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Decision Situation Simulation: A Lab for Research on Decision Making and Decision Support

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INTRODUCTION

This paper presents the concept of a Decision Situation Simulator (DSIM) as a vehicle for research on decision making and decision support. The simulator has much in common with the use of management (policy) games to study decision making behavior and information system use (see, e.g., Guetskow, 1962; Steinbrunner, 1970; Hedberg, 1970). In both instances, the vehicles provide an analogue of management tasks in a controlled setting. A key distinguishing feature of the DSIM concept is that we aim to provide a degree of realism unmatched by earlier games and simulators.

We propose DSIM as an approach to research on understanding and improving managerial decision making effectiveness in ill-structured tasks. This research topic is difficult because it involves a fundamental contradiction: in order to study decision making and decision support in ill-structured tasks empirically, we must necessarily impose some degree of structure. The process of research thereby easily obscures what we want to study, and we too easily overgeneralize from constrained experiments. Conversely, if we use, say, case studies to capture the full complexity of a task, we lack controls, precision, and comparability.

The DSIM concept is basically an idea of both how and when to impose structure and still maintain the essential elements of ill-structured tasks. Our approach seeks to resolve the basic contradiction primarily by facing it explicitly throughout the process of developing and using the simulator. In particular, building (as opposed to using) the simulator is seen as an important research activity in itself.

To balance realism and control, we restrict the simulator to a relatively narrow class of decision situations. Doing so provides the basis for using experts from the work environment to be simulated as a means to bootstrap DSIM toward increasingly realistic versions.

Building a realistic simulator of, for example, "corporate bank loan decisions," will obviously require that we immerse ourselves in the unique characteristics of this particular class of decision situations. We think this is a useful strategy at this stage in research on decision making and decision support. There seems to be diminishing returns to pursuing general, domain-independent concepts and perspectives. Instead of continuing to search for theories and results that apply in the broadest possible set of situations, we feel that the time is ripe for a more detailed study of issues and concepts than at the outset we solely view as relevant to a more limited class of decision situations chosen because they are relevant to the applied but scholarly study of decision support. Such an idiographic approach may permit us to grapple more effectively with the interplay of the substantive and the procedural aspects of decision making (see Stabell, 1982).

Artificial Intelligence (AI) research provides a model in this respect. AI has attempted to identify general characteristics of problem solving (cf. Newell and Simon's General Problem Solver (1972)). However, most of the progress in AI has come from the detailed study of heuristics and representations in quite limited problem domains: chess (Newell, Simon, and Shaw), logic (Newell and Simon), children's blocks (Winograd), mass spectrograms (Buchanan, Sutherland, and Feigenbaum), diagnosis of bacterial infections (Davis, Buchanan, and Shortliffe). The AI experience also suggests that we should not expect easy results. Perseverance might be as important as great ideas for research on decision making and decision support.

Realistic simulation of ill-structured tasks requires that the simulator reproduce both formal and informal aspects of the decision situation and that it include a wide variety of media. DSIM is therefore not computer-based. Instead it attempts to simulate decision situations that include computerized aids and information systems as an alternative among a wide variety of decision aids and information sources available to the decision maker.

Obviously, our concept of a simulator is not "new." Aspects of it are quite similar to the work using "in-basket" tasks (Buchin), policy games, and computer-based simulations (see, e.g., McKenney, Guetzkow, Cohen, and Winters, Marcotte, Hedberg). The distinguishing features of the simulator, explained in the rest of this paper, are:

(1) the focus on a narrow class of situations through the simulation of a quite specific decision situation;

(2) the use of experts to bootstrap the simulator and evolve more realistic versions;

(3) the emphasis on testing our understanding of the decision process and context by testing the realism of the simulator;

(4) extensive use of non-reactive instrumentation as a means to map decision behavior.

DSIM is primarily an idea of how to research decision making and decision support. The thrust of this paper is therefore primarily methodological. The more substantive research issues to be investigated are only addressed indirectly: first as we assess earlier research in the second section as a means to motivate the simulator, and then as we present in more detail the simulator concept in the third section. We conclude in the final section with a brief review of some outstanding and unresolved issues for the DSIM-approach.

BACKGROUND

Two lines of research meet in the concept of the Decision Situation Simulator:

(1) the study of human decision processes in complex, ill-structured tasks (e.g., Mintzberg, Stewart, Greenberger, et al., George);

(2) the more applied research on how to improve the effectiveness of decision making in such contexts, through decision support and decision support systems (Keen and Scott Morton, 1978).

The simulator is a vehicle for basic research on decision making as a cognitive and organizational phenomenon and for applied research on decision support. It is meant to serve both re-

search orientations and provide a laboratory where they can meet.

This is a key point. We argue that there is a need for an approach where the two orientations meet. Decision support as a normatively oriented perspective on decision making requires its own kind of understanding of how decisions (in the descriptive sense) are made. There is a need for new research methods that explicitly seek to integrate the two underlying perspectives on decision making.

(1) After the last 25 years of research, what have we learned about decision making as a cognitive and organizational phenomenon?

(2) After 10 years of practical experience, what have we learned about building and using DSS?

Formulated in broader terms, what does research and practical experience tell us about both the need and the potential for improving decision making?

A review of existing research along the lines of these questions helps clarify some of the issues and problems that motivate DSIM. Although the arguments might apply more broadly, our discussion considers primarily research on individual decision making in an organizational context.

Let us start by noting that decision support issues have not been given much attention in basic behavioral research. We lack a well-articulated and empirically grounded theory (or theories) that covers such fundamental issues as the evolution of human decision making behavior, learning in ill-structured situations, and individual differences in decision making effectiveness. Understanding the interplay of cognition and external artifacts (such as a DSS or other decision aids) is an example of a more specialized concern for decision support. A

theoretical perspective on this interplay would seem to provide the basis for investigations of more applied issues such as, for example, how and when decision aids should either complement or supplement decision makers, on the importance of direct versus indirect use (e.g., via chauffeurs and intermediaries), and on the choice among formal and informal information sources (Stabell).

There are important issues. Many results from experimental research (e.g., on heuristics, biases, and simplifying procedures) might be expected to help shed some light on them. However, this research has relied on relatively mechanistic models of human choice behavior. Typically the decision maker, by design, has not been allowed to use even such simple and common aids as pencil and paper. The individuals studied are not given access to the reference material available in naturalistic decision situations. Unrealistic situations provide experimental control (and ease of implementation), but exclude proactive, creative behavior. Ward Edwards, at a recent conference on decision processes (Englander, et al., 1982), argued this point forcefully. Reviewing work over the past twenty years, Edwards suggested that the results that portray the human decision maker as a "cognitive cripple" do not reflect fundamental properties, but follow largely from the research approach taken (see also Ebbesen and Konecni (1980) for another recent statement of similar arguments).

Work in more realistic settings has largely been case-based. A good example is the seminal work on The Behavioral Theory of the Firm (Cyert and March, 1963). The research is generally not very cumulative. The more recent work by March provides a case in point: Although "Ambiguity and Choice in Organizations" (March and Olsen, 1976) references earlier work,

It is apparently difficult to state explicitly how it corroborates, extends, or modified the earlier theoretical and empirical positions.

When more cumulative, the research is often operating with a broad and relatively general conceptual scheme. It therefore cannot easily capture the interplay between substance and procedure that appears to be essential in any attempt to provide both meaningful descriptions and operational prescriptions for decision making.

It seems easier to study the building of a DSS than its use. The DSS is in itself a vehicle for case studies of decision situations. Such studies, which constitute the bulk of the empirical, field-based DSS research, provide realism without control. They focus on real decision makers and can address political, organizational, and managerial issues. However, they seldom tell us very much about the process of decision making, about how the DSS is actually used in the context of the manager's overall <u>decision</u> situation.

Part of the problem is that it is often difficult to perform even case research. Getting access to live decision situations, especially at senior levels of an organization, requires an inordinate amount of time, effort and sheer luck. Even when we get access we find that managers often cannot tell us much about HOW they make decisions. They are more comfortable and more used to talking about WHAT they decide. And we typically are unable to apply the necessary range of methods and instruments that might help both researcher and manager find out how decisions are made.

Consider the Mintzberg study of five managers (1973). This is perhaps one of the most detailed field studies of managerial work that has been published. However, the general findings of the study are to a large extent built into the measurement technique used to sample behavior: brevity, variety, and fragmentation is only a partial picture of managerial behavior, as Mintzberg's structured observation cannot "see" the cognitive and organizational processes that link activities over time (Stabell, 1982). A more complete and balanced picture obviously requires a more comprehensive conceptual framework. However, the key point here is that it also requires a broader methodological base. This is extremely costly, if not impossible to establish in a field setting.

Behavioral science research on the design, use and impact of interactive computer-based systems has largely been disappointing. The work on the importance of the format (e.g., tables versus graphs) and the output medium (e.g., printed versus video display units--VDUs) used to present data is quite representative. The findings are typically inconclusive. For example, in one series of experiments (Dickson, et al., 1977), results are reported that the use of VDU as medium is associated, in certain cases, with more rapid, and in other cases, with more rapid decision making. The implications that one can draw for design are at best commonsensical: "VDU output CAN lead to faster decisions"--i.e., it CAN also lead to slower decisions!

Again, the problem is to a large extent research without a suitable theory--at times, without any theory--of what are the key properties of the medium, what are the important attributes of the context (such as, e.g., phase of decision process). In an attempt to be relevant, the research operates with concrete artifacts (e.g., VDUs) as theoretical constructs. Thus empirical questions are often posed as if the only possible answers are either yes or no. There is therefore also seldom the motivation to secure

the instrumentation and methods that are necessary in order to investigate, for example, how the graph is used, what the user perceives how the information is interpreted.

Many of our engineering-oriented colleagues in management science and computer science take the understandable position that they will continue to ignore the behavioral science perspective until better theories and results become available. Given the amount of effort already spent, they may wait in vain. As we see it, part of the problem is that they are looking for the wrong kind of results: basic reserach will never provide general knowledge and rules akin to the design tables and charts commonly used by engineers in the design of, e.g., buildings. However, basic behavioral research can provide methods to help define effective systems in a specific decision situation; the link between basic and applied behavioral research is primarily method.

OVERVIEW OF THE SIMULATOR CONCEPT

The essential elements of our concept of a Decision Situation Simulator are (bound to):

-- the scope of the decision situation to be simulted;

-- how the simulator is to be built;

-- how the simulator is to be built;

-- how we anticipate using the simulator for research, training design and evalution.

These three elements are interdependent. Limited scope is key to the use of experts as a means to build a realistic simulator; feedback from and the study of expert users of early versions provide the basis for gradually

developing more realistic versions of the simulator. The process of defining, building, and establishing realism is a first-order research activity. Defining realism implies a theory of decision making, while building and establishing realism involves methods and measurements.

Scope of Decision Situation

A central idea is to focus the simulator on a decision situation that belongs to a relatively well-delineated class of decision situations (see Figure 1 for some possible examples). The challenge is to choose a decision situation that balances the conflicting considerations of restricted scope and wholeness.

As a first approximation, scope can be specified as requiring that the decision situation correspond to a (a part of) the work situation of a distinct category of professionals or experts. Figure 1 indicates the categories of professionals and corresponding decision situations.

With a focus on a situation that corresponds to the task of a group of professionals (experts) we still must select what part of their work situation is to be reproduced. We must choose what aspects will be emphasized, since not all elements can be simulated equally well.

By sufficiently restricting the scope of the situation to be simulated, it is conceptually possible to recreate completely the target work environment. One might imagine reproducing the work setting of a professional manager by "moving" the manager's office to the lab. However, this notion of "transposing" a work setting is deceptively simple for several reasons.

We can and most likely will attempt to recreate the material attributes

DECISION SITUATION	PROFESSIONAL
Corporate Loan decisions in small U.S. bank	Loan officer
Brand marketing decisions in large consumer goods firm	Brand manager
Office procedure design decisions in Norwegian government agencies	Systems engineer
Personnel decisions in R & D	Personnel manager

Figure 1. Examples of Decision Situations

(room, furniture, filing cabinets, computer technology, etc.) and artifacts (files, documents, forms, etc.) present at a particular point in time. However, it is much less obvious how to reproduce (or what aspects to reproduce of) the social structure, the processes, and the history of the work environment. The boundary for the work setting has to be chosen. One approach is to define away these issues by restricting the simulator to situations with, for example, no history.

Our approach follows from the focus on a decision situation Simulator: the scope and boundaries should be such that the simulator embodies the essential elements of a decision situation. Determining the scope of the simulator is thus transformed into an issue of defining the concept of a decision situation.

At this stage we do not want to give a precise and operational definition of a "decision situation." The concept can and should evolve as our work with the simulator proceeds. The important point is too recognize that at some stage we have to provide a definition. The key requirement is that the simulated situation be a unit that retains all the basic properties of decision making as a whole and where the unit cannot be further divided without losing them. As suggested by Vygotsky (1962, pp. 3-5) in his discussion of language and thought, a focus on the whole can be contrasted with the analysis of a complex phenomenon by breaking it into elements. He suggests the analogy of the chemical analysis of water into hydrogen and oxygen: neither element possesses properties of the whole and each element (hydrogen and oxygen) possesses properties not

present in the whole. For example, if we were interested in why water (the whole) extinguishes fire, we are surprised to find that hydrogen burns and oxygen sustains fire!

We do not yet have a satisfactory equivalent of Vygotsky's concept of word meaning as the unit of analysis in the study of language and thought. However, we can identify certain general features that seem necessary to ensure that the simulated situation is a meaninful whole. In terms of structure, the situation should present a combination of goals, means, and constraints. There should be room for perceiving goals as conflicting, ill-defined and the relationship between means and ends should be uncertain. In terms of process, it should be possible to exhibit a complete decision cycle from problem finding--through problem solving, choice, implementation--to the monitoring of results and control. The situation should provide room for behaviors that include creativity, convergent and divergent learning, and value choices. From our perspective, tic-tac-toe is too constructed and overstructured, as is chess, even though the latter poses many cognitive challenges and permits immense varieties of problem solving strategies.

Choosing the focus and scope of the simulator is a theoretical statement. Stated differently, the simulator must necessarily reflect a particular view of decision making in organizations. Much of the DSIM concept can be used to study decision making from widely different perspectives. However, we envisage initially using the simulator to study expert decision making in ill-structured tasks with an emphasis on problem finding and learning. Our research can thus in part be conceived as an investigation of what it means to be an expert decision maker. The design of the simulator implies that the combination and interplay of sub-

stance and procedure (cf. March and Simon, 1956), of general knowledge and knowledge bound to the particular time and place (cf. Hayek, 1947) is at the heart of the issue.

Building the Simulator

To develop the simulator (Figure 2), we start by performing a case study of one example (or several examples) of the decision situation in a live setting. Such a case study can serve several purposes:

(1) position the decision task in its full context;

(2) collect interview data on the perceptions, concepts, and vocabulary of the decision maker;

(3) provide first-order calibrational data on activities and behavior that can be used to validate the simulator;

(4) identify opportunities for improving the effectiveness of the decision process.

In a later section of this paper, we describe a real application for which we hope and intend to use DSIM.

The data collected in this way, together with any other available information about the particular class of decision situations, is used to design the initial version of the simulator.

Using the simulator in itself is a means to develop successively more realistic and credible versions. This process tests out understanding of decision behavior in the particular decision situation. The development of a simulator is in fact a key research activity; the process of successively refining it is a method of investigating and testing our theories of decision making in ill-structured tasks.
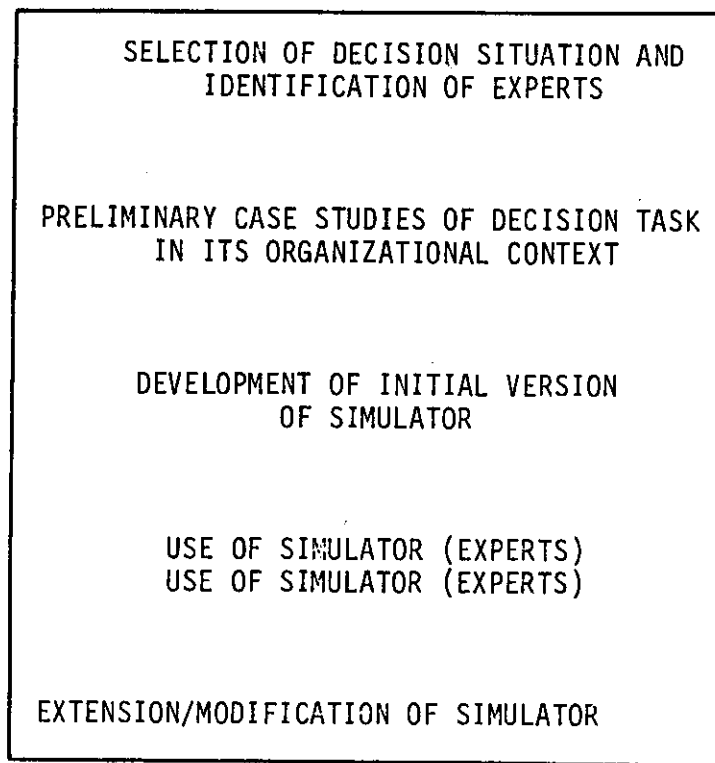
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┌─────────────────────────────────────┐
│  SELECTION OF DECISION SITUATION AND │
│      IDENTIFICATION OF EXPERTS       │
│                                      │
│                                      │
│  PRELIMINARY CASE STUDIES OF DECISION TASK │
│      IN ITS ORGANIZATIONAL CONTEXT   │
│                                      │
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│     DEVELOPMENT OF INITIAL VERSION   │
│           OF SIMULATOR               │
│                                      │
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│       USE OF SIMULATOR (EXPERTS)     │
│       USE OF SIMULATOR (EXPERTS)     │
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│  EXTENSION/MODIFICATION OF SIMULATOR │
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Figure 2. Developing the Decision Simulator

To achieve this, we seek out expert decision makers, rather than relying on naive subjects. Instead of asking decision makers to describe their decision situation, or observing them at their work, as is done with case studies, we get them to tell us where and in what ways the simulated decision situation is not realistic (and our theory hence incomplete or incorrect). Over the course of time the simulator is altered to conform to their comments and criticisms. This bootstrapping process is practicable only by focusing the simulator on a limited class of decision situations. In short, building DSIM is very much linked to how we imagine running the simulator.

Running the Simulator

The simulator is a mix of role-playing, experimentation, and gaming

from the player's perspective. We choose the term "player" rather than "subject" or "participant" as capturing the flavor of the experience.

The simulator is an artifact that is a new experience to the decision maker; even though well-designed it remains an analogue, not an equivalent, of the real situation. However, the player is told to expect a familiar situation. The player is asked to think of himself or herself as filling in for a colleague and thus substituting in a situation that is not same as in his own work, but that is similar. (So that the grammar of our paper does not become that of the fine print in an insurance policy or car warranty, we will generally use the masculine pronoun and adjective hereafter.)

Initially, the player is given a quick rundown of the rules of the game. A

memo explains what has been happening beforehand in the decision situation. The memo may be complemented by a dossier containing background material: letters, reports, newspaper clippings, or messages. The exact content of such a dossier can in part be based on the study of what "fill-ins" (or incumbents) are provided and ask for when they first meet a job in an unfamiliar organization.

The player is then given the opportunity to familiarize himself with the "office"--files, memos, colleagues, subordinates, superiors, computer-based aids, reports, etc. The process of familiarization is a key aspect of the experience and will be recorded.

Events are reproduced through suitable channels: mail, phone, personal statement, request, or command. The decision maker is asked to deal with these as he would in his job. He is able to request additional information. As in a live setting, the player can propose and is requested to both recommend and execute actions.

Both substantive events (e.g., competitive price change, disruption in production facilities, new hire on board, client default) and more procedural events (e.g., delivery of report on competitor pricing, telephone call from production manager, memo from personnel department, visit by client's financial officer) will obviously partly be pre-selected. Partly, however, the events will be conditioned by the player's substantive and procedural choices.

A typical simulation run might consist of four to eight sessions of between one and three hours over a two-to-five day period. Simulated time will flow at different speeds relative to real time during a run. By varying the time flow we are able to study a whole decision style and at the same time perform more detailed analysis of key ac-

tivities or phases of the decision making process.

At the outset of a simulation run the player is requested to note and comment throughout on characteristics of the decision situation that do not seem realistic or that are not familiar. At the end of the experience, the player is debriefed more systematically. The interview may focus only on the realism of the simulator or include questions about what the decision maker has learned from it, if and how he or she views the decision in real life. This process in itself, we feel, adds rigor to research on decision making. A given version of DSIM represents at best theory of the factors to be considered in studying this task. The player's assessment of its realism is one test of that theory and the extent to which we can apply our laboratory conclusions to the whole task in an organizational context.

Instrumentation

One advantage of the simulator is that "hardware" and "software" instrumentation can be applied and can gradually be improved, due to the laboratory setting. Hardware instruments include video recording, eye movement recorders to explore the use of graphic displays, or voice recording for tracing think-aloud protocols; software includes interviews, questionnaires, and observational methods.

Development of unobtrusive, valid, and reliable methods is a major element of the task of building the simulator. Methods include not only instruments to record data, but also coding, representation, and analysis.

Consider the use of "think aloud protocols" as a method for investigating cognitive processes. Building the necessary base for this kind of method requires:

-- techniques, skills, and expertise that create an environment where the player feels comfortable and is encouraged to think aloud;

-- instruments to record and transcribe protocols;

-- procedures to code protocols.

Establishing that "problem space" (Newell and Simon, 1972) the decision maker apparently is operating in requies an enumeration of the major alternatives relevant to the particular (aspect of the) decision situation simulated. The set of alternative problem spaces can be established gradually through simulator use.

The point of the example is to indicate that developing methods is a key activity. Experience suggests that the more unobstrusive the methods, the greater the requirements for methods that are intimately linked to the more substantive aspects of the simulated decision situation. In particular, Edwards' criticism of making the decision maker a cognitive cripple highlights the importance of not allowing methods of observation and measurement to eliminate the player's ability to "make" decisions, to search the problem space, and exercise choice.

Simulator Use

Building DSIM is an overriding research task in our lab concept. The major research result will be the simulator itself with the supporting documentation that describes in what sense and why the simulator is realistic. The research results will come from the systematic analysis and interpretation of player comments on the realism of the simulated decision environment. The comparison of behavior in the simulator with (published and our own) data on the behavior of the same or similar experts in their neu-

tral work environment is another important source of empirical data.

There are obviously limits to the process of comparing the simulator and the natural environment. Some of the limitations are due to the fact that the scope of the simulator has to be restricted. However, in terms of the focal elements of the decision situation that are covered and from certain limited perspectives, it should be possible to attain quickly an adequately high degree of reaslism. Thus, for example, in terms of the micro-level investigation of the isolated use of decision aids, the processes might be reasonably valid, even though the processes might be inadequate from the perspective of the overall decision cycle.

An important reason for calling DSIM a laboratory for research on decision making and Decision Support is that the simulator will provide an arena for a number of different research efforts in parallel and over time. The efforts might be concerned with different aspects of decision making and decision support. The variety of research perspectives, disciplines and methods will further contribute to the elaboration of the validity and help identify the limits of the simulator.

Simulator use is key to the validation process. It is therefore important to bootstrap quickly to a level of realism and provide the necessary instrumentation so that the simulator also can be used as a vehicle for more traditional laboratory research. crude simulator should be possible to use for exploring, for example, the process of problem formulation or the viewing of information displayed graphically, while, at the same time, checking for the realism and validity of the overall decision situation.

Simulator use will not be limited to basic research. By embedding the simu-

lator runs in a larger program, DSIM can become a training and education vehicle, particularly for both acting and prospective experts in the target decision situation. It is probable that a combination of research and training is necessary in order to obtain the participation of a satisfactory number of players.

The simulator can also be used for evaluation. For example, new or alternative decision aids can be assessed by introducing them into the simulator. Experience with new aids might be an important motivation for participants.

Although the value for both training and evaluation depends on simulator realism and instrumentation quality, it should be possible to start up use with a relatively crude version.

UNRESOLVED ISSUES

In this paper we have outlined some of the basic ideas for a Decision Situation Simulator as an approach to research on decision making and decision support in ill-structured tasks. A number of questions need to be addressed before the concepts can be transformed into an operation simulator. We conclude by reviewing four key unresolved issues: choice of decision situation, social context, problem finding, and time flow problem.

Choice of Decision Situation. Choosing the decision situation should be given careful consideration for several reasons. The choice implies a relatively long-term commitment. It affects the supply of experts that are potential players. It probably affects the viability of the research effort in terms of funding and support.

Given the focus on individual--as opposed to group or organizational-- decision making, it is preferable to use a decision situation where the expert decision maker operates relatively independently. Independence refers here to latitude in decision making and ability to have decisions implemented directly and immediately. These are characteristics that commonly define a professional.

In order to achieve realism, we propose to restrict the class of decision situations covered. This has to be traded off against the size of the pool of prospective experts. Thus the concern for realism might suggest restricting the simulator to, for example, "loan officers in small Norwegian banks." However, the concern for interested and available participants might suggest that we increase the class of situations to "loan officers in Norwegian banks."

Social Context. The focus on decision situations where the decision maker is relatively independent would seem to simplify a great deal the task of building the simulator. However, it is not satisfactory to restrict the simulator to written material and computer-based aids. We want in particular to study decision making behavior where both formal and more informal information sources are available. The simulator is to explore use of decision aids in situations where aid and information alternatively can be acquired from one or several persons.

Introducing multiple actors increases dramatically the complexity and costs of the simulator. One approach is to have a complete organizational setup with trained lab personnel playing the different roles that are required (e.g., secretary, administrative assistant, colleague, superior). A more restricted, but much less demanding approach would be to create a social context by running several experts at the same time. The experts would not operate as a single decision making

group, but as a set of colleagues. In addition, lab personnel could play a couple of key common support roles (such as secretary and administrative assistant).

Problem-Finding. The simulator is a free game (Steinbrunner, 1970) in the sense that the player is given a large amount of latitude in defining the situation and how he or she will deal with it. This reflects the desire to use the simulator for exploring problem finding behavior.

A fully free game in terms of problem finding implies the use of weak or ambiguous signals from any number of a wide variety of sources and channels. Part of the problem is to provide signals that are likely to be observed in a reasonable amount of time without forcing the player to attend to them. For example, it might be interesting to study how bankers become aware of potential deteriorations in a country's or company's ability to repay its loans. We could reconstruct a context in which most debts are repaid and there are only a few, relatively hidden, hints of trouble. The result might be a game that apparently is so uneventful that the player loses interest. A possible solution is to quickly overload the decision maker with an excessive quantity of strong signals. This, however, will primarily permit the investigation of the allocation of attention to multiple problems and less illuminate how problems are found.

Time Flow. A key design requirement for DSIM is that it permit the study of the whole decision cycle from problem finding through problem solving, choice, and implementation to evaluation and monitoring of results. This requires, among other things, that we be able to link decision and outcome, just as we must be able to satisfy information requests. Therefore we have to accept the variation in the flow of

simulated time relative to real time. However, the problem remains of how to produce realistic results and responses. The simulator will have to rely on a combination of three mechanisms: umpires to judge ex post, but "online," the effect of actions and requests of players, (computer-based) models to articulate the relationship between selected decisions and outcomes (including perhaps elements of randomness), and a set of pre-specified scenarios for developments that unfold independently of the actions and requests of the players. The costs in terms of preparing and running these elements of the simulator will be the primary limiting factors.

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