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Expertise in Judgment and Decision Making: A Case for Training Intuitive Decision Skills

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Introduction

Research on expertise is largely founded on the idea that experts have achieved a rare proficiency in a domain that most of their peers never quite reach. What is the nature of such expertise? How does someone become an expert? How do experts differ from novices? These are questions that have intrigued the vast majority of expertise researchers (e.g., Chi, Glaser, & Farr, 1988; Ericsson & Smith, 1991). Research on expertise within the judgment and decision making (JDM) community has been primarily concerned with quite a different set of issues. What role should experts play in forecasting and decision support systems? Do experts suffer from the same judgmental biases that have been demonstrated in undergraduates? How can experts know so much and predict so badly? (e.g., Camerer & Johnson, 1991; Smith & Kida, 1991; Wright & Bolger, 1993). There may be value in addressing some of these questions. Nevertheless, the stress in this chapter is on the former set of issues as they apply to decision making, with the goal of convincing the reader that such questions deserve a dramatically greater role in JDM research on expertise than they ordinarily receive. First, however, we address the skeptical view of expertise implied in some of the JDM questions above.

There are several programs and approaches in the study of decision making, as illustrated in the first section of this book. Arguably, the dominant program since the 1970s has been the heuristics and biases approach initiated by Daniel Kahneman and Amos Tversky (hereafter K&T; see Chapter 5). The theoretical contribution of K&T was to demonstrate that human judgment arises from qualitatively different processes than suggested by normative theories, and to argue that heuristics would provide a better starting point for the development of psychological theory. K&T's research strategy was to demonstrate sharp departures of human judgment from the normative principles. The uncovered biases were intended to illuminate the heuristic nature of the underlying system (e.g., Gilovich & Griffin, 2002; Kahneman & Tversky, 1972).

Much work on expertise in the JDM literature has also followed the heuristics and biases tradition (e.g., Arkes, Wortmann, Saville, & Harkness, 1981; Bazerman, Loewenstein, & Moore, 2002; Camerer & Johnson, 1991; Koehler, Brenner, & Griffin, 2002; Loftus & Wagenaar, 1988; McNeil, Pauker, Sox, & Tversky, 1982). The goal of such research has been to demonstrate that biases exist outside of normal, laboratory populations. For example, Arkes et al. (1981) demonstrated hindsight bias effects among practicing physicians. Koehler et al. (2002) showed that experts in a variety of domains were poorly calibrated probability assessors. McNeil et al. (1982) illustrated that framing effects can be exhibited in doctors and statistically trained graduate students.

Decision researchers have often been concerned with developing prescriptions for improving decision processes in addition to describing basic mechanisms. A view that has developed out of the heuristics and biases program is that decision making can be improved by striving to eliminate biases (see Chapter 16, this volume). On the whole, efforts to "debias" individuals in lab settings have met with mixed success at best (e.g., Fischhoff, 1982). And beyond lab demonstrations of effectiveness, there are several underlying assumptions that present serious challenges to the utility of such an approach in actual "on the job" decision making. First, the frequency and magnitude of biases studied in laboratory research has not been assessed in natural settings. Second, for debiasing to even have a marginal impact, the procedures have to be accessible or transfer to the situations encountered in natural settings. Finally, the specific recommendation has to fit within the confines of the decision maker's job. This full range of issues must be dealt with in order to demonstrate the value of the debiasing approach, and thus far, progress has been remarkably limited.

Interestingly, despite the general focus of this program and the lack of success of debiasing efforts generally, domain expertise has been found to alleviate biases (e.g., Bornstein, Emler, & Chapman, 1999; Cohen, 1993; Keren, 1987; Shanteau, 1989; Smith & Kida, 1991). For instance, Bornstein et al. (1999) found that medical residents endorse sunk cost reasoning less on medical than on non-medical decisions. Keren (1987) found that expert bridge players rendered extremely well-calibrated predictions that their contracts would win. Smith and Kida (1991) discovered that accountants were less biased on accounting than non-accounting decisions. Expertise undoubtedly offers far more to decision makers than bias reductions. Given that, intensive study of the central questions concerning expertise is clearly warranted.

In this chapter, we cover three topics: (1) the nature of expertise; (2) expertise in decision making; and (3) advancing expertise in a given domain.

The Nature of Expertise

Many researchers have speculated about the nature of expertise, most notably Chi et al. (1988); Ericsson and Smith (1991); Feltovich, Ford, and Hoffman (1997); and Hoffman

(1994). In this section we highlight some of their observations, particularly those that are relevant to decision making. We draw on two research traditions, a laboratory-based examination and a naturalistic investigation of expertise.

The laboratory-based approach to studying expertise attempts to maintain the advantage of precision granted by laboratory settings, but strives to utilize tasks that are highly representative of the experts' domain. The goal of this approach is to approximate the natural performance of experts under controlled conditions (Ericsson & Charness, 1997).

The naturalistic approach to conducting research around expert judgment is exemplified by the Naturalistic Decision Making (NDM) framework (see Flin, Salas, Strub, & Martin, 1997; Klein, Orasanu, Calderwood, & Zsambok, 1993; Lipshitz, Klein, Orasanu, & Salas, 2001; Salas & Klein, 2001; and, Zsambok & Klein, 1997 for a review of NDM). NDM researchers set out to examine expertise in natural settings, instead of in the laboratory. The goal is to study people performing tasks under conditions that are typical for their workplace. NDM researchers have been interested in domains that require high-stakes, time-pressured decision making under conditions of uncertainty and competing goals. Nevertheless, we believe that findings about experts' judgment and decision processes drawn from these domains generalize to domains that are not so crisis-driven.

How should expertise be conceptualized? The term is unfortunately often given a weak connotation in JDM research. For example, Camerer and Johnson (1991, p. 196) offer the following definition:

> For our purposes, an expert is a person who is experienced at making predictions in a domain and has some professional or social credentials. The experts described here are no slouches: They are . . . intelligent, well paid, and often proud. We draw no special distinction between them and extraordinary experts, or experts claimed by their peers (cf. Shanteau, 1988). We suspect that our general conclusions would apply to more elite populations of experts . . .

In our view, these people would be better termed "professionals" who are not necessarily experts. And we strongly disagree with their final conclusion. Words can obviously be used in different ways. However, to attain continuity with the broader research community on expertise, the above definition of "expert" should be dropped by the JDM community (also see Bendor, 2003).

When we speak of expertise we refer to individuals who have achieved exceptional skill in one particular domain. Operationally, peer nomination is essential in determining whether someone has achieved exceptional skill; when searching out experts, we routinely ask "Who is the guy who knows it all?" Furthermore, we are highly selective, and occasionally "cut" those professionals who do not appear to us to be true experts. With respect to domain specificity, there is little evidence that the skill of an expert transfers to an alternate context (Chi et al., 1988; but see Schunn & Anderson, 1999). The primary distinction that separates experts from novices appears to be the breadth and depth of their domain-specific knowledge. These definitional considerations are extremely important in considering the intersection between JDM and expertise. Competence is inherent in the definition of expertise, so questions like "Why do experts predict badly?" do not make sense. A better framing would be, "Why do experienced professionals in some domains not appear to be experts?" This is a complicated question. An important possibility with respect to JDM research is that the researchers have set up judgment tasks that require knowledge outside of the experts' domain, i.e., the specific knowledge that the expert relies upon on the job (e.g., Asare & Wright, 1995). We turn now to review in-depth conceptions of expertise that have emerged from research in that field.

Ericsson and Smith (1991) describe the study of expertise as seeking to understand "what distinguishes outstanding individuals in a domain from less outstanding individuals in that domain, as well as people in general" (p. 2). The term "outstanding" is intentionally vague; it fosters the acceptance of several research approaches to the question of what constitutes expertise.

Some definitions describe changes that occur when expertise is developed. For example, Glaser (1996) describes the following:

- Variable, awkward performance becomes consistent, accurate, complete, and efficient;
- Individual acts and judgments are integrated into overall strategies;
- With perceptual learning, a focus on isolated variables shifts to perception of complex patterns; and
- There is increased self-reliance and ability to form new strategies as needed.

Another perspective on expertise is to view it in terms of representation. Experts seem to represent a problem at a deeper level than do novices, who are relatively superficial in their problem representations (Chi, Feltovich, & Glaser, 1981; Glaser & Chi, 1988; Larkin, McDermott, Simon, & Simon, 1980). For example, experts in the domain of physics were compared with novices in which the task was to represent the topic contained in a physics problem. The experts showed a much deeper, functional understanding of the problem, whereas the novices responded in terms of superficial characteristics of the problem (Anzai, 1991). In a study of battle commanders, Serfaty, MacMillan, Entin, and Entin (1997) found several examples of how higher-expertise commanders saw situations differently than their less-expert counterparts. The high-expertise subjects were able to consider the effects of sequencing and timing of events, as well as the effects of terrain and distances on the battlefield. These are more complex elements of a tactical problem.

We can also discriminate experts from others by describing what experts *know* that others do not, and what experts *can do* that others cannot – the declarative and procedural knowledge described by Anderson (1983). Klein and Militello (in press) suggested several additional categories of knowledge related to expertise, along with the two offered by Anderson:

- *Perceptual skills*: Perceptual skills, in particular the ability to make fine discriminations, seem an essential component of expertise in many settings (e.g., Klein & Hoffman, 1993).
- *Mental models*: Experts have a broader and deeper knowledge and experience base than journeymen and novices. They understand the dynamics of events in their domain. They know how tasks and subtasks are supposed to be performed, how equipment is supposed to function, and how teams are supposed to coordinate. This mental

representation of "how things work" is referred to as a mental model, an internal representation of the external world. Mental models enable the decision maker to describe, explain, and predict (Rouse & Morris, 1986).

- *Sense of typicality and associations*: The knowledge here is often in the form of a repertoire of patterns. Several studies support the assertion that experts can perceive large, meaningful patterns of information (Ericsson & Smith, 1991). One of the classical studies in this area was the work of Newell and Simon (1972) showing expert/novice differences in pattern repertoire for chess positions. Experts can rapidly recognize and interpret complex patterns in a set of information in order to assess the situation more quickly and accurately than non-experts (e.g., Chase, 1983; Dreyfus, 1997; Gentner, 1988). The repertoire of patterns that allows experts to recognize situations as typical, also enables them to spot information that is expected but missing from the picture, and to detect anomalies that are present but not expected.
- *Routines*: This category corresponds to the "knowing how" discussed by Anderson (1983). Experts know a wider variety of tactics for getting things done.
- *Declarative knowledge*: This category corresponds directly to Anderson's (1983) account. Experts simply know more facts, more details. They have command of more explicit knowledge, to use Polanyi's (1966) terminology, to go along with their tacit knowledge. The tacit knowledge of experts would fall in the preceding four categories.

In addition to the different types of knowledge experts possess, Klein and Militello (in press) also describe some of the things experts can do with this knowledge, including:

- *Run mental simulations*: Mental simulation was originally introduced by Einhorn and Hogarth (1981) as an aspect of decision making. They suggested that people use mental simulation to adjust a known value so that it fits a new situation. They imagine various configurations of events by combining what they know to be true with what might be, based on what they see in the new situation. This account of mental simulation comes out of research on anchoring and adjustment strategies.

Other more traditional decision research has also referred to the same process of mental envisioning. For example, Kahneman and Tversky (1982) described a simulation heuristic by which the individual "runs" a mental model of a situation to determine how to react. DeGroot (1965), in his studies of chess players, introduced the concept of progressive deepening to describe how players consider their next move. He observed that skilled players identify a small rather than broad set of plausible moves. Then they simulate the counter-moves their opponent might choose, and the moves they could make in reaction to those.

Experts can use their detailed mental models, coupled with their understanding of the current state of the situation, to construct simulations of how the situation is going to develop in the future, and thereby generate predictions and expectations. For example, Klein (1998) relates studies of firefighter decision making where experienced commanders were able to look at a burning building and know what was happening inside. They could tell from the look and location of the smoke and flames how it was burning and where the fire was probably located. From the exterior of the building they could envision stairways, elevator shafts, and roof supports, and how the fire was impacting each. Mental simulations of how a fire will burn and spread enable them to project into the future.

- *Spot anomalies and detect problems*: Experts spend relatively more time analyzing the situation than deliberating about a course of action, whereas non-experts show the reverse trend; they spend less time on the dynamics of the situation and more determining how to respond (Kobus, Proctor, Bank, & Holste, 2000).

  The richer mental models of experts enable them to identify atypicalities and therefore adjust the story they are developing to explain events. Feltovich, Johnson, Moller, and Swanson (1984) designed an experiment with medical practitioners to test the flexibility of experts versus non-experts on diagnostic tasks. A series of actual clinical cases were presented to the subjects in which the patient information followed a "garden path" structure. That is, early data strongly suggested an incorrect diagnosis, but data that were added to the picture later suggested a different, accurate, diagnosis. The results showed that novices were more rigid and tended to get trapped on the garden path. Experts, on the other hand, were able to identify that the path on which they were headed (toward the incorrect diagnosis) was the wrong one. They were able to detect that a switch needed to be made. The authors attribute this flexibility to a finely discriminated disease schema, where small anomalies that fail to fit the early diagnosis can be detected. In the same study, another clinical case could be successfully diagnosed if the subject interpreted a particular finding correctly. Novices tended to read the finding according to the textbook interpretation and therefore missed the diagnosis. Experts, on the other hand, noticed that the textbook interpretation was not appropriate for this particular patient, and were able to adjust the rules accordingly and generate an accurate diagnosis (Feltovich, Spiro, & Coulson, 1997).
- *Find leverage points*: Klein and Wolf (1998) hypothesized that people can generate novel courses of action by identifying and capitalizing on unapparent opportunities for useful interventions, i.e., leverage points. Mental simulation is a powerful tool for using leverage points to support improvisation, and experts are able to improvise better than non-experts when the situation is novel by forming new, effective strategies (Klein, 1998). We can attribute this to a mental model that provides rich detail around the dynamics of events and a sense of the opportunities that resources provide, in some cases other than their intended use (Lipshitz & Cohen, submitted). As an example, a fireground commander once used a belt intended to secure firefighters while on a ladder to rescue a woman who was dangling on the metal supports of a highway sign. He was able to mentally simulate a series of approaches to rescuing the woman, and eventually determined that the ladder belt would do the trick (Klein, 1998).
- *Manage uncertainty*: Lipshitz and Strauss (1997) and Schmitt and Klein (1996) described a range of strategies for managing uncertainty in field settings. Expert decision makers tend to use their mental models to fill in gaps with assumptions, to mentally simulate and project into the future, to formulate information seeking tactics. The strategies used in the field for managing uncertainty are quite distinct from probability judgment paradigms that are the focus of much research in JDM, and this is very likely an important part of why experts often appear deficient in

dealing with uncertainty in such research (e.g., Christensen-Szalanski & Bushyhead, 1981; Loftus & Wagenaar, 1988).

- *Take one's own strengths and limitations into account (i.e., metacognition)*: Several studies indicate that experts are better self-monitors than non-experts. In experiments with physics problems, experts would check their answers more than non-experts (Simon, 1975) and would more frequently abandon a route to a solution before carrying out the calculations (Larkin, 1983). Chi, Feltovich, and Glaser (1980) found that experts were better able to judge the difficulty of a physics problem, and a follow-on study by Chi et al. (1981) noted that the problem features on which the subjects judged difficulty were different for experts and non-experts. The experts in their sample more often considered the underlying principles addressed in the problem, while novices more often considered characteristics unrelated to the problem itself. They suggest that experts' superior self-knowledge is based not only on their greater domain knowledge, but also on the way in which that information can be represented in order to carry more meaning. In studies of chess players, experts were found to have better accuracy than novices when they predicted how many times they would need to see a configuration of pieces on the board before they could reproduce the board (Chi, 1978).

Expertise in Decision Making

In this section we discuss a 15-year research program to understand how experts make good decisions. The fundamental idea is that the first option experts generate is of high quality. The Recognition-Primed Decision (RPD) model (see Figure 15.1) describes how in naturalistic settings, experts rely on an extensive knowledge base to make judgments about situations and decide how to act. While the RPD model is intended to be descriptive with regard to the decision-making process of experts, it also provides a frame within which characteristics of experts can be distinguished from those of novices.

The RPD model (Klein, 1998; Klein, Calderwood, & Clinton-Cirocco, 1986) was originally developed based on observations of firefighter decision making. The researchers set out to show how experienced fireground commanders did not have the luxury of time to compare several options when fighting a fire. Instead, they hypothesized that the commanders would compare two options, one that was their intuitive "favorite" and one that they developed as a comparison to show that the favorite was better. The researchers were surprised by the findings. The subject-matter experts that they interviewed and observed said that they never made decisions. They just acted. In fact, the interview data showed that decisions were made, however, they were perceived by the firefighters to be just actions because multiple options were not directly compared.

The data from this and several other studies of naturalistic decision making, in domains ranging from wildland firefighting to system design to military command and control, indicate that in natural settings, experts typically use a recognition-primed strategy to make decisions. The observational and interview data indicate that 80–90 percent of difficult decisions are made in this fashion (see Klein, 1998, for a review of this research).

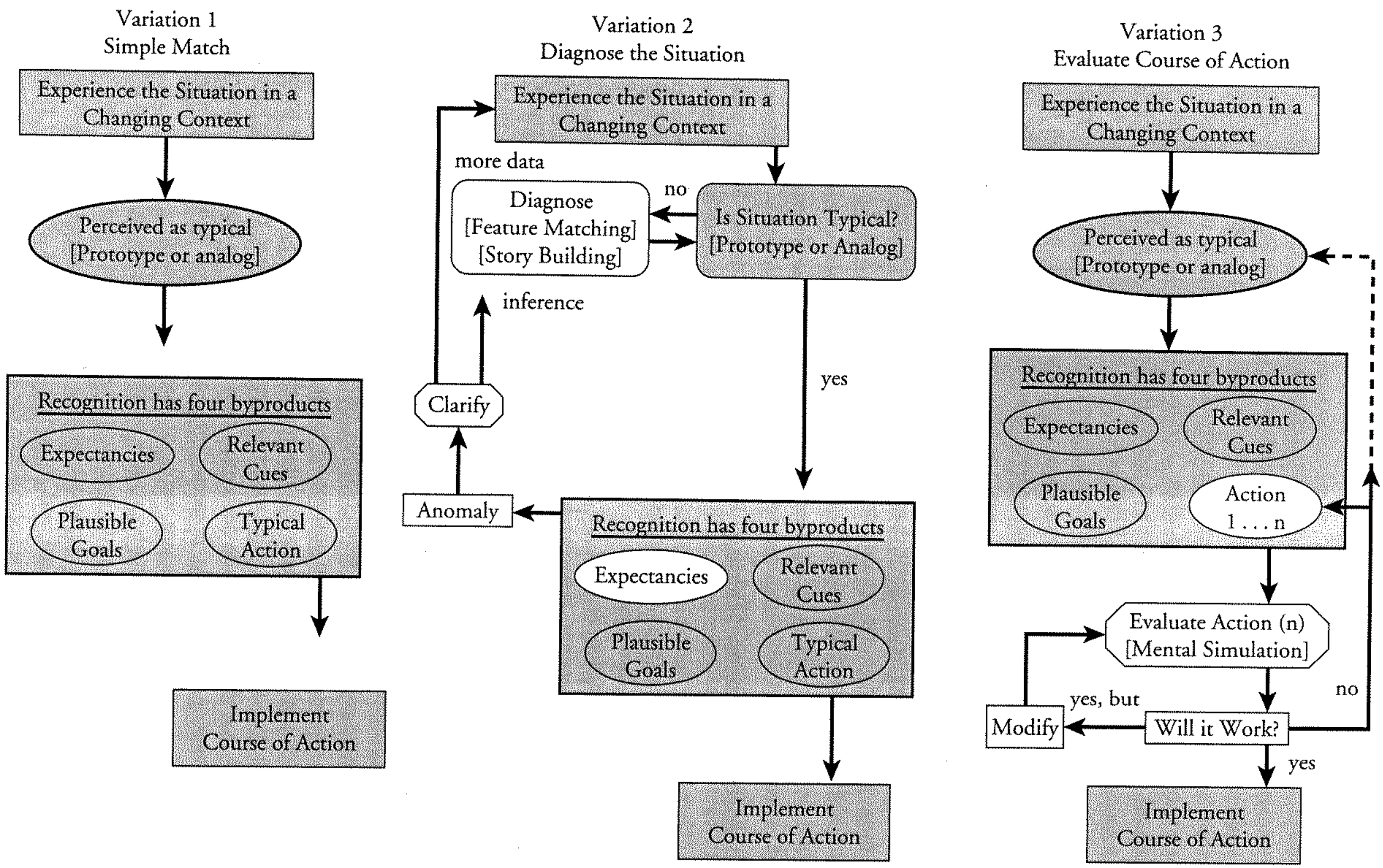

Figure 15.1 Recognition-primed decision model

These general findings have been replicated in several other domains (e.g., Fischhoff, 1996; Flin, Slaven, & Stewart, 1996; Mosier, 1991; Pascual & Henderson, 1997; Randel, Pugh, & Reed, 1996).

The basic explanation is that skilled decision makers make sense of the situation at hand by recognizing it as one of the prototypical situations they have experienced and stored in their long-term memory. This recognition match is usually done without deliberation. Once the decision makers have arrived at a recognition match, an appropriate course of action, or decision, becomes clear. This is Variation 1 of the RPD model. If the situation is familiar and judged to be routine, the decision is intuitive and automatic.

However, not all situations are that straightforward. Sometimes the decision maker runs up against a situation that is ambiguous or unfamiliar. The expert must then deliberate about the nature of the situation, often seeking additional information to round out the picture. In other cases it might be necessary to resolve an anomaly, or a piece of information that was not expected. This is Variation 2 of the RPD – the decision maker must actively work at generating an accurate assessment of the situation, but once that is accomplished, the course of action becomes obvious. Mental simulation may be used to construct a story of how the current situation has arisen, and the most plausible story then is treated as an explanation and as a basis for understanding the current dynamics.

In many cases, the decision maker seeks to evaluate the quality of the initial course of action suggested by a recognition match. This is Variation 3 of the RPD model. In these situations experts envision a plausible course of action and then use mental simulation to mentally "test" its effectiveness. If the first course of action is judged inadequate, then the decision maker develops a second course of action and mentally simulates it. This process continues until the decision maker finds a course of action that passes the test and is implemented.

An important attribute of expert decision makers is that they seek a course of action that is workable, but not necessarily the best or optimal decision. This "satisficing" concept was first described by Simon (1957). In naturalistic settings the time pressures often dictate that the situation be resolved as quickly as possible. Therefore it is not important for a course of action to be the best one; it only needs to be effective. Interestingly, we see satisficing behaviors in situations that are not subject to intense time pressures, such as system developers (Klein & Brezovic, 1986). The time and effort that could be spent generating and contrasting multiple options is instead spent in testing and critiquing and improving the initial options.

As can be seen, our theoretical views on expert decision makers share the basic premise of K&T's heuristics and biases research program. We agree that human decision making is qualitatively different from normative theories, and believe that this is so among experts as well as novices. There are also specific points of connection between the RPD model and the primary heuristics proposed by K&T, especially with respect to the importance of similarity and mental simulation. The RPD further moves beyond lists of heuristics by dealing with issues of representation and process that have largely been ignored in the heuristics program (cf. Smith & Osherson, 1989). From a practical stance, the critical implication is that expert decision makers are not better than novices because their processing literally begins to look more like that of normative theories. Instead, expertise leads to a broader and more refined set of heuristic processes that promote exceptional performance on the specific task domains to which they are attuned.

This broad view of expertise in JDM suggests a counterintuitive approach to improving decision making. The standard methods typically recommend that decision makers strive to develop domain-general decision skills with the goal of following processes that are closer to normative standards, and that eliminate biases (e.g., Hammond, Keeney, & Raiffa, 1999; Hogarth, 2001; Russo, Schoemaker, & Hittleman, 2001). Our proposal is far less radical. Instead of trying to dramatically revise decision processes, we seek merely to improve their quality by facilitating the development of substantive, domain-specific expertise. This is discussed presently.

Acquiring Decision-making Expertise

It has been noted by some that ten years is a sufficient span of time for individuals to acquire expertise in a given domain (e.g., Chase & Simon, 1973; Hayes, 1985). However, mere experience does not produce expertise. Serfaty et al. (1997), in their study of battle command expertise, found clear expert–novice differences in the quality, level of detail, and flexibility of the courses of action generated. Interestingly, high performance on this task was not correlated with years of experience, nor was it correlated with rank. This indicates that experts, more so than their equally experienced counterparts, may make better use of their experience. In a review of the literature, Klein (1998) identified four key ways in which experts learn:

1 engaging in deliberate practice, and setting specific goals and evaluation criteria;
2 compiling extensive experience banks;
3 obtaining feedback that is accurate, diagnostic, and reasonably timely; and
4 enriching their experiences by reviewing prior experiences to derive new insights and lessons from mistakes.

Along with these learning strategies, it is likely that motivational characteristics of the individual also impact the odds of performing at expert levels. For example, we have heard firefighters say that some individuals in their department are passionate about the job. They seek opportunities to learn and improve themselves through whatever means are available. They engage in lively conversations with other firefighters about their experiences. They attend conferences. They read extensively and practice on simulations. These are the people who tend to excel at their jobs. Then there are other firefighters who seem to have less motivation to learn. They seem to be happy clocking in and out and receiving a paycheck. They will never perform at the level of experts.

In addition to personal characteristics, the task domain influences a person's ability to achieve expertise (Shanteau, 1992; Stewart, Roebber, & Bosart, 1997). For example, in weather forecasting, where feedback on one's predictions happens on a daily basis, it is easy to obtain accurate and timely feedback. However, in a domain like clinical psychology, there is likely to be less opportunity for effective feedback (Klein, 1998). It may be impossible to achieve expert predictive or diagnostic ability in such a domain. Perhaps greater reliance on validated scoring rules presents a strategy for improving judgment and acquiring expertise in such high-variability settings (e.g., Sieck, 2003).

Within the confines of the personal and task characteristics presented above, how can people acquire expertise in judgment and decision making? Before we consider specific techniques, we need to distinguish specific versus general intuitions. We define *specific* intuitions as judgments related to a particular task within a domain. For example, contractors must repeatedly generate cost estimates for new projects, and they must estimate the time it will take to complete the project. People often seek to improve their intuitions about key, recurring decisions like these. Because such judgments are relatively discrete, they are amenable to isolation as targets for training. Much of the literature on quantity judgment, multiple-cue probability learning, and judgmental forecasting can be associated with this approach (e.g., Hammond, McClelland, & Mumpower, 1980; Lee & Yates, 1992; Wright & Goodwin, 1998). The advantage to exercising specific intuitions is the ease with which they can be identified – most professionals can articulate which of their decisions are both challenging and important. These intuitions can also be structured within a program of improvement. The disadvantage lies in the practicality of this approach; it is time-consuming and costly to address more than a few judgments in this manner.

We define *general* intuition as knowledge and experience within a particular domain, such as battle command or personnel management. Individuals seek to get better at their jobs, but "getting better" entails improving know-how across a broad range of judgments and actions. The battle commander must read the adversary's intentions and project his course of action, and integrate that with an understanding of his own resources and troop readiness, in order to affect mission accomplishment. And this is a simplistic description of the commander's job. At this broad level it is not realistic to rely on practice and feedback as a training approach due to the difficulty of isolating discrete tasks in order to produce a performance improvement. A different approach must be taken for general intuitions. We have derived six goals from the empirical findings reviewed earlier on expert and novice differences in knowledge and learning strategies, as follows:

1 enhance perceptual skills;
2 enrich mental models about the domain;
3 construct a large and varied repertoire of patterns;
4 provide a larger set of routines;
5 provide a larger experience base of instances; and
6 encourage an attitude of responsibility for one's own learning.

Our ongoing research indicates that a scenario-based instructional approach that addresses these six goals is a promising one for facilitating the development of decision-making expertise in a specific domain. For example, Phillips and Battaglia (2003) showed that a carefully designed series of decision scenarios combined with effective coaching can significantly increase decision quality. Further, Ross, Battaglia, Phillips, Domeshek, and

Lussier (in press) describe a similar training approach that targets and enriches the mental models pertinent to tactical thinking. However, both of these instances took place in single (or two, at most) sessions lasting only a few hours. There is a need to conduct research on the longitudinal development of intuitive decision skills, over a period of months or years, to better understand how to expedite the learning process.

One direct approach to improving specific judgments to facilitate the development of expertise is to establish a regimen of practice and feedback. This approach is the traditional way to strengthen skills that can be defined and for which progress can be monitored. Thus, to strengthen intuitions in a given area the prescription would be to practice the judgments and decisions, and then obtain feedback. While the "practice and feedback" approach sounds reasonable, in fact it is inadequate. It oversimplifies the learning need, and it may even be misleading in some contexts. What is wrong with "practice and feedback"? It is well documented that practice alone cannot affect performance improvement. Salas, Wilson, Burke and Bowers (2002) assert that practice without feedback is usually insufficient. "Task exposure, though beneficial, does not equate to learning" (p. 23). Schneider (1985) explains that many tasks can be identified where practice does not make perfect and may not lead to improvement if the trainee fails to obtain coaching about better strategies.

There are also problems with combining practice and outcome feedback. One issue with outcome feedback is that it is often inconsistent in judgment tasks that are even moderately variable, and many judgment researchers are not optimistic that outcome feedback will be effective in such situations. For example, Hammond, Summers, and Deane (1973) showed that in a multiple-cue probability learning task, providing outcome feedback actually resulted in lower performance compared to a group given no outcome feedback. In a review of the literature, Brehmer (1980) expressed extraordinary pessimism that in probabilistic tasks the provision of outcome feedback would result in substantial improvement in performance.

Fortunately, better forms of feedback can be made available. One form is cognitive feedback, which consists of information about the relations in the environment, relations perceived by the person, and relations between the environment and the person's perceptions. Cognitive feedback has been found to reliably improve performance on judgment tasks (Balzer, Doherty, & O'Connor, 1989). A related form of feedback is process feedback (Cannon-Bowers & Salas, 2001). Process feedback can inform people of necessary changes to their approach, whereas outcome feedback only indicates whether they tend to be improving or not.

Furthermore, to develop intuitive decision-making expertise, we can go beyond practice and feedback. We suggest three additional learning tactics. First, it can be informative for the learner to observe, interview, and/or study subject-matter experts in order to glean insights into why task accomplishment was successful for them. Interview methods exist that identify the heuristics and decision strategies, among other things, used by experts (e.g., Hoffman, Crandall, & Shadbolt, 1998; Klinger & Militello, 2001). The use of case studies is a predominant approach for studying and reflecting on decisions that were made under particular circumstances, and drawing lessons learned from them. Case studies can boost the vicarious experience base and enrich the mental models of the decision maker.

A second approach is to employ coaching as an adjunct to practice. Coaches can provide feedback, but good coaches can go further than that and facilitate the strengthening of the learner's intuitions. Ross et al. (in press) describe skilled tacticians functioning as coaches while the learner engages in a tactical simulation. The coaches in their study were attempting to build the students' mental models of small unit infantry tactics. To do so, they asked questions to direct the student's attention to a pertinent aspect of the simulation, and they asked questions to force the student to describe what was happening, what might happen next, and why. They probed as to how the student envisioned his or her own course of action impacting the situation, in order to reveal potential unintended consequences. All of these techniques contribute to a guided learning strategy whereby the coach facilitates the student in grasping the intricacies and dynamics of the tactical situation.

A third technique for building intuition is to present the learner with advance organizers, or previews of the instructional material, that direct attention to the relevant aspects, declarative information, and descriptions of mental models. However, these tools must be utilized in the context of actual or simulated practice. Feltovich et al. (1997) cautioned about the distortions that enter when people treat continuous processes as discrete, dynamic processes as static, simultaneous events as sequential, organic processes as mechanical, interactive processes as separable, conditional processes as universal, heterogeneous processes as homogeneous, and nonlinear processes as linear. Attempts to provide formal explanations may distort the phenomena, and instill faulty mental models. Schneider (1985) made the additional point that even acquiring an accurate mental model is not sufficient for using it well. Thus, we can obtain a good mental model of a manual transmission, but that will not translate into smooth decision making about when to shift gears while driving. The need is to couple the advanced organizers and documentation of the task with the practice sessions so that the learner can apply the information in context and generate a more accurate mental model around its meaning.

To summarize, we believe it is possible to facilitate the acquisition of decision-making expertise in specific domains with well-structured, scenario-based training sessions. It is prudent at this stage to incorporate what has been learned by judgment researchers with the efforts of naturalistic researchers to assist the acquisition of expertise. By building on the findings from both frameworks we can design additional research to better understand the development of skilled judgment and decision making.

Conclusion

The study of expertise in JDM is important for several reasons. At a theoretical level, we believe that the blending of naturalistic and laboratory-based research can generate a variety of lawful relationships. For example, the RPD model has led to a set of hypotheses about lawful relationships: First, that in most domains handled by experienced decision makers, most decisions will be made using recognitional strategies, rather than an analytic comparison of courses of action (Klein, 1998). Second, as people gain experience, they make more decisions relying on recognitional matches rather than comparison of courses of action (Klein, 1998). Third, for decision makers with even moderate experience, the first option they generate is usually satisfactory (Johnson & Raab, 2003; Klein, Wolf, Militello, & Zsambok, 1995). Fourth, options are more likely to be evaluated using mental simulation than by comparing the options on a generic set of criteria (Klein & Crandall, 1995). Fifth, as decision makers gain experience, they shift from spending most of their time examining options, to spending the majority of their time assessing the situation (Kobus et al., 2000). To date, the supporting evidence for these propositions comes largely from the field. Extensive laboratory research is needed to further test, refine, and possibly reject these and alternative hypotheses.

We also see great practical implications for studying expertise in JDM. It is important to understand the components of expertise to better prepare novices and less experienced individuals to become more expert and build their intuitions. Several researchers and practitioners are applying models of expertise to generate training interventions to help people acquire skill and knowledge more quickly. The goal is to move people up the learning curve at a faster rate by giving them low- and high-fidelity simulations to deliberately practice decisions and judgments. These simulations and their lessons learned help the individual form a base of experience and more complete mental models of the domain (Phillips & Battaglia, 2003; Pliske, Klinger, Hutton, Crandall, Knight, & Klein, 1997; Pliske, McCloskey, & Klein, 2001; Ross et al., 2003; US Army Research Institute, 2001). There are also many implications for Artificial Intelligence (AI) and system designers with regard to what human capabilities can and cannot be replicated by a computer. While systems are good at rule-based tasks, they cannot approximate human judgment when it comes to highly complex cognitive tasks. It is also important to know exactly what humans are capable of and how they do it, so that we can make better choices about how to design effective and acceptable systems to aid human decision making (Hutton, Miller, & Thordsen, 2003; Yates, Veinott, & Patalano, 2003).

Potentially interested JDM laboratory researchers will need to take several steps to make this happen. First, they must push beyond the most dominant experimental paradigms that are currently in fashion. This entails giving up the security and comfort that comes with further replication of old biases or striving to discover new ones. Examination of paradigms from experimental work on expertise outside the JDM area may provide a useful starting point. It also means giving up some of the statistical tightness of results to which most experimental psychologists have become accustomed. Schunn & Anderson (1999) provide guidelines on standards of evidence for research with experts that may facilitate individual thinking, as well as publication decisions. Finally, it is imperative to develop and maintain connections with subject matter experts, and be open to learning about the actual judgment and decision problems that they face. None of this is easy, but we feel strongly that the potential theoretical and practical gains to the JDM field are enormous.

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