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Naturalistic Decision Making

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Objective: This article describes the origins and contributions of the naturalistic decision making (NDM) research approach. **Background:** NDM research emerged in the 1980s to study how people make decisions in real-world settings. **Method:** The findings and methods used by NDM researchers are presented along with their implications. **Results:** The NDM framework emphasizes the role of experience in enabling people to rapidly categorize situations to make effective decisions. **Conclusion:** The NDM focus on field settings and its interest in complex conditions provide insights for human factors practitioners about ways to improve performance. **Application:** The NDM approach has been used to improve performance through revisions of military doctrine, training that is focused on decision requirements, and the development of information technologies to support decision making and related cognitive functions.

ORIGINS OF NDM

A major contribution of the naturalistic decision making (NDM) community has been to describe how people actually make decisions in real-world settings. This statement might seem odd because decision researchers had conducted experiments and developed models for decades prior to the emergence of NDM in 1989. However, that research primarily identified optimal ways of making decisions (defined as choices among alternatives) in well-structured settings that could be carefully controlled.

The heuristics and biases paradigm (e.g., Kahneman, Slovic, & Tversky, 1982) demonstrated that people did not adhere to the principles of optimal performance; respondents relied on heuristic as opposed to algorithmic strategies even when these strategies generated systematic deviations from optimal judgments as defined by the laws of probability, the axioms of expected utility theory, and Bayesian statistics.

So by 1989, it was fairly clear how people didn't make decisions. They didn't generate alternative options and compare them on the same set of evaluation dimensions. They did not generate probability and utility estimates for different courses of action and elaborate these into decision trees. Even when they did compare options, they rarely employed systematic evaluation techniques.

But what did they do instead? Researchers were not likely to find out how people actually made decisions by conducting experiments to test hypotheses derived from statistical and mathematical models of ideal choice strategies. Even the decision researchers who performed studies in field settings, using experienced participants, primarily assessed performance according to formal standards. (For a fuller discussion of this history, see Lipshitz, Klein, Orasanu, & Salas, 2001.)

Unfortunately, the training methods and decision support systems developed in accord with the formal standards did not improve decision quality and did not get adopted in field settings. People found these tools and methods cumbersome and irrelevant to the work they needed to do (Yates, Veinott, & Patalano, 2003).

The initial NDM researchers tried a different approach. Instead of beginning with formal models of decision making, we began by conducting field research to try to discover the strategies people used. Instead of looking for ways that people were suboptimal, we wanted to find out how people were able to make tough decisions under difficult conditions such as limited time, uncertainty, high stakes, vague goals, and unstable conditions

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(see Orasanu & Connolly, 1993). Researchers in fields such as medicine (Elstein, Shulman, & Sprafka, 1978) and business (Isenberg, 1984) had already been studying these kinds of issues.

The basic research program at the Army Research Institute for the Behavioral and Social Sciences began funding several of the NDM researchers during the mid-1980s. The U.S. Navy became interested in naturalistic decisions following the 1988 USS *Vincennes* shoot-down incident, in which a U.S. Navy Aegis cruiser destroyed an Iranian commercial airliner, mistaking it for a hostile attacker. Both the Army and the Navy wanted to help people make high-stakes decisions under extreme time pressure and under dynamic and uncertain conditions.

The first NDM conference, in 1989, assembled researchers studying decision making in field settings. In a chapter that emerged from that meeting, Raanan Lipshitz (1993) identified no less than nine NDM models that had been developed in parallel.

One of these was Hammond's cognitive continuum theory (Hammond, Hamm, Grassia, & Pearson, 1987), which asserts that decisions vary in the degree to which they rely on intuitive and analytical processes. Conditions such as amount of information and time available determine where decisions fall on this continuum and whether people rely more on patterns or on functional relationships. A second account of decision making was Rasmussen's (1983) model of cognitive control, which distinguished skill-based, rule-based, and knowledge-based behavior operating within the context of a decision ladder that permitted heuristic cutoff paths. A third, the recognition-primed decision model (Klein, 1989), is discussed in more detail later.

Working separately, we all reached similar conclusions. People were not generating and comparing option sets. People were using prior experience to rapidly categorize situations. People were relying on some kind of synthesis of their experience – call it a schema or a prototype or a category – to make these judgments. The categories suggested appropriate courses of action. The static notion of decisions as gambles, which portrays people as passively awaiting the outcomes of their bets, did not fit leaders who were actively trying to shape events.

The NDM researchers studied people in field settings, such as Navy commanders, jurors, nuclear power plant operators, Army small unit leaders, anesthesiologists, airline pilots, nurses, and highway engineers. From this perspective, making a decision means committing oneself to a course of action where plausible alternatives exist, even if the person does not identify or compare these alternatives.

The NDM movement shifted our conception of human decision making from a domain-independent general approach to a knowledge-based approach exemplified by decision makers who had substantial experience. The decision-making process was expanded to include a prior stage of perception and recognition of situations, as well as generation of appropriate responses, not just choice from among given options. This perspective took advantage of advances in cognitive psychology such as knowledge representation concepts of scripts, schemas, and mental models, to contrast expert versus novice behavior.

To provide a fuller account of the NDM view of decision making, I will describe the recognition-primed decision model; I am more familiar with it than with the others, and it has received a fair amount of attention. However, all of the nine NDM models Lipshitz (1993) listed show a strong family resemblance.

Recognition-Primed Decision Model

The recognition-primed decision (RPD) model describes how people use their experience in the form of a repertoire of patterns (Klein, Calderwood, & Clinton-Cirocco, 1986). These patterns describe the primary causal factors operating in the situation. The patterns highlight the most relevant cues, provide expectancies, identify plausible goals, and suggest typical types of reactions in that type of situation. When people need to make a decision they can quickly match the situation to the patterns they have learned. If they find a clear match, they can carry out the most typical course of action. In that way, people can successfully make extremely rapid decisions. The RPD model explains how people can make good decisions without comparing options.

However, there is more to the RPD model than pattern matching. How can a person evaluate an option without comparing it with others? We found that the fireground commanders we studied evaluated a course of action by using mental simulation to imagine how it would play out within the context of the current situation. If it would work, then the commanders could initiate the action. If

it almost worked, they could try to adapt it or else consider other actions that were somewhat less typical, continuing until they found an option that felt comfortable. This process exemplifies Herbert Simon's (1957) notion of satisficing – looking for the first workable option rather than trying to find the best possible option. Because fires grow exponentially, the faster the commanders could react, the easier their job.

Therefore, the RPD model is a blend of intuition and analysis. The pattern matching is the intuitive part, and the mental simulation is the conscious, deliberate, and analytical part. This blend corresponds to the System 1 (fast and unconscious)/System 2 (slow and deliberate) account of cognition put forward by Kahneman (2003), Epstein (1994), and others (for an overview, see Evans, 2008). A purely intuitive strategy relying only on pattern matching would be too risky because sometimes the pattern matching generates flawed options. A completely deliberative and analytical strategy would be too slow; the fires would be out of control by the time the commanders finished deliberating.

We formulated the RPD model based on in-depth interviews with fireground commanders about recent and challenging incidents and found that the percentage of RPD strategies generally ranged from 80% to 90% (Klein, 1989) (see Figure 1). Other researchers have replicated these findings (see Klein, 1998).

Most critically, we tested the prediction from the RPD model that for experienced decision makers, the first option they consider is usually satisfactory. Klein, Wolf, Militello, and Zsambok (1995) found that chess players were not randomly generating moves that they would then evaluate. Rather, the first moves that occurred to them were much better than would be expected by chance. These findings support the RPD hypothesis that the first option considered is usually satisfactory. These results were later replicated by Johnson and Raab (2003).

Contributions of NDM

The demands of NDM research have spurred the development of cognitive field research and cognitive task analysis methods, as described by Crandall, Klein, and Hoffman (2006). These methods have contributed to the field of human factors and ergonomics by enabling practitioners to explore the cognitive underpinnings of different types of work.

NDM has affected Army doctrine. The current edition of the *Army Field Manual on Command and Control* (FM 101-5) includes for the first time a section on intuitive decision making, largely influenced by research on the RPD model.

Schmitt and Klein (1999) have adapted the RPD model to military planning guidance. Their strategy reduces planning time without sacrificing plan quality (Ross, Klein, Thunholm, Schmitt, & Baxter, 2004) and has become the basis for tactical decision making in the Swedish armed forces (Thunholm, 2006).

The field of NDM has also provided guidance for training decision making and related cognitive skills. Cannon-Bowers and Salas (1998) have described the range of lessons learned from the TADMUS (Tactical Decision Making Under Stress) project initiated by the Navy following the USS *Vincennes* shoot-down decision. These include methods for providing stress inoculation along with approaches for individual and team decision training.

The NDM movement has seen a surprisingly rapid adoption of its findings. Within 10 years of the initial NDM meeting, experiential models were accepted as the standard account of decision making by most practitioners. NDM conferences have been held every 2 to 3 years, alternating between the United States and Europe. In addition, the Cognitive Engineering and Decision Making Technical Group, formed to provide an outlet for NDM research, has become one of the largest and most active in the Human Factors and Ergonomics Society.

Where is NDM heading? Because cognitive field research methods have proven so effective for generating insights about decision making, they are being used to study other "macrocognitive" functions, such as situation awareness, sensemaking, planning and replanning, and the ways they are linked (Klein, et al., 2003). Macrocognition, the study of cognitive adaptations to complexity, may reflect the next step in the evolution of NDM. Macrocognitive functions are performed at the level of individuals. These functions are also performed by teams, as emphasized by Letsky, Warner, Fiore, Rosen, and Salas (2007), who build on NDM research on shared mental models and team knowledge (e.g., Cooke, Salas, Kiekel, & Bell, 2004). The growth of interest in macrocognition suggests that the premises of NDM are stimulating research and applications that cover a broader and interrelated

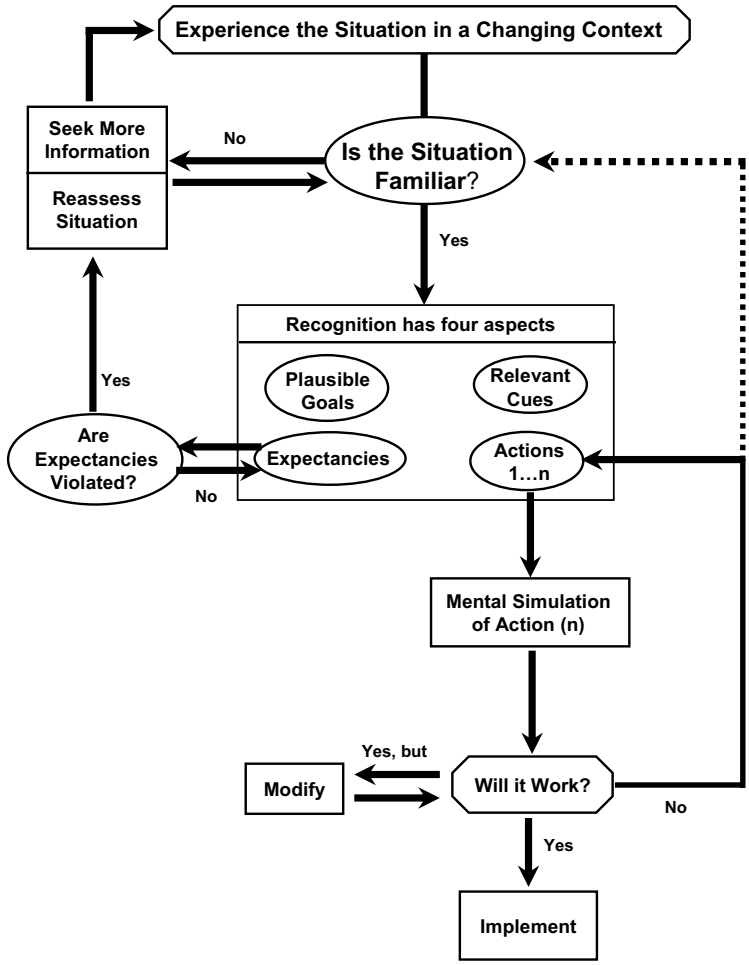

Figure 1. Model of recognition-primed decision making. (*Decision making in action: Models and methods.* G. A. Klein, J. Orasanu, R. Calderwood, C. E. Zsambok, Editors. Copyright © 1993 by Ablex Publishing Corporation. Norwood, NJ. Reproduced with permission of Greenwood Publishing Group, Inc., Westport, CT.)

set of cognitive functions at the team, organizational, and individual levels.

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REFERENCES

Cannon-Bowers, J. A., & Salas, E. (1998). *Making decisions under stress: Implications for individual and team training.* Washington, DC: American Psychological Association.

Cooke, N. J., Salas, E., Kiekel, P. A., & Bell, B. (2004). Advances in measuring team cognition. In E. Salas & S. M. Fiore (Eds.), *Team cognition: Understanding the factors that drive process and performance* (pp. 83–106). Washington, DC: American Psychological Association.

Crandall, B., Klein, G., & Hoffman, R. R. (2006). *Working minds: A practitioner's guide to cognitive task analysis.* Cambridge, MA: MIT Press.

Elstein, A. S., Shulman, L. S., & Sprafka, S. A. (1978). *Medical problem solving: An analysis of clinical reasoning.* Cambridge, MA: Harvard University Press.

Epstein, S. (1994). Integration of the cognitive and psychodynamic unconscious. *American Psychologist, 49,* 709–724.

Evans, J. S. B. T. (2008). Dual-processing accounts of reasoning, judgment and social cognition. *Annual Review of Psychology, 59,* 255–278.

Hammond, K. R., Hamm, R. M., Grassia, J., & Pearson, T. (1987). Direct comparison of the efficacy of intuitive and analytical cognition in expert judgment. *Proceedings of IEEE Transactions on Systems, Man, and Cybernetics, SMC-17,* 753–770.

Isenberg, D. J. (1984, November–December). How senior managers think. *Harvard Business Review,* pp. 80–90.

Johnson, J. G., & Raab, M. (2003). Take the first: Option generation and resulting choices. *Organizational Behavior and Human Decision Processes, 91*(2), 215–229.

Kahneman, D. (2003). Maps of bounded rationality: Psychology for behavioral economics. *American Economic Review, American Economic Association, 93*(5), 1449–1475.

Kahneman, D., Slovic, P., & Tversky, A. (Eds.). (1982). *Judgment under uncertainty: Heuristics and biases.* Cambridge, MA: Cambridge University Press.

Klein, G. A. (1989). Recognition-primed decisions. In W. B. Rouse (Ed.), *Advances in man-machine systems research* (Vol. 5, pp. 47–92). Greenwich, CT: JAI Press.

Klein, G. A. (1998). *Sources of power: How people make decisions.* Cambridge, MA: MIT Press.

Klein, G. A., Calderwood, R., & Clinton-Cirocco, A. (1986). Rapid decision making on the fireground. *Proceedings of the Human Factors and Ergonomics Society 30th Annual Meeting, 1,* 576–580.

Klein, G. A., Orasanu, J., Calderwood, R., & Zsambok, C. E. (Eds.). (1993). *Decision making in action: Models and methods.* Norwood, NJ: Ablex Publishing Corporation.

Klein, G. A., Ross, K. G., Moon, B. M., Klein, D. E., Hoffman, R. R., & Hollnagel, E. (2003). Macrocognition. *IEEE Intelligent Systems, 18*(3), 81–85.

Klein, G. A., Wolf, S., Militello, L., & Zsambok, C. (1995). Characteristics of skilled option generation in chess. *Organizational Behavior and Human Decision Processes, 62*(1), 63–69.

Letsky, M., Warner, N., Fiore, S. M., Rosen, M., & Salas, E. (2007). Macrocognition in complex team problem solving. In *12th International Command and Control Research and Technology Symposium (ICCRTS)* (CD-ROM). Washington, DC: Command and Control Research Program (CCRP). Available from http://www.dodccrp.org/events/12th_ICCRTS/CD/iccrts_main.html

Lipshitz, R. (1993). Converging themes in the study of decision making in realistic settings. In G. A. Klein, J. Orasanu, R. Calderwood, & C. E. Zsambok (Eds.), *Decision making in action: Models and methods* (pp. 103–137). Norwood, NJ: Ablex.

Lipshitz, R., Klein, G., Orasanu, J., & Salas, E. (2001). Focus article: Taking stock of naturalistic decision making. *Journal of Behavioral Decision Making, 14,* 331–352.

Orasanu, J., & Connolly, T. (1993). The reinvention of decision making. In G. A. Klein, J. Orasanu, R. Calderwood, & C. E. Zsambok (Eds.), *Decision making in action: Models and methods* (pp. 3–20). Norwood, NJ: Ablex.

Rasmussen, J. (1983). Skill, rules and knowledge: Signals, signs, and symbols, and other distinctions in human performance models. *IEEE Transactions on Systems, Man and Cybernetics, SMC-13*(3), 257–266.

Ross, K. G., Klein, G., Thunholm, P., Schmitt, J. F., & Baxter, H. C. (2004). The recognition-primed decision model. *Military Review, LXXIV*(4), 6–10.

Schmitt, J. F., & Klein, G. (1999). How we plan. *Marine Corps Gazette, 83*(10), 18–26.

Simon, H. (1957). *Models of man: Social and rational.* New York: Wiley.

Thunholm, P. (2006). A new model for tactical mission planning for the Swedish Armed Forces. In *Proceedings of the 2006 Command and Control Research and Technology Symposium: The state of the art and the state of the practice* (CD-ROM). Washington, DC: Command and Control Research Program (CCRP). Available from http://www.dodccrp.org/html4/events_past.html#2006

Yates, J. F., Veinott, E. S., & Patalano, A. L. (2003). Hard decisions, bad decisions: On decision quality and decision aiding. In S. L. Schneider & J. Shanteau (Eds.), *Emerging perspectives on judgment and decision research* (pp. 13–63). New York: Cambridge University Press.

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