A New Look at Decision Making

Symposium Organizers:

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Academic research on decision making appears to have become boxed into a rather narrow and restrictive paradigm. Recently some decision researchers introduced their work approximately as follows: "A decision problem consists of three basic elements: (1) the alternatives available to the decision maker; (2) probabilities of events that relate outcomes to the choice of alternatives; and (3) the values associated with the outcomes." Much research has addressed the problems that arise when human beings are asked to carry out a rational decision analysis within that framework, the difficulties that people have in estimating probabilities and values at all, let alone consistently.

Perhaps those difficulties should cause us to ask some more fundamental questions. In life, how often do decision situations resemble "decision problems" as formulated in the psychological laboratory? Although every action could be said to entail a decision, it seem rare that life lays out before us a clearly defined problem accompanied by a finite set of alternatives, and then pauses long enough to permit a full rational analysis. Rather, perceiving that there is a problem which calls for a decision and thinking of any reasonable alternative that might be taken seems more the issue. Is it even true that decisions pass through a representation that resembles the laboratory problem? No clear evidence exists that they do. Of course, traditional decision researchers can retreat to the position that this is the way decision making ought to occur, even if in fact it does not.

When life does present clear occasions for decisions, and sometimes even moderately clear alternatives, time is often very limited. Views of the way decisions ought to be made often fail to take that factor into account. Seven minutes in July. That is the time that elapsed in the entire Vincennes incident, from the first report of a possible contact with a plane until the airliner was shot down. Is it reasonable to think about a decision-theoretic analysis in that time period? Even if it were, on what basis would one assign probabilities to the possible identities of the aircraft? What is the proper cost to assign to the possible damage to one's own ship and the possible deaths of one's own men? What is the proper cost to assign to the possible deaths of the passengers on an aircraft? As is so often true, these values and probabilities seem very difficult to assign. Whatever the rational appeal of the process, the outcome remains uncertain. Mistakes -- as seen in hindsight -- will be made.

Yet, as we shall hear in this symposium, many important decisions must be made in less than seven minutes -- decisions about what to do for a patient arriving in an emergency room, decisions about how to combat a rapidly developing fire. Most such decisions are made in less than one minute.

In this symposium, we present several samples of newer approaches to decision making, approaches that go beyond the bounds of the neat and clean laboratory "decision problem." We shall see that understanding decision making outside the laboratory is a challenge that calls for all the methods and techniques that the full range of cognitive science has to offer. This undertaking is necessary in order to develop valid and useful methods for training people to make more effective decisions and to design effective and useful aiding systems.

The first presentation is Gary Klein's naturalistic studies of decision making processes as they actually occur in time-pressured life-and-death situations, the source of the data cited above. These studies are leading to the conclusion that decision processes of expert performers in these situations involve perceptual recognition of the type of situation they face, which triggers appropriate actions suggested by past experience, which are then evaluated in rapid imaginal processes and patched if necessary.

If decision making involves perception, psychology has a rich repertoire of psychophysical techniques for figuring out what is going on in such processes. The presentation by John Swets displays an elegant orchestration of those research techniques in order to understand and aid the process of classifying mammograms.

But some situations are more complex, or at least very different in kind, from those that can be understood in terms of a set of perceptual or conceptual patterns. Sometimes the decision maker needs to make sense of a diverse collection of facts, to mold them into something like a consistent story or scientific theory. Paul Thagard will discuss the extension of his approach to the self-consistency of theories to understanding what occurs in decision-making situations.

For several years, Marvin Cohen has worked on the problem of creating practical, usable, and acceptable decision aids for time- pressured military decision making. He will discuss how it has been possible to make use of past decision making research and where the serious gaps lie, where the existing body of research knowledge has little to say.

Finally, it is true that many, if not most, critical decision making situations involve several actors. Judith Orasanu will describe on-going research into the decision processes and problems revealed in the tape recordings of flight crews faced with critical problems.

Participants:

Susan Chipman, ONR, Chair
Gary Klein, Klein Associates
John Swets, Bolt Beranek & Newman, Inc.
Paul Thagard, Princeton University
Marvin Cohen, Decision Sciences Corporation
Judith Orasanu, ARI and Princeton University

Recognitional Decision Making in Natural Situations

Gary Klein

Klein Associates

A model of proficient decision making will be described that emphasizes situation assessment rather than a comparative evaluation of different options. The model is a descriptive account of research on skilled decision makers in different domains. Research will be presented that suggests that proficient decision makers rarely contrast options; rather, experience enables decision makers to generate a plausible course of action as the first they consider. In contrast, the novices we studied were more apt to generate a set of options for careful evaluation. Research will be reviewed from areas including urban firefighting, forest fire operations, tank platoon maneuvers, battle planning, and training device design. These are domains marked by high time pressure, ill-defined goals, ambiguous and incomplete information, high stakes, and personal responsibility for outcomes. In all, we have examined over 450 decision points that were examples of nonroutine and difficult incidents, and we found that a recognitional strategy generalized across domains. One of the important aspects of recognitional decision making is the use of mental simulation to evaluate options without having to contrast strengths and weaknesses. The presentation will address the role of the simulation heuristic within a decision making framework.

Improving Perception-Based Decisions

John A. Swets

BBN Laboratories
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Images and other visual representations are used to make diagnostic decisions about underlying conditions in many fields, including clinical medicine, materials testing, geological prospecting, and national defense. In many cases, it may prove possible to describe, refine, and improve the decision processes by viewing them as consisting of numerical assessments of the relevant perceptual features of an image and a merging of the feature assessments with appropriate weights to yield an overal diagnostic probability. I describe how certain psychological and statistical techniques can be used to develop decision aids for such diagnostic tasks, specifically in the context of mammography for the diagnosis of breast cancer.

Specialists in mammography participated in a four-step procedure: 1. individual interviews produced a comprehensive list of features; 2. similarity judgments of pairs of representative cases were subjected to multidimensional scaling to refine the feature list; 3. a consensus meeting refined feature names, descriptions, and rating scales; 4. ratings of a set of known positive and negative cases were submitted to discriminant analysis to produce a minimal but sufficient set of effective features and their optimal weights. The resulting decision aids were a checklist of features with rating scales and a computer-based (discriminant analysis) algorithm that accepted the ratings for a case and issued an estimate of the probability of malignancy. In a test of the aids, general radiologists read a set of known cases first in their standard manner and then with the aids. The aids produced a substantial improvement in accuracy.

The presentation will conclude by opening a discussion of the extent to which this approach might generalize to situations with conceptual as well as perceptual features, and with a discussion of possible limits on feature representations.

Explanatory Coherence and Naturalistic Decision Making

Paul Thagard

Cognitive Science Laboratory, Princeton University

This talk will describe the relevance of my theory of explanatory coherence (*Behavioral and Brain Sciences*, 1989) for decision making in cases where decisions depend on evaluation of competing hypotheses. In complex cases it is often necessary to form and evaluate hypotheses concerning the nature of the situation. For example, a fire chief may need to infer the source and nature of a fire before deciding how best to fight it. Judges and juries are frequently called upon to evaluate explanatory hypotheses in criminal trials, asking, for example, whether the proposition that the accused murdered the deceased is the best explanation of the death and other evidence. But inference to the best explanation in such cases is not just a matter of considering what hypothesis explains the most evidence, since it is standard in trials to consider a *motive* that could explain why the murder was committed. The acceptability of a hypothesis increases on the basis of there being explanations of it, as well as on the basis of what it explains. Everyday decisions that involve other people often require explanatory inferences concerning their beliefs, desires, and intentions. In adversarial situations such as competitive games, business, diplomacy, and war, it is often necessary to infer the plans of the adversary. Plans can sometimes be inferred as part of the best explanation of what the adversary has done so far.

The theory of explanatory coherence applies naturally to cases such as these. The theory is implemented in ECHO, a program that takes input about explanatory relations to create networks of hypotheses. It then performs parallel constraint satisfaction to evaluate hypotheses using standard connectionist algorithms. ECHO has been used to analyze the decision made in July 1988 by Captain Rogers of the USS Vincennes to shoot down what appeared to be an attacking aircraft. The true hypothesis that the plane was a commercial airliner was considered and rejected in favor of the hypothesis that the plane was an attacking F-14.

Cognitive Strategies and Adaptive Aiding Principles in Submarine Command Decision Making

Marvin S. Cohen

Decision Science Consortium, Inc.

Decision aiding efforts have often been premised on the assumption that unaided decision making is subject to fundamental flaws or "biases," which can be corrected only by adoption of "normative" methods such as Bayesian decision analysis. Such an approach may force decision makers to adopt highly unfamiliar modes of reasoning; as a result, aids may not be used, or if used, may fail to exploit user knowledge. An alternate approach is to start with the user's preferred way of solving the problem and to examine carefully its strengths and weaknesses. Aids are then designed which support more optimal *iants* of the user-preferred strategy. This approach, called Personalized and Prescriptive Aiding, has recently been applied to submarine tactical decision making. Experiments were conducted to investigate the decision strategies adopted by submarine staff in handling multiple goals (attacking high-value targets versus avoiding counter-detection), combining multiple uncertain estimates (of target range), and dealing with ambiguous probability assessments (of hit and counterdetection). In each case, a significant number of subjects failed to aggregate information into a single abstract measure as required by the standard normative approaches to these problems (i.e., a measure of expected utility, a pooled target range, or an expected probability). Neither the results nor the comments of subjects were consistent with the "psychophysical" approach to decision biases proposed by Prospect Theory (Kahneman and Tversky, 1979), with a workload-versus-accuracy tradeoff hypothesis (Johnson and Payne, 1984), or with individual-differences models (Lopes, 1987). The findings are best understood as reflecting the adoption by subjects of simplifying assumptions in order to exploit their knowledge of the problem environment. Decision makers appear to utilize a basic or natural level of representation (Rosch, 1976)--in terms of specific evaluative dimensions, range estimates, or conditional probabilities--that effectively captures their causal or correlational knowledge. Decision aiding concepts have been developed and demonstrated for range pooling and attack planning, which permit users to adopt such assumptions while guarding against potential pitfalls in their preferred decision-making strategy; rather than demanding adoption of an abstract numerical representation, such aids keep track of assumptions, amke users aware of alternatives, and actively warn them when alternatives have significantly different implications.

Shared Mental Models and Crew Decision Making

Judith Orasanu

U.S. Army Research Institute and Princeton University

When faced with decisions in high-stress situations, groups, like individuals, typically narrow the range of information they consider and revert to dominant behavior patterns. Yet some groups are clearly more successful than others in coping with emergencies. Compared to individual decision makers, groups offer expanded cognitive resources, but these contribute to increased effectiveness only if they are appropriately orchestrated and exploited. The research described here aims to account for differences in group decision making effectiveness in critical situations using process tracing and discourse analysis techniques.

Subjects were experienced airline cockpit crews making decisions about how to handle realistic emergencies, such as hydraulic failure or low fuel in bad weather, in high fidelity simulators. The hypothesis addressed in this work is that effective crews develop shared mental models and use language to support joint cognitive functions critical to decision making. These include situation assessment, interpreting information, constraining solutions, anticipating future events, and justifying and priming future actions. We hypothesize that the net result of developing shared models is to reduce information processing demands during high workload periods, permitting better decisions and assuring coordinated actions. The presentation will conclude with implications for training and aiding groups for decision making.