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Implications of Modern Decision Science for Military Decision-Support Systems

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Summary

Decision science contributes to (1) the understanding of human decisionmaking and (2) the development of methods and tools of analysis to assist that decisionmaking. This study addresses both components, albeit selectively, and suggests a number of principles and themes to be taken into account in work on decision-support systems. We discuss the decisionmaking component first, and then the analysis component. While the discussion applies broadly, we focus on military decisionmaking and support to it.

The Decisionmaking Component

There is much to report on descriptive, normative, and prescriptive research on decisionmaking (Chapter Two). Many of the foundations were laid decades ago in pioneering studies by individuals, groups, and firms; since the 1970s, we have gained an in-depth understanding of how humans depend upon heuristics that are often apt and valuable but that can also introduce unintended biases, sometimes severely undercutting the quality of decisionmaking. Over the past decade, this body of knowledge has been supplemented by the "naturalistic" school, which notes (and champions) how experts make decisions by exploiting many of the very same wired-in attributes that trouble those in the heuristics and biases school. A debate now exists as to the form that decision support should take, with doubts arising

about the appropriateness of the "rational analysis paradigm" because of its unnatural fit with human cognition. Research in this domain arguably should be achieving a synthesis of knowledge across these schools. That is just beginning to occur, and this monograph suggests a number of practical suggestions consistent with such a synthesis (Chapter Five).

One aspect of synthesis is the recognition that, while commanders in the midst of battle will and should depend heavily upon intuition, their intuition can be much improved by peacetime education and training that has been structured to teach the right lessons, build the right pattern-matching skills, and *debias* the decisionmaking judgment. Traditional analysis can do much to structure that learning program, even if the techniques used for the learning itself are more naturalistic.

A second aspect of synthesis is more speculative, but it is clear from modern research that decision-support systems that rely exclusively on rational-analytic methods are often quite ineffective—even in what appear to be "analytic settings," such as peacetime decisionmaking in the Pentagon or major commands—because of the cognitive mismatch with the decisions supposedly being supported. It would seem possible, in some circumstances, to present sound analytic information in ways that would be effective and would reduce the propensity to biased judgments. How to do so is a research issue, but we present a number of initial suggestions in Chapter Five. These include artful use of "stories" packaged so as to present alternative perspectives and pros and cons suggested by more analytically structured work accomplished offline. The routine use of *alternative* adversary models can be seen as a special case. Other suggestions relate, for example, to presenting subtle statistical information in graphical ways that humans grasp quickly. This is not always straightforward, however, because the available statistical information may not be appropriate.

The Analysis Component

Turning from issues of human cognition and behavior to decisions themselves, the analysis component of decision science owes much to a classic period, roughly from the 1950s into the 1970s, during which the principal concepts of systems analysis and policy analysis were developed. These included (Chapter Three) early methods such as "taking a systems approach," assuring that an appropriately broad range of strategies is considered; "decision analysis," with its emphasis on maximizing expected utility; game theory, which considers the decisionmaking of adversaries; and cost-benefit analysis. These methods were accompanied by related tools, such as operations-research procedures for optimization. Policy analysis extended the scope of analysis and greatly improved its treatment of relatively soft factors, such as desires, emotions, and motivations; it also introduced methods, such as policy scorecards, for relating analytical results.

More recent developments are considered in Chapter Four. Some were anticipated philosophically early on but have become practical only with the advent of powerful desktop computing. Others represent an evolution of our knowledge about analysis and how to do it well.

Understanding the System and Related Modeling

One development has been an increased emphasis on building "realistic" models and simulations, including so-called virtual worlds. These are more than mere analytic constructs designed to capture just enough about a system to do system analysis; they are attempts to study, understand, and interact with the real world through models that have increasingly high fidelity in many respects. We are still in the early stages of these developments, but experiments with virtual worlds are becoming a major element of decision support. Good decision support, however, often needs analytic work at different levels of detail and from different perspectives. A challenge at the frontier of decision science is developing well-conceived *families of models and human games* that are much more rigorous and mutually informed than what have been regarded as families of models in the past. These matters are discussed briefly in Appendix B. Another major challenge is learning how to exploit the technology of modern recreational games, including massively parallel online activities.

Methods for "Out of the Box" Planning

A second development has been new methods to help in the creative and imaginative aspects of strategic planning. Three such methods are Uncertainty-Sensitive Planning (USP), Assumption-Based Planning (ABP), and "Day After . . ." games. Although there are numerous strategic-planning methods in the community, with distinct names but highly overlapping functions, we mention these because they are well documented, and from RAND experience, we know them to be effective. Successful application of these methods has typically depended more on art than on science in the past, but with experience and documentation, they have become increasingly well defined.

Planning Under Uncertainty

The developments noted above have been stimulated by an enhanced general appreciation for the vast extent of uncertainties afflicting the planning effort. To a considerable degree, earlier approaches to analysis underemphasized the uncertainties and conveyed inappropriate goals of prediction and optimization.

Complex Adaptive Systems. The emergence of the theory of *complex adaptive systems* (CAS) has had profound effects on how we view and model many systems, further increasing our humility about prediction amid uncertainty. It has sometimes been claimed that CAS cannot be controlled because of nonlinearities, but that is an overstatement; such systems may be well behaved in large domains and essentially unpredictable in others. A challenge, then, is understanding the landscape and finding ways to increase the size of the well-behaved domains. Viewing problems in this way greatly affects the form of good analysis. Modern methods and tools for decision support should be defined accordingly. As an example, displays to a commander should help him define strategies that are either in safe zones (e.g., overwhelming force) or in zones with risks that can be at least mitigated by attention to particular factors (e.g., achieving surprise, assuring support of local populations, and avoiding collateral damage that might trigger highly adverse reactions).

Evidential Reasoning. Related to planning under uncertainty is reasoning under uncertainty. Much cutting-edge work is also being done on evidential reasoning and related topics relevant to "connecting the dots" correctly. These are only touched upon in this monograph.

Planning for Adaptiveness. Because of the increased appreciation for uncertainty and the infeasibility of getting plans "right" in cases where events are simply not very predictable, modern decision science tends to emphasize planning for adaptiveness (Davis, 2002a). It is also providing associated methods and tools. These include the method of *exploratory analysis*, which forgoes prediction for a broad, synoptic view of possibilities and a search for flexible, adaptive, and robust strategies. This represents a paradigm shift in analysis. Various enabling concepts include *multiresolution modeling*, the use of *families of models and games*, and methods of exploring uncertainty both parametrically and probabilistically. *Agent-based modeling* is an important new contributor to such modeling, although it is still at an early stage of development and sometimes is severely lacking in rigor and transparency. *Bayesian-network methods* can be quite useful in agent-based modeling and related risk analysis. More top-down methods based on hierarchical decision tables are quite different and are useful in contexts such as providing support to very high-level decisionmakers. Another contributor to adaptive planning is *model composability*, which is much more difficult to achieve than software composability because the meaningfulness of connecting models (as distinct from whether the connected models "run") often depends on subtle and context-dependent assumptions that are evident not at the interfaces between models, but rather in their interiors (if at all). Thus, model components cannot be treated as black boxes when considering composability.

Capabilities-Based Planning. A special application of planning for adaptiveness in the Department of Defense (DoD) context is *capabilities-based planning* (CBP). In addition to the methods and concepts mentioned above, some new methods for CBP include conceiving programs in terms of *mission-capability packages* and assessing effectiveness using *mission-system analysis*. Both of these constructs reflect a systems perspective in which operational capability is judged poorly unless all critical components are in place, including command and control (C^2), training, platforms, weapons, and doctrine. Traditional models have not been designed to highlight such matters easily, but decision-support systems should do so. Capabilities-based planning also requires making choices within a budget; it is not a blank-check approach. An important new approach to assisting choice is the use of *portfolio-management* tools that can illuminate holes or imbalances in an investment program, encouraging shifts across what otherwise might be inviolable categories. Such shifts should reflect both objective and subjective considerations and can only seldom be based on rigorous calculations. Nonetheless, decisions can be significantly assisted by such displays. In addition, portfolio-management tools can assist with marginal analysis or chunky marginal analysis, in which one may ask about how to spend not the next dollar but the next billion dollars. Chunky marginal analysis is important when some of the alternatives require significant investment before any return is seen.

Command and Control and Networking. Modern decision science is also placing much greater emphasis on C^2 and the networking that facilitates it. Older systems analysis and policy analysis were often structured around units and platforms. Modern work is increasingly concerned with C^2 structures, processes, and mechanisms for adaptation, as well as ubiquitous networks that allow tasks to be accomplished with resources appropriate to a problem—to a given time, place, and context. Information science is playing a central role in all of this, as illustrated by the emphasis on concepts such as *shared information awareness*. This modern work involves *virtual collaboration* and operations of virtual organizations. It is largely in the domain of information science, but understanding the effects of virtual collaboration (in comparison with face-to-face collaboration) is very germane to today's problems.

Recommendations

Consideration of decisionmaking and analysis of decisions yields a number of recommendations for the design and practice of decision-support systems and for further research. Reflecting the synthesis of rational and intuitive theories of decisionmaking, decision tools should complement human strengths and counteract weaknesses through attention to features of the tools themselves, the user-tool interaction and the tool-use environment, and development of users' decisionmaking skills. In particular, the user should be able to interact with and personalize the tools at multiple levels.

Decision support should appeal to both the rational-analytic and the intuitive capabilities of the decisionmaker, with a balance of "cold" and story-based presentation of analysis and recommendations. The particular balance should depend on characteristics of the decision, the decision environment, and the decisionmaker. Decisionmaking is well supported by providing the decisionmaker access to a variety of advisors and interlocutors. Communication tools that allow for virtual decisionmaking groups can promote consideration of alternative views and a healthy skepticism.