structuring and representing human knowledge and behavior. It can be

successfully applied to structure, represent and simulate negotiation processes, and to support the analysis of complex negotiation problems and negotiators' behavior. It does not imply that all that negotiators know and do can be reduced to a set of rules.

We have already mentioned such advantages of rule-based systems as separation of knowledge and control, modularity, tracing and explanation of the execution and system's state. Other advantages of the rule-based systems are: ease of modification, readability, and uniformity. Ease of modification results from modularity. Since knowledge is represented in chunks and it is independent from control change, deletion, or addition of a rule can be accomplished without having to worry about direct effects on the other rules. The system has different knowledge as a result of the change and this enables a continual increase of the system's body of knowledge.

An important attribute of production systems is the uniform structure imposed on knowledge. The information is encoded within a rigid structure of production rules. Therefore, it can be understood by user, and this is closely related to readability, but it can be interpreted and processed by other systems. This feature is used in systems that automatically modify their own rules.

We would also like to reiterate the naturalness of the production systems. Statements about 'What to do?' or 'How to do?' in predetermined situations are naturally encoded into production rules. It is these kinds of statements that are often used by experts to explain how they do their job (Barr and Feigenbaum, 1981).

We do not want to suggest that rule-based systems or expert systems are a panacea for complex problems in general or negotiation in particular. On the contrary, there is a number of limitations. Separation of knowledge and control makes it hard to follow the flow of control in problem solving. Although antecedant-consequent or situation-action knowledge can be expressed naturally in production systems, algorithmic and procedural knowledge is not expressed naturally.

A related problem is that criteria for ordering of a rule or its part within a rule are only implicit in the rule set, but they may have critical importance on the system behavior. Consider the example we gave in Section 3.3. The order of rules is such that the first question the system poses is about the user's profession. The system, however, may begin

with a question about communication, which for some users is not relevant or even may not be understood. The order in which the rules are written, and within the rules their parts, have great impact on the final outcome (Jackson, 1990).

Human experts have background and common-sense knowledge which stops them from asking obviously wrong questions. The knowledge of expert systems is narrow and, therefore, it is heavily dependent on the control structures. But control structures are opaque to the users.

4.2. Benefits

Production systems can provide several benefits to users. They can work faster than humans, access knowledge of many experts, and use knowledge of those who cannot be consulted at the given time. Production systems can increase quality of analysis, evaluation, prediction or classification by providing consistent advice and reducing error rate. While they may not compete with highly qualified experts, their advice is often better than the advice of novices. The advice is always available; that is the knowledge can be accessed at any time and under any circumstances, which is rare in case of human experts.

Important benefits include reliability and the ability to capture scarce expertise. These systems do not have human fragility, and sometimes they are developed because an expertise may be lost, for example, due to retirement of the expert. They are reliable because they consider all input information. They are consistent and take into account all possible solutions (within given controls). Also, they can be used many times to reason and explain the reasoning without getting bored, tired or upset. In this respect they can increase users' understanding through explanation.

An important benefit is related not to the use of a system but to the development of a knowledge base, testing and experimentation. The uniform structure, very limited number of distinct operators and connectives, and simple inference mechanisms force experts or knowledge engineers to develop simple representations. During the develop-

ment process the domain knowledge is being revised, analyzed and evaluated. The strict representation also forces a particular viewpoint which may discover inconsistencies or loopholes. This benefit becomes especially apparent when a rule-based system is coupled with a decision support system.

The practical importance for negotiation support is the ability to develop representations of negotiation situations, opponents (their needs, requirements and goals), and of environment. The complexity, scope and detailness of the representation depends on the needs. It is possible to develop a specific system describing one unique negotiation problem (e.g., U.S.A.–Canada trade negotiation). The rule-based approach makes it possible to attempt to integrate different viewpoints, search for inconsistencies, and verify if the assumptions are feasible and the goals are achievable. The support then may provide negotiators with possible scenarios and their consequences, with the analysis of the impact of the proposal of one side on the situation of the other side, and with simulation of the negotiation process.

The use of knowledge-based systems to unique problems is presently justified only when these problems are very complex, require substantial effort and are prolonged in time. Typically, knowledge-based systems are developed for repetitive problems which involve different decision makers at different times. These decision makers may need access to basic domain knowledge and to descriptions of past cases. They may use a knowledge-based system to enter information about the problem at hand. The system then may use the domain knowledge to analyze the problem, provide some basic recommendations and retrieve similar cases.

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STEPHEN J. ANDRIOLE

INFORMATION MANAGEMENT SUPPORT FOR INTERNATIONAL NEGOTIATIONS

ABSTRACT. This paper examines the information processing requirements that surround the international negotiations process. General problem-solving models and generic task taxonomies are explored to provide insight into this process, a process that can be characterized as iterative options analysis. The paper also identifies a set of existing and emerging information technologies that can support the negotiation process, technologies that range from electronic mail to group decision support systems. The premise of the paper is that cost-effective information technology can support many important negotiation tasks and that existing technology has been vastly under-exploited by negotiators and their staffs. A program for introducing and evaluating information technology is also proposed.

Keywords: Negotiations, problem-solving models, task taxonomies, information technology, information systems.

1. INTRODUCTION

This paper examines the extent to which state-of-the-art and emerging information technology can satisfy the information management and analytical requirements that surround the international negotiations process. It examines these requirements in some detail and then matches available and emerging information technology-based systems, tools and methods to these requirements. The working premise of the analysis is that international negotiations can be supported productively by systems that permit the sharing of information, instant local and remote communications, the organization of small and large data bases, and even group problem structuring and problem solving, among other activities and processes. This paper identifies the extent of this support and proposes an agenda for its application.

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2. NEGOTIATION REQUIREMENTS

The negotiation process, regardless of whether it involves two individuals or several nations, requires information, organization, analysis, and management. At the heart of the process is the data, information and knowledge that helps negotiators assess situations, generate and evaluate options, and implement decisions. In fact, an argument can be made that information is the essence of the negotiation process, since it is the basis for understanding, action and reaction.

In order to systematically understand the negotiation process, it is helpful to first assess existing models of the problem-solving and decision-making process and then distill elements of these models into a model of the negotiation process. Such a model will then permit the matching of information technology and systems support to specific requirements. One of the earliest models of the decision-making process belongs to Lasswell (1956), who identified the following seven steps:

1. Intelligence	Information, prediction, planning
2. Recommendation	Promotion of alternatives
3. Prescription	The enactment of general problem-solving rules
4. Invocation	Provisional characterization of conduct according to prescriptions
5. Application	The final characterization of conduct according to prescriptions
6. Appraisal	The assessment of the success and failure
7. Termination	The ending of prescriptions

Anderson (1976) suggests a slightly different process model:

1. Problem formation	What is the problem? How does it get on the agenda?
2. Formulation	How are alternatives developed?
3. Adoption	How is an option adapted?
4. Implementation	What is done to carry a decision into effect?
5. Evaluation	How is effectiveness measured?

A somewhat different view of the process belongs to Wohl (1976), whose stimulus–hypothesis–options–response – or SHOR – process

model has attracted a lot of attention particularly from those who see the problem-solving process as iterative and adversarial. Wohl's SHOR model appears in Figure 1. These process models and taxonomies

Generic Elements	Functions Required
Stimulus (Data) S	Gather/Detect
	Filter/Correlate
	Aggregate/Display
	Store/Recall
Hypothesis (Perception Alternatives) H	Create
	Evaluate
	Select
Option (Response Alternatives) O	Create
	Evaluate
	Select
Response (Action) R	Plan
	Organize
	Execute

Fig. 1. Wohl's stimulus–hypothesis–option–response (SHOR) model.

provide insight into the problem-solving, decision-making and negotiation process, especially to the extent that negotiations share many of the steps and tasks of the above models. In fact, with the help of these models it is possible to construct a top level requirements specification for negotiation processes, a specification that, in turn, permits a matching of current and emerging information technology.

3. A PROCESS-TASK MODEL OF THE INTERNATIONAL NEGOTIATION PROCESS

The above models suggest the steps that negotiators and their staffs execute as they navigate troubled negotiation waters and the tasks they must perform in order to do so successfully. The model which follows thus represents a synthesis of several process models and several generic task taxonomies. The process/task model also represents a high level requirements specification necessary to determine the form and substance of support. While the emphasis here is on information management support, the process/task model is readily adaptable to analytical support requirements specification as well:

Process Steps	*Tasks*
• Problem/Opportunity Definition	• Define the current negotiation context and problem • Identify the range of acceptable negotiation outcomes • Identify range of negotiation constraints • Conference and communicate definitions, constraints and outcomes • Local and distributed meetings
• Option Generation	• Friendly option generation • Opponent (hypothetical) option generation • Categorize options • Conference and communicate options

	• Local and distributed meetings
• Options Analysis	• Friendly-opponent gaming • Forecast actions and reactions • Calculate options costs and benefits • Rank-order options • Communicate options • Local and distributed meetings
• Option Proposal Development	• Option refinement • Option packaging • Option communication • Local and distributed meetings
• Implementation	• Option communication • Option presentation • Local and distributed meetings
• Feedback/Assessment	• Friendly Impact Assessment • Opponent Impact Assessment • Local and distributed meetings
• Option (Re-) Generation	• Friendly option (re-) generation • Opponent (hypothetical) option (re-) generation • (Re-) categorize options • (Re-) conference and communicate options • Local and distributed meetings
• Option (Re-) Analysis	• Friendly/opponent (re-) gaming • (Re-) forecast actions and reactions

- (Re-) calculate options cost and benefits
- (Re-) rank-order options
- (Re-) communicate options
- Local and distributed meetings

- *N*th Option Proposal Development ...
- *N*th Implementation ...
- *N*th Feedback Assessment ...
- *N*th Option (Re-)Analysis ...

This synthesized model suggests a process and – more essential to the purpose here – a set of tasks that negotiators and their staffs must perform to achieve desired outcomes. These tasks permit a matching of information management tools, techniques and systems (from the range of options described below).

4. INFORMATION MANAGEMENT TOOLS, TECHNIQUES, AND SYSTEMS

There are many methods, tools, and techniques available to support the negotiation process. We are here interested primarily in information management, while recognizing that other qualitative and quantitative methods certainly have major roles to play in the negotiation process.

The kinds of tools, techniques, and systems that can be defined as data base management approaches include simple arrays of data in tabular and graphic form, systems capable of supporting analytical and realtime queries, data bases capable of directing searches of complex queries, and systems capable of organizing data, information *and* knowledge.

The systems should also be capable of supporting various kinds of analyses of the contents of data/information/knowledge bases. Low level expert systems can help organize the data management systems as well as help with fast searches through them (see also Samarasan in this issue).

Natural language processing systems – systems that permit freeform

English interaction – will enhance negotiation support efficiency and contribute to a wider distribution of support systems of all kinds. This is especially important in negotiations since we cannot expect negotiators or their staffs to always be proficient with applications programs. In fact, natural language interface and query systems will permit inexperienced users to perform all sorts of analyses.

Expert systems will also routinize many decision-making processes. It will be possible to teach systems about past and similar 'cases' and recall the cases during negotiations. Staffs unfamiliar with past negotiations will thus be able to retrieve information pertinent to the problems at hand. 'Case-based reasoning' will support international negotiations in a variety of ways, just as 'low-level' expert systems – systems that perform simple deductive tasks – could proliferate negotiation analyses. It is also possible to develop knowledge bases comprised of data, information and knowledge about specific countries, country-by-country problems and issues, and national interests. The kinds of problems that will benefit the most from knowledge-based solutions and systems are well-bounded, deductive inference problems about which a great deal of accessible and articulate qualitative and quantitative problem-solving expertise exists.

International negotiations occur in a virtual reality, simultaneously in host countries and in allied and unfriendly capitals; negotiations occur around the globe, around the clock. When Russia negotiates with the United States about arms control, many other nations directly and indirectly participate in the process. The ability to communicate is critical to successful negotiations. Communications technology is capable of supporting local and remote communications and processing. It is possible via satellite communications to link negotiators and their staffs with each other as well as with analytical computer programs that permit them to share data, models, and scenarios.

Local and remote full-motion video teleconferencing is also now possible – and will become more affordable in the immediate future. It is possible for negotiators in different parts of the world to communicate instantly and visually, to share ideas and concerns about issues and problems.

International communications networks permit realtime large scale networking of data, information, knowledge and people. This, in turn,

will help to short-circuit problems and accelerate progress. The systems embedded in such networks can help negotiators and their staffs develop, propose and teleconference alternatives.

Twenty years ago no one paid much attention to user interface technology. Since the revolution in microcomputing – and the emerging one in workstation-based computing – software designers have had to devote more attention to the process by which data, information and knowledge are exchanged between systems and operators. There are now millions of users who have absolutely no sense of how a computer actually works, but rely upon its capabilities for their very professional survival. A community of software vendors is sensitive to both the size of this market and its relatively new need for unambiguous, self-paced, flexible computing. The 'desktop' metaphor, icon-based navigational aids, direct manipulation interfaces, and user guided/controlled interactive graphics – among other innovations – are all part of this movement.

Where did all these ideas come from? The field of cognitive science and now 'cognitive engineering' is now – justifiably – taking credit for the progress in user-computer interaction (UCI) technology, since its proponents were the (only) ones asking why the UCI process could not be modeled after some validated cognitive information processing processes. UCI models were built and tested, and concepts like 'spatial database management' (from MIT's Architecture Machine Group: Bolt, 1984), hierarchical data storage, and hypertext were developed. It is no accident that much UCI progress can be traced to findings in behavioral psychology and cognitive science; it is indeed amazing that the cross-fertilization took so long.

The most recent progress in UCI technology is multimedia, or the ability to store, display, manipulate and integrate sound, graphics, video and good old fashioned alphanumeric data (Ragland, 1989; Ambron and Hooper, 1988; Aiken, 1989). It is now possible to display photographic, textual, numerical, and video data on the same screen, as Figure 2 – from Aiken (1989) – suggests. It is possible to permit users to select (and deselect) different displays of the same data. It is possible to animate and simulate in realtime – and cost-effectively. Many of these capabilities were just too expensive a decade ago and much too computationally intensive for the hardware architectures of

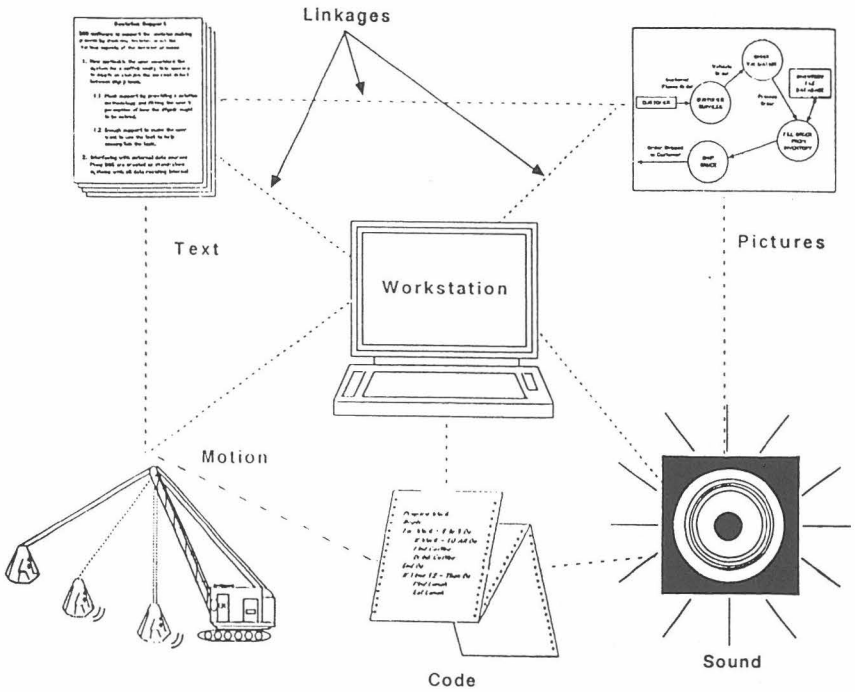

Fig. 2. Analytical methods to support international negotiations.

the 1970s and early 1980s. Progress has been made in the design and execution of applications software and in the use of storage devices (such as videodisks and compact disks [CDs]). Apple Computer's Hypercard software actually provides drivers for CD players through a common UCI (the now famous 'stack'). Designers can exploit this progress to fashion systems that are consistent with the way future systems are designed and used. The gap between the way humans 'see' and structure problems will be narrowed considerably via the application of multimedia technology.

The use of graphical displays of all kinds will dominate future UCI applications. Growing evidence in visual cognition research (Pinker, 1985) suggests how powerful the visual mind is. It is interesting that many problem-solvers – professionals who might otherwise use a support system – are trained graphically, not alphanumerically. Military planners receive map-based training; corporate strategists use

graphical trend data to extrapolate and devise graphic scenarios; and a variety of educators have taken to using case studies laden with pictures, icons, and graphics of all kinds. Complicated concepts are often easily communicated graphically, and it is possible to convert complex problems from alphanumeric to graphic form. There is no question that future support systems will exploit hypermedia, multimedia, and interactive graphics of all kinds.

Speech input and output should also emerge over the next five to ten years as a viable UCI technology. While predictions about the arrival of 'voice activated text processors' have been optimistic to date, progress toward even continuous speech input and output should be steady. Once the technology is perfected there are a number of special purpose applications that will benefit greatly from interaction using neither keyboard nor mouse.

UCI technology will also permit the use of more methods and models, especially those driven by complex – yet often inexplicable – analytical procedures. For example, the concept of optimization as manifest in a simplex program is difficult to communicate to the typical user. Advanced UCI technology can be used to illustrate the optimization calculus graphically and permit users to understand the relationships among variables in an optimization equation (see Wierzbicki, Krus, and Makowski in this issue). Similarly, probabilistic forecasting methods and models anchored in Bayes' Theorem of conditional probabilities, while computationally quite simple, are conceptually convoluted to the average analyst. Log-probability and other graphic charts can be used to illustrate how new evidence impacts prior probabilities. In fact, a creative cognitive engineer might use any number of impact metaphors (like thermometers and graphical weights) to present the impact of new evidence on the likelihood of events.

Finally, advanced UCI technology will also permit the range of negotiations support to expand. Anytime communications bandwidth between systems and users is increased, the range of applied opportunities grows. UCI technology permits designers to attempt more complex system designs due to the natural transparency of complexity that good UCI design fosters.

5. REQUIREMENTS/TOOLS/SYSTEMS MATCHING

All of this suggests it is possible to match information technology and systems to negotiation phases and tasks. Table I attempts to match a set of systems, tools, methods and techniques to the phases and tasks that comprise the international negotiation process.

TABLE I

Process Steps	Tasks	Tools and Systems
Problem/Opportunity Definition	Define the current negotiation context and problem	Hierarchical decomposition tools
	Identify the range of acceptable negotiation outcomes	Text/graphic retrieval systems
	Identify range of negotiations constraints	Hypermedia and multimedia data base systems
	Conference and communicate definitions, constraints and outcomes	Interactive maps
	Local and distributed meetings	Electronic mail
		Full-motion color video teleconferencing
		Case-based deductive reasoning tools
		Natural language interfaces
Option Generation	Friendly option generation	Case-based deductive reasoning tools
	Opponent (hypothetical) option generation	Opponent data bases
	Categorize options	Data base management tools
	Conference and communicate options	Electronic mail
	Local and distributed meetings	Group decision support systems
		Hypertext/multimedia systems
		Full-motion color video teleconferencing
		Geographic information systems
		Natural language interfaces
Options Analysis	Friendly/opponent gaming	Case-based inductive and deductive reasoning systems
	Forecast actions and reactions	Simple extrapolation models
	Calculate options costs and benefits	Tradeoff analysis templates
	Rank-order options	Criteria lists
	Communicate options	Decision logic tables
	Local and distributed meetings	Electronic mail
		Group decision support systems
		Hypertext/multimedia systems
		Geographic information systems
		Full motion color video teleconferencing
		Natural language interfaces
		Animated presentation tools

TABLE I (cont.)

Process Steps	Tasks	Tools and Systems
Option Proposal Development	Option refinement Option packaging Option communication Local and distributed meetings	Criteria lists Desktop publishing systems Electronic mail Large screen color display systems Full-motion color video teleconferencing Natural language interfaces
Feedback/Assessment	Friendly Impact Assessment Opponent Impact Assessment Local and distributed meetings	Impact matrices Decision logic tables Electronic mail Full-motion color video teleconferencing Natural language interfaces
Option (Re-) Generation	Friendly option (re-) generation Opponent (hypothetical) option (re-) generation (Re-) categorize options (Re-) conference and communicate options Local and distributed meetings	(Same as for Option Generation)
Options (Re-) Analysis	Friendly/Opponent (re-) gaming (Re-) forecast actions and reactions (Re-) calculate options costs and benefits (Re-) rank-order options (Re-) communicate options Local and distributed meetings	(Same as for Options Analysis)
*N*th Option Proposal Development	...	(Same as for Proposal Development)
*N*th Implementation	...	(Same as for Implementation)
*N*th Feedback Assessment	...	(Same as for Feedback Assessment)
*N*th Option (Re-) Analysis	...	...

6. USAGE PROFILE

The above tools, techniques and systems are intended to support the negotiation process. They are also intended to be placed into the hands of negotiators and their staffs. The nature of the tools and systems is straightforward; little or no training is necessary to operate natural language front-ends to simple data base systems, for example; nor should it be necessary for sophisticated analysts to stand between negotiators and the somewhat less technical members of their staff.

7. THE SHORT-TERM AGENDA

There are any number of ways to determine the effectiveness of the above ideas. In effect, all of the information technology-based methods, tools and systems represent hypotheses about effectiveness. In order to determine the contribution that the tools and systems might make to the negotiation process, it is necessary to develop some measures of effectiveness and baseline performance data (for today's unaided negotiation teams). Evaluation questions should be raised early in the design process; in fact, they should guide the selection of tools and systems to initially install.

The emphasis here is on information technology and how it might enhance the international negotiations process. Identified above are candidate tools and systems that range from the very simple to the relatively complex. In order to determine the contribution that information technology might make to the international negotiation process a series of small steps should be taken. They include the introduction of the most basic, easy-to-use tools and systems now available. Such tools and systems would include electronic mail systems, teleconferencing systems, simple data base systems with natural language front-ends, and templates for organizing information, criteria, and options. More complex tools and systems, such as low-level deductive inferential expert data base systems and interactive executive information and group decision support systems, should be phased into application only after assessments about the impact of the simpler tools and system have been made.

In order to test the tools and systems, scenarios should be developed to support laboratory testing; in order to raise the fidelity of the evaluation perhaps an actual negotiation could be supported with a limited toolset to determine qualitative and quantitative impact (vis-a-vis an explicit set of measures of effectiveness).

8. LONGER-TERM RECOMMENDATIONS

Longer-term recommendations include the introduction of increasingly sophisticated data, information and knowledge processing tools and systems in a way that would permit incremental impact assessments. It

should also be possible to integrate the information handling tools and systems with systems that incarnate analytical methods – such as game theory, linear programming, and decision analysis, among many others. Eventually, whole systems could be evaluated to determine the overall effectiveness of negotiations supported by tools and systems that range all the way from electronic mail to automated expert option generators.

But perhaps more important is the perspective that needs to direct a long-term plan. Currently there are only pockets of technology supporting the negotiation process. The call here is for a systematic plan to introduce increasingly sophisticated tools and systems to – ideally – an enthusiastic community. In order to stimulate enthusiasm – and create a positive perspective on the applicability of the tools and systems – early successes will be necessary.

9. SUMMARY AND CONCLUSIONS

This paper argues that it is possible to decompose the negotiation process into a series of phases and tasks and then match a set of information technology-based tools and systems. The matches themselves actually constitute a set of hypotheses about performance impact: the paper argues that we have underexploited current and emerging information technology in the negotiation process and that significant performance enhancements are possible through the careful application of the technology. It is essential that measures of effectiveness be developed so that baseline performance data can be collected and then compared with data collected after the introduction of selected tools and systems.

Motivation for the matching process and subsequent testing is grounded in assumptions about the value of the tools and because negotiation requirements are growing in number, frequency and complexity. Just as the military has invested heavily in information management tools, decision aids and decision support systems in response to changing requirements, so too should the negotiation community begin to assess the contribution that current and emerging information technology might make to the negotiation process.

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THE USE OF ANALYTICAL METHODS AND TOOLS IN INTERNATIONAL NEGOTIATIONS: A PRACTITIONER'S PERSPECTIVE

ABSTRACT. This paper presents a practitioner's perspective on the use of systematic analytical techniques to improve the practice of international negotiations, primarily in a multilateral context. A generic model of the negotiation process is presented and the utility of various analytical methodologies is evaluated against the component functions described by the model. Overall, analytical tools for negotiation support are viewed as most useful in the prenegotiation phase. Conclusions are based primarily on practical experience, not on theories of negotiation.

Keywords: Decision support systems, practitioner perspective, negotiation models.

Various analytical methods that might be useful in supporting international negotiations have been addressed in this issue. These descriptions may lead one to ask why such tools are not being employed by all delegates to international negotiations, letting the tools perform the tasks of negotiating. They would certainly find Pareto-optimal solutions.

But real life is not quite so simple. Let me offer an example. During the biggest negotiating effort of this century, the Third United Nations Conference on the Law of the Sea (UNCLOS III), the less developed countries (LDCs) laid claim to a very broad national continental shelf, which they considered their national wealth, and from which they expected substantial benefits. In his statement, the United States representative offered evidence showing that natural resources in the continental shelves were very unequally distributed. In his view, most LDCs would not find *any* resources in their continental shelf. They would profit most, according to his argument, from a formula that identifies very narrow national continental shelves *and* designation of a broad international area where *all* states would have access to available resources. This line of thinking, which seems to be the most reasonable, maximizing benefit for the most number of countries,

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encountered strong opposition from the LDCs which successfully defended the broad continental shelf doctrine. The United Nations Law of the Sea Convention now indicates that the continental shelf can extend up to 350 nautical miles from the coast. The result is well known. Only a few, mostly industrialized states, benefit from the new regime. There are numerous examples of this type of suboptimal outcome.

The actual outcome of international negotiations is very rarely an optimum or even a second-best solution. In this context, it may now be asked whether analytical methods and tools can possibly help to overcome these deficiencies.

1. THE PROCESS OF NEGOTIATION

Any evaluation of the use of systematic analytical methods requires a thorough examination of the negotiation process itself. Such an assessment can help in matching methods with practical requirements, satisfying the reasonable needs of the negotiation process.

Figure 1 illustrates, in a simplified manner, a negotiation process modeled on an actual case of Austrian diplomacy. This process resulted in an international multilateral convention elaborated under the auspices of a specialized agency of the United Nations.

The process was triggered by an event which convinced influential and competent officials that new standards were required to address a specific problem of international politics. A first draft text was drawn up by the Legal Division of the Ministry for foreign Affairs (MfA) after discussions with other departments (inter-departmental level). The draft was then discussed with other ministries which presented their own evaluations and interests and proposed modifications (inter-ministerial level). In the course of this process, a number of decisions had to be taken (D 1–D 4 in Figure 1; in practice these decisions are more numerous).

After the national decisions were made, international negotiations were begun. To create a first coalition, contacts were established with other states regarded as supportive for various reasons; these varied from a general friendly attitude (resulting from close economic, cultural, and historic links) to a positive attitude concerning the issue

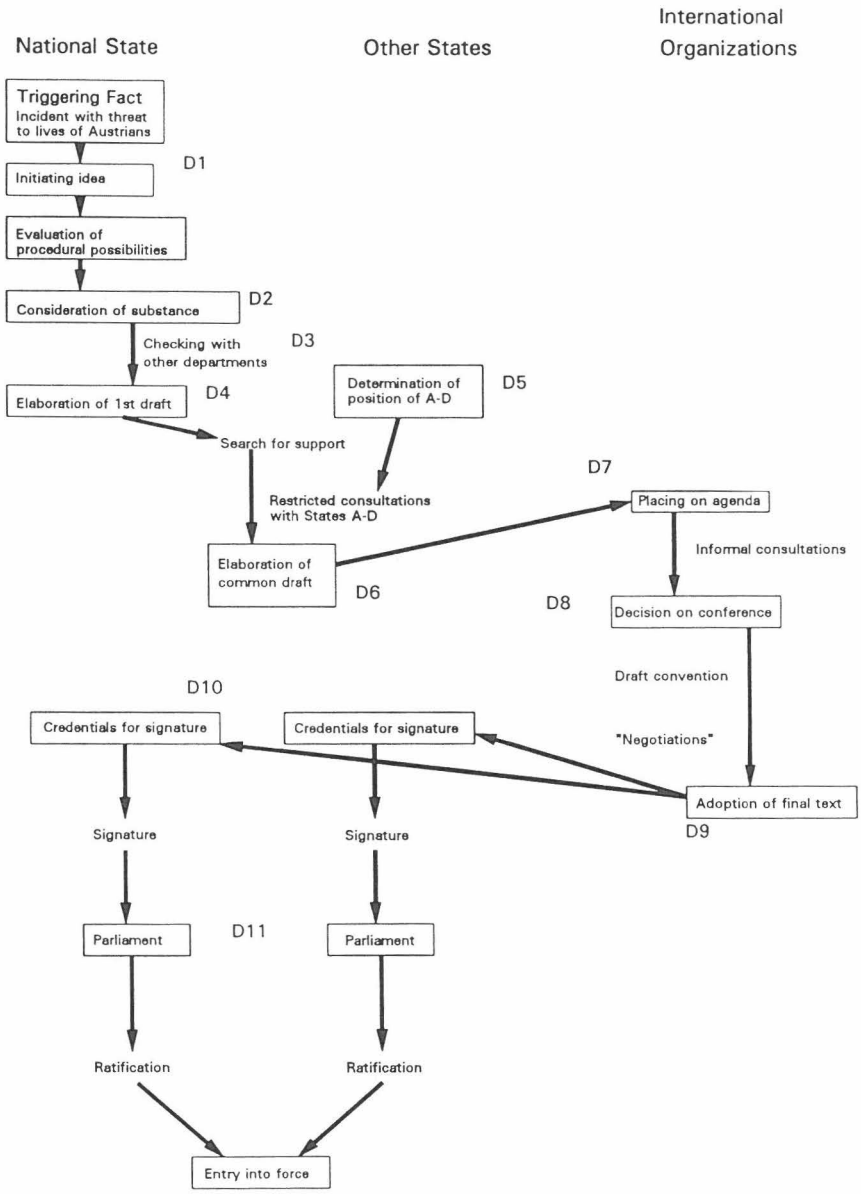

Fig. 1. Generic international negotiation process.

itself. These states each underwent a similar decision-making procedure as described above. In discussions with these coalition partners, a new draft was drawn up, accommodating the views of these states (D 5–D 6).

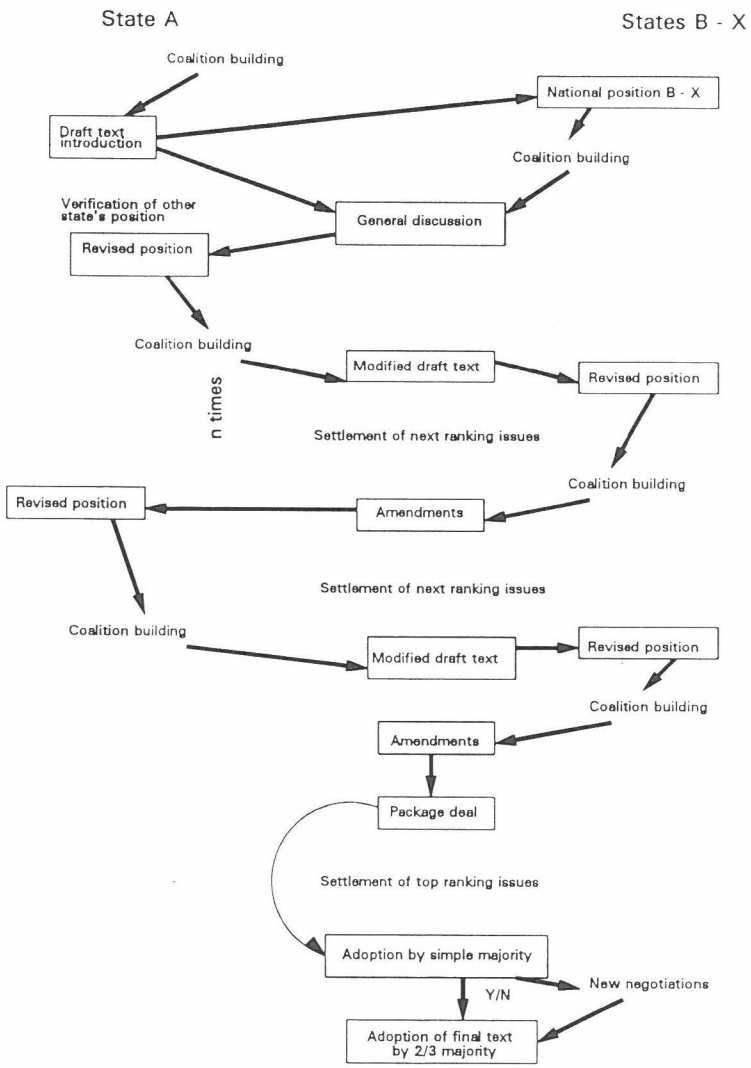

Fig. 2. The formulation process.

The next step involved placing the matter on the agenda of the competent international organization. This step required the consent of the other member states of the organization (D 7). After agreement on the site, time, privileges, and immunities of the conference had been achieved (D 8), the true negotiations started (see Figure 2). They ended with the adoption of the final, but non-binding text (D 9). For this, a further domestic decision-making process had to be activated which led to signature (D 10) and, after approval by the parliament, to ratification by the head of state (D 11). However, in this multilateral case, the treaty became effective only after a certain number of states had ratified it; in the case of bilateral treaties, the ratification of both parties is required.

Thus the entire negotiation process possesses – an extremely complex structure – consists of hundreds of decisions, and sometimes, lasts for several years. The most striking example of this is UNCLOS III. The initiative to discuss the Law of the Sea was taken in 1966 with the request for including the relevant item in the agenda; the end of the negotiations (carried out in the Preparatory Committee) is not yet in sight.

Two different phases of negotiations have been singled out in the literature: the prenegotiation and negotiation phase. As illustrated by Figure 1, it is also necessary to add the *post*-negotiation phase, since it is relevant to the legal effect of the outcome and is a necessary factor during the deliberations of the decision-makers (DM).

1.1. The Prenegotiation (Diagnostic) Phase

This phase begins with the triggering event or evidence which prompts the competent civil servant to realize the need for a new regulation which is deemed to benefit the existing situation, or at least, not to damage it. The set of decisions necessary for the formulation of the first national draft has to be preceded by a process of harmonization of the positions of other departments, an evaluation of the goals to be pursued in accordance with the supreme values esteemed by the state (e.g., respect of international law and democracy), and an assessment of feasibility in light of different alternatives. Feasibility also has to be decided with regard to the assumed reactions of other states and

historical precedents. Both factors are interlinked. The expected reaction of other states is derived from the history of past reactions and historical precedents, the geopolitical situation, economic activities, and comparable attitudes of like-minded countries.

Thus, during this phase, national interests concerning the case are established, the interests of the other states are forecasted, and, on this basis, the national decision is taken of how to proceed in the most effective and cost-avoiding manner. In the course of this process, the following issues have to be addressed: self-interests (in light of existing practice); the optimum outcome; domestic restraints; the outcome respecting these constraints; the interest and reaction of other states; the outcome adapted to these limits; the most appropriate procedure; and the most probable result, which could include various alternatives. The decision-making procedure incorporates various loops and iterative stages.

The evaluation carried out during this phase is mainly twofold. On the one hand, it deals with the assessment of options relating to the matter under discussion (option-analysis) and, on the other, it relates to the most appropriate procedure and strategy. For this purpose, most analytical methods can be applied – prescriptive tools, such as multi-attribute utility analysis, cost–benefit analysis, and multi-criteria optimization (see Wierzbicki *et al.* and Spector in this issue), as well as descriptive methods, such as cognitive mapping (see Bonham in this issue). These methods can facilitate the processing of information and can make them more accessible.

1.2. The Negotiation (Formulation) Phase

The negotiation phase is that part of the process during which the views of different states are expressed and then merged to form a common position, and the final text agreed upon. During this phase, national decisions and the assumptions upon which foreign decisions are based are tested and verified. During the verification process, national assessments have to be adapted continuously, depending on the position of each state, as illustrated in Figure 2.

In a continuous and iterative process, these negotiations, whether bilateral or multilateral, seek to itemize the issues and then rank them.

Items of lesser importance are usually negotiated first, as an agreement on them is often easier to achieve. In multilateral negotiations, these rounds of adaptation, consisting of concessions and adapted claims, are accompanied by a constant search for alliances in order to obtain a majority and to impress the other side with sheer numbers. The most sensitive issues are left for the so-called package deal, which contains a bundle of proposals with payoffs for the states still involved in the negotiations. Such packages are often developed by a delegation that enjoys a free vote and is therefore able to act as mediator. Finally, the procedure of adoption can consist of various stages; sometimes, a first vote is taken by simple majority in a committee and the final vote by two-thirds majority in the plenary.

During this phase, certain analytical methods and tools could facilitate the negotiation process: conflict analysis methods (Fraser, 1992) could be used to assess the significance of the conflict or of the intended result; and decision-tree analysis, multi-attribute utility analysis, and multiobjective optimization could assist in evaluating either the various options and preferences under discussion (Ulvila and Snider, 1980) or the strategy to be selected (situational diagnosis; see Druckman in this issue).

1.3. Post-Negotiation Phase

Very often, negotiations are not really terminated when a text has been agreed upon because the agreement can become effective only when it has gone through the domestic ratification procedure of each nation. The SALT II and the Vienna Convention on the Representation of States in their Relations to Universal International Organizations are examples of negotiations in which treaties have been adopted by the necessary majority, but have yet to enter into force because of obstacles encountered at the national level. Another striking case is the Law of the Sea Convention. The text was adopted in April 1982 and signed by more than 150 states in December 1982. Nevertheless, genuine negotiations are still going on in various organs, such as in the Preparatory Committee and in smaller groups, as a result of which the text may be amended.

This phase of negotiations does not exist when a text becomes

effective with the adoption of the agreement, as is the case with the Conference on Security and Cooperation in Europe (CSCE) documents or resolutions of the UN General Assembly. However, it may be argued that such documents are not effective in regulating or influencing state behavior as they lack a certain degree of legitimacy (see Samarsan in this issue).

2. SOME CHARACTERISTICS OF NEGOTIATIONS

Any attempt at finding the most appropriate analytical method to assist international negotiations has to take into account the specific features and needs of such negotiations.

- There are many kinds of negotiations. A major distinction has to be made between negotiations solving high-pressure conflict and involving high-level politics of a small number of states from the negotiations concerning the elaboration of a codification convention, for example. The structure underlying the first case comes close to a zero-sum scenario where the most decisive step toward a solution is establishing communication between the states involved and getting them to the negotiation table, rather than into the negotiation process itself. In this respect, analytical methods could be helpful only insofar as they could assist in working out proposals which might convince the relevant states that negotiation could provide a result which is preferable to the existing situation. Contrary to this, in the second case, the will of the states to negotiate, has already been established, as most participants are convinced that they would benefit from the negotiations.
- Another distinction can be made between small and large negotiations. A negotiation may be a bilateral event with only two decision makers, or a universal event, like a UN conference with 166 delegations.
- Negotiations also vary according to the kinds of states represented at the conference and the kinds of relations prevailing among them. Even the mood dominating the negotiations can be different as it can range from hostility to cordiality. A further distinction can be made between the different nature of the issues under discussion.

These could range between human rights, on the one hand, and disarmament, on the other, for example, both with totally different implementation procedures. The environment of negotiations or the conditions under which negotiations are held can also influence the progress of negotiations.

- As a delegate must be able to communicate with officials in his own state, the negotiations are usually conducted at a place where communication to outside capitals is ensured. Sometimes however, a place is sought where no communication is possible for the same reason – namely, to ensure fruitful discussions.
- An important factor of any negotiation is the time element. As a consequence of intolerably increased transaction costs, the length of a conference usually cannot be stretched. All decisions have to be taken within a given time. Hence, despite the so-called 24-hour rule, decisions are very often taken in great haste during negotiations so that no time is left to obtain the necessary information. A simple example of this point is when a delegate has to make a decision on which clause relating to reservations to a multilateral treaty is to be supported. This decision usually influences the number of possible parties to the treaty. The three options are no clause (ensuring the application of the regime as provided in the Vienna Convention on the Law of Treaties, 1969 or customary international law), a clause specifying the treaty provisions to which reservations may relate, and a clause excluding reservations. In evaluating these options, several factors and aspects have to be evaluated. As this matter is usually taken up toward the end of a conference, the time element is a crucial factor and frequently outweighs all others. Analytical methods aimed at finding an optimum agreement are, in this respect, of little value unless they are used by mediators selecting from various alternatives.
- Very often, a delegation is unable to participate in decision making due to its small size; this happens when several committees meet simultaneously.
- Negotiations are frequently characterized by their openness. The subjects of the negotiations are not necessarily confined to the conference, so that new trade-offs or payments can be made during negotiations, even outside the terms of reference of a conference.

- Most negotiations are marked by competitive instead of cooperative strategies and are mostly based on a zero sum approach. What is deemed a gain by one side, is considered a loss by the other. One reason for this attitude may be the personal character of the actors: in order to enhance their career at home they try hard to derive the maximum benefit for their states.
- Negotiations are pluridimensional. The decision maker often bases his decision on interests pertaining to different levels. Considerations at a community level are merged with those of state interests and the personal intentions of the delegate.

3. POSSIBLE BENEFITS OF ANALYTICAL METHODOLOGIES

Taking into account the characteristics which govern international negotiations and the possible analytical methods, the following conclusions concerning potential benefits can be drawn:

(a) Some methods are able to rationalize the negotiating position at the outset by indicating the potential for cooperation and the potential for conflict. The method used, for instance, by Anderson (1991) to determine this potential in the case of the Euphrates and Tigris conflict rather convincingly establishes that the actual power distribution in that region would be very conducive to fruitful negotiations at the moment. Other methods could help in selecting the best solutions to an existing problem – subject, however, to reliance on historical precedents and experiences. Examples include decision-tree analysis or multi-attribute utility analysis. Statistical methods are needed for evaluating one's own and the other's positions. Cognitive maps could clarify the various interrelationships among positions as well. Any accurate perception of a delegate's position requires a thorough cost-benefit analysis, including transaction costs. In practice, such an analysis is regularly performed, albeit in a relatively basic manner.

(b) As already shown, any decision relating to negotiation positions requires an assessment of probable reactions from other participants. A prerequisite for this assessment is an evaluation of the foreign state's position concerning the issue at stake. Methods

which are able to derive the interests of a foreign state from certain factors, such as past behavior and geographical factors, are extremely helpful. These methods include foreign policy analysis in the sense described by Sprout and Sprout (1965). Statistical methods for comparing various states' indices related to their interests would also be of help.

(c) During the negotiation process a continuous review of the optimum alternatives, by means of multi-attribute utility analysis, could be helpful in finding the best negotiating position and in classifying the various proposals. This type of analysis could also be of use to those serving in a mediating role.

(d) The only method which truly takes into account the personal factor in negotiation and which is widely used in combination with other methods is simulation. Human nature often eludes the mathematical yardstick. Only in simulations are attempts made to anticipate the attitudes of participants in negotiations, relying on the perception of various actors and including historical precedents.

(e) Multilateral negotiations require coalition-building. Insofar as coalitions are not predetermined but freely formed during the conference, it is important to anticipate their formation in order to find the best negotiating position. Various methods aimed at ascertaining the positions of other states could be used for this purpose.

(f) The amount of time available to carry out analyses during negotiations is uncertain. Thus, it is more practicable to conduct these analyses during the *prenegotiation* phase than during the actual negotiations.

4. LIMITS AND INADEQUACIES OF ANALYTICAL METHODS

The analytical methods described in this issue are not free of drawbacks. These can be summarized as follows:

• These methods and tools are likely to increase the inequalities among the states simply because they require human resources, money, and time. Only a few states can expend such extra resources. A delegation would need personnel who are used to handling such methods. Even in a situation where a delegation wants to convince

another of the 'correct' result based on computerized analysis, the latter delegation must have confidence in such a method.

- Even if analytical research has been carried out before the negotiations, decisions have to be taken so hastily during the negotiations that appropriate reflection of the results of these methods can hardly be made. Moreover, positions of states in the course of negotiations are relatively immovable, as the delegates follow their instructions.
- Many analytical methods proceed from the assumption that other states' attitudes are based on the REMM theorem (resourceful, evaluating, maximizing man). Experience has shown that this is not always the case or, at least, that there are different views on what a REMM attitude could be. On the other hand, it is extremely difficult for an outsider to define the real position of a particular state; sometimes, for instance, a state may attach more value to group solidarity than to some other more concrete interests. In this respect, the findings of Jervis (1976) on perception and misperception in international relations deserves attention.
- No negotiation process can exclude the possibility of a delegation resorting to irrational behavior. An example of a miscalculation or misperception in this respect is the view of the International Court of Justice enunciated in the North Sea Continental Shelf cases – that landlocked states are not interested in the law of the sea. At UNCLOS III, the group of landlocked and geographically disadvantages states proved the contrary. Further, it is often hard to assess whether a state which shows firm resistance to a certain proposal would not, at the last minute, make a concession to avoid failure of the negotiations.
- A problem exists in the selection of criterion factors for decision models. For instance, the criteria regarded as important for defining negotiation interests by Ulvila and Snider (1980) are certainly representative, but not exhaustive. Decision analysts frequently derive their criteria from statements delivered by the relevant countries. For this reason, general statements are usually examined because they are first on the agenda. However, it is not certain that such general statements reveal the true interests of a country; on the contrary, they are frequently used to disguise genuine interests.
- A major limit to the use of analytical methods is the need to code

the available information and to attach specific values to the various factors and alternatives in terms of criterion weights. It seems rather doubtful that a delegation would be able to indicate precisely the weight it attaches to different issues or even the preferences accorded to them. Nevertheless, many analytical methods, depend on such codes. Druckman and Hopmann (1991) quite rightly point to the time factor connected with performing such coding: a transcript of a three-hour negotiation requires another three hours to assign codes.

- An additional problem might be caused by the relative nature of national interests. A state may have interests of a given value in relation to one country, but interests of a different value in relation to another country. Which interests eventually will prevail are hard to forecast.
- Finally, existing analytical models are relatively simple. They address negotiations with only a few variables and very technical implications. For example, the identification of national interests in negotiations are often simply and unambiguously portrayed. In practice, however, such simple situations rarely exist; usually, the problems posed during negotiations have complex ramifications. Likewise, the complexity of coalitions, as well as their identification with specific interests, sometimes escapes complete analysis in these models, in particular, where the interests are extremely diversified.

5. CONCLUSIONS

Finally, the questions raised in the Introduction to this issue call for a response.

What type of support can analytical methods and tools provide that would be useful for negotiators? The diagnostic phase of negotiation has to be distinguished from the formulation phase. Most analytical methods are useful in the diagnostic phase (see Spector in this issue); their support is mainly threefold:

(i) These methods are able to assist the decision maker in identifying his state's interests.
(ii) They can help in finding preferable solutions among alternatives in the process of decision making.

(iii) They can help in assessing the position and possible reaction of other states and, by that, to facilitate coalition building.

It seems that little has been done to develop methods that help identify new alternatives; most methods proceed from existing alternatives.

How should these tools be presented and packaged to facilitate their utility? These tools must be presented and packaged so that diplomats who do not have access to a staff of technicians can use them, in addition to methodological analysts. If they are not, inequalities among states would only be emphasized. Overall, the methods of evaluation and coding must become more transparent and less time-consuming.

Who is likely to use such tools? The user will vary depending on the negotiation phase. During the prenegotiation phase, staff experts are most likely to use these tools in the domestic decision-making process. In the negotiation phase, the persons on national delegations are likely to use such tools. The average size of a delegation to international conferences is not more than two persons, sometimes consisting only of one. Therefore, a certain simplicity in the method is indispensable.

How can system designers provide support on substantive issue development, as well as on the process of negotiation? Basically, there is a need for elaborating methods capable of generating new solutions to a given problem, not only for evaluating possible solutions which have already been developed. Such methods must certainly perform appropriate conflict analyses, as well as analysis of already existing solutions, to reveal their deficiencies and benefits. System designers should focus their efforts on the elaboration of simple and easily understandable evaluations of proposed alternatives and of the consequences for the entire negotiation process ensuing therefrom. A practical way of using the analytical results in negotiations are in seminars held for delegations during the negotiation process.

How can confidence and trust in such tools best be achieved? Confidence and trust in such tools can be developed over long periods of time by continuous exposure to them and by demonstration of reliable results.

In summary, analytical methods for negotiation support can serve a

useful function in the negotiation process, in particular during the prenegotiation phase. However, we must not overlook the fact that there are limits to such use under actual conditions. Therefore, it is necessary to continue the exchange of views and information among those who have practical experience and those who are able to work with and improve the analytical methods, keeping in mind the overall objective of better solutions to international conflicts which meet the requirements of justice and fairness.

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DECISION SUPPORT AND NEGOTIATION RESEARCH: A RESEARCHER'S PERSPECTIVE

ABSTRACT. The intellectual interchange between methodologists interested in supporting negotiation practice and negotiation researchers who have been developing conceptual frameworks of the process and outcome must be enlivened. Taking the perspective of a researcher concerned with understanding and explaining the process of negotiation, the author highlights several key theoretical concepts that DSS developers should consider in designing techniques for practitioners which will introduce dynamic and creative aspects and provide a firm theoretical underpinning for their DSS approaches.

Keywords: Negotiation analysis, integrative bargaining, analytical methodologies, power.

There are decision support systems and decision support systems, as a New Yorker would put it. Some of them can be very useful for developing a better and more informed conduct of negotiations. Others have a long way to go before they can meet negotiations. Although these methodologies talk much about negotiation, many of them are ill-tuned to the process. The nature of the analysis and its assumptions, both about itself and about negotiation, need much revision and updating before they can meet the reality of negotiation as it is portrayed in various analytical approaches. For the most part, the problem lies in the static nature of the situation as apprehended for analysis by decision support systems (DSS) and the assumption of fixed options that stifles the creativity necessary for effective negotiation. DSS writers, for the most part, are using old, mechanical models of negotiation that do not take into account much of the recent literature, particularly on integrative negotiation and negotiation analysis. To bridge the two methods of analysis, ways must be found to introduce dynamic open-ended aspects into DSS approaches.

There are some DSS approaches, however, which have begun to break out of their static assumptions and reach out creatively to the practice and analysis of the negotiation process. Decision analysis

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based on multi-attribute utilities (MAU), computer simulation modelling, statistical analysis, and cognitive mapping have already shown their usefulness to the diagnostic phase which precedes and accompanies the actual bargaining exchanges. MAU can indicate the highest payoffs available to a negotiator across issues and coalitions based on the negotiator's preference schedule, and computer modelling shows the outcomes based on multiparty issue coalitions. These two methodologies provide a sharp evaluation of outcomes so as to help negotiators produce optimal results.

Statistical analysis can be applied to anything quantifiable, and it is presented here to test hypotheses against results gained from experiments and from content analysis. There is no doubt that controlled experimentation has provided many insights into the negotiation process that have permitted a better understanding of the practice of negotiation in much messier circumstances (e.g., Rubin and Brown, 1975), and that empirical data from content analysis has shown effects – such as the phenomenon of crisis and turning point (Druckman, 1986) – in sharp clarity. Cognitive mapping portrays the way parties think about the encounter and issues by showing both values and causal chains. The methodology allows parties to understand their adversaries better and construct winning arguments and analyses.

These four methodologies provide a more explicit and precise evaluation of images, processes and outcomes than is otherwise available, and the input–output modelling removes some of the uncertainty that often has negotiators fighting over the the wrong thing. They also have been extended to serve as the basis for an analysis of the process itself, providing explanations for the outcomes and for the process by which they are achieved (Spector, 1993). Much of their explanation is based on 'as if' rationality, showing what would happen if the negotiators acted rationally, and then leaving it to ad hoc analysis to account for idiosyncratic deviations from that predicted baseline.

Other DSS methodologies are at such a basic level in the chain of theoretical development as to be far away from application to negotiation. Information management deals with classification of options, rule-based systems deal with logical linguistic structures, multi-objective optimization models assume a powerless process of discovery

rather than an interactive bargaining process, and game theory as presented here also deals with structures of choice in the absence of strategic interaction. The latter approach, of course, has been developed at the hands of many analysts to produce powerful insights into the manipulative process of negotiation, including the conceptualization and use of power, showing that even basic concepts can be carried to the point of analytical usefulness. On the other hand, rule-based systems and information management seem so broad-brush as not even to have arrived at the door of negotiation as yet.

Once diagnosis has been established, negotiation proceeds through a process of establishing the general framework of principles or formula for an agreement and then the application of these principles to the settlement of details. The most important aspect of this two-fold process is creativity – actually the breaking away from fixed options and values that make the conflict irresolvable and that underlie much of DSS analysis. Thus the mutation of these approaches to a useful form involves first relaxing the assumption of fixed positions and second introducing ways in which the methodologies can be used to foster creativity.

The other important aspect that removes the process from one of mere discovery is the Toughness or Negotiator's Dilemma (Zartman, 1983; Lax and Sebenius, 1986): the negotiator always has a range of choice between the one extreme of playing tough, thus increasing the chances of a favorable agreement but decreasing the chances of any agreement at all, and playing soft, thus increasing the chances of agreement by decreasing the chances of a favorable agreement. Thus, Wierzbicki, *et al.*'s assumption (see article in this issue) that negotiators are prepared to agree and prepared to accept a mediator's efforts to find an agreement define arbitration, not negotiation. The refinement of these approaches to allow for strategic interaction requires both a relaxation of the assumption of fixed optimality and also the introduction of ways in which the methodology can be used to enhance productive use of power. Some initial suggestions will be made.

Creativity or reframing, by definition, eludes the possibility of portrayal by any kind of preference schedule. Reframing means not simply finding optimal ways of putting together known preferences,

including the addition of new items not yet on the schedule, but the recasting of known and yet unknown items in such ways as to bring out new natures and, therefore, new preferences. This takes the process back to diagnosis, in preparation for better formulas, in order to review precedents, similarities, alternative definitions, underlying goals, components, and so on. There is a methodological Catch-22 in this process: the potential outcomes cannot be portrayed precisely until the qualitative searching process has identified them, but outcomes cannot be checked for optimization until they are portrayed precisely. Preference analysis can therefore serve as an imperfect but useful support for the diagnosis of alternatives, but only if it recognizes that the preliminary identification of optimizing perspectives lies outside of its capabilities.

Similarly, power can be used to try to force suboptimal agreements, but it can also be employed to expand thinking about optimality. Negotiation is a political encounter, with a number of implications that go beyond the capabilities of DSS. Negotiated outcomes must be fought over, so that the negotiators and the home audience see that a real effort was made. Negotiation is a surrogate for combat, and in the political psyches and processes of an entity – nation, organization, firm or person – satisfaction is as much a function of the process as of the outcome. Looking up an outcome on a preference schedule won't do. Issue items are not all part of a single negotiation front but belong to many of them. It is therefore often quite rational, for other than preference reasons, to exclude items from a bargain, just as it may be equally rational, in the search for optimal tradeoffs, to include those items. The use of pressure, influence, persuasion – in other words, power – to work out the size and composition of the front is a normal part of the process that schedules cannot portray. Once these elusive elements of the process are recognized, however, DSS can contribute useful assistance by presenting the new preferences and their combinations so as to assure optimality and facilitate process (Friedheim, 1993).

It can also expand its own horizons beyond the fixed-position assumption. One way would be to work on methodologies to deal with reframing and develop alternative optimal outcomes as a baseline for analysis. DSS methods have the advantage of being able to provide

sound portrayals of optimality, for use not only prescriptively but also analytically. Despite some of the above-mentioned problems, it is true that real-life negotiators often neglect the expansion of their negotiating front to include items that would enhance the value of the agreement for all parties. DSS methods can focus attention on this possibility, illustratively if not exhaustively. These methods can also establish several optima as a basis for analyzing the process and reasons why they were (or were not) attained. More can thereby be learned about the real process, for both conducting and correcting it. Recent work in other areas of negotiation analysis (e.g., Young, 1992) has pushed relevant research on negotiation beyond the limitations of its initial methodology.

Another needed methodological expansion would be to deal with power. Despite initial claims that power was outside its scope (Nash, 1950; Rapoport, 1964), game theory has moved to take advantage of the obvious elements of power hidden within its matrices (Brams, 1985, 1990; Axelrod, 1984). By using the threat position of diversely acceptable deadlock and by rerunning trials on the same or varied arrays of payoffs, it has gone beyond its original assumptions of determinate outcomes into manipulable outcomes. Matrical portrayals are also used as baselines or snapshots, leading analysis into the periods outside and between the matrices, to find out *how* they are changed. Other methodologies, too, can be modified to take strategic interaction into account (Young, 1975).

Experimental and content analyses have taken on the power question in many ways, although the latter – a time consuming and perhaps overly cumbersome methodology – can be used more frequently than it has in either its quantitative or qualitative forms to identify various effects associated with power. In the 1960s and 1970s, experimental analysis in social psychology focused on many aspects of power, particularly power asymmetry, but thereafter turned to other things (Rubin and Brown, 1975; Rubin and Zartman, forthcoming). Intervening variables need to be identified to compare the four ways of using power – threats, warnings, promises, predictions – as one example.

What could decision theory do with power? Decision theory combined with content analysis has been used to show the flow of

consensus building at the UN Conference on the Law of the Sea with great effect (Friedheim, 1993; also Sebenius, 1984), but with multiparty dynamics overriding the individual exercise of power. Power as an added value has been identified as a promising concept (Schelling, 1960; Zartman, 1974), but only with decision analysis can it be employed and tested. There is much material here for both historical and experimental analysis.

The dynamics of the negotiation process – multiparty or bilateral – are the most important subject of inquiry and explanation, whether they move by their own mechanisms or are directed by the power of individual parties. Game theory has provided much insight into that process and its assumptions have been modified along the way. Simulation modelling has a similar potential, beginning inductively as it is now presented and then being used deductively as theories are developed. The use of computer simulations as teaching devices (Antrim and Zartman, 1991) can also be extended to the generation of experimental data on process.

In conclusion, the challenge of usefulness still stands before DSS methodologies. Some are at a primitive level of abstraction with little promise of a greater grasp of reality. Others are able to continue a development that has already shown some practical insights and applications; game theory has made a major impact on negotiation analysis, and decision and content analysis have helped identify some important effects. In between lie a number of potentially useful support systems that purport to enhance creativity, but are locked in early and outmoded models of the negotiation process. These methodological approaches need to come to terms with such basic components of current negotiation analysis, such as variable values, integrative bargaining, problem-solving, multiple trade-offs, and others. They need to relate to questions that arise from the analysis of the process, informing research that is concept-driven rather than methodology-driven. Therein lies a serious potential for payoffs.

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