The Psychology of Experts:

An Alternative View

James Shanteau

Department of Psychology

Bluemont Hall 492

Kansas State University

Manhattan, Kansas 66506

(PH: 785/532-0618)

(FAX: 785/532-5401)

(E-MAIL: shanteau@ksu.edu)

In, G. Wright & F. Bolger (Eds.), *Expertise and Decision Support*. Plenum Press, NY, 1992. (pp. 11-23).

Introduction

"Trust one who has gone through it" (Virgil).

"No lesson seems to be so deeply inculcated by the experience of life as that you never should trust experts" (Lord Salisbury).

"There are not competent people enough in the world to go round." (George Bernard Shaw).

These quotes illustrate two facts: First, the topic of experts and expertise is of interest to many writers, both in literature and in science. Second, these writers disagree about the value of advice from experts. The goal of this paper is to explore the issue of expertise from a psychological perspective and to use that perspective to provide insights into the differing views of experts.

The paper is organized into five sections. The first section describes the prevailing view of experts in judgment and decision making research. The second outlines the view on experts in cognitive science research. The next describes a "third view" based, in part, on my studies of experts. The fourth contains some observations about common psychological characteristics and strategies of experts. The final section considers implications of these observations for expert systems.

Experts as Viewed in Decision-Making Research

The first known analysis of experts was by Hughes in 1917 for agricultural judges. He found that grain rated highest by corn judges did not always produce the highest crop yields (a result largely supported in a later reanalysis by Wallace, 1923). More recently, Trumbo, Adams, Milner, and Schipper (1962) studied the validity (accuracy) and reliability (repeatability) of wheat judges. Nearly one-third of the samples were misgraded and more than one-third of the samples were graded differently when judged a second time. Finally, more experienced judges were more confident but not necessarily any more accurate.

Comparable findings were reported in studies of soil judges by Shanteau and Gaeth (1981; also see Foss, Wright, & Coles, 1975; Gaeth & Shanteau, 1979). Slightly less than half the assessments agreed with laboratory results (where chance is roughly 8%). Reliability of repeated judgments was 50%.

Such validity and reliability results are not unique to agricultural judgments. Psychological analyses of medical diagnosticians (Einhorn, 1974), clinical psychologists (Oskamp, 1962), parole officers (Carroll & Payne, 1976), and court judges (Ebbesen & Konecni, 1975) show that experts are often inaccurate and unreliable. Moreover, the experience of judges is not related to their judging ability (Meehl, 1954).

The conclusion from this research is that experts are inadequate decision makers. That has been reinforced in recent studies (e.g., Chan, 1982) which have reported deficiencies in calibration (subjective-objective comparability) and coherence (internal consistency) of probability judgments. Furthermore, experts are apparently unaware of these various shortcomings.

Another approach to characterizing expert judgment has been to look at the amount of information used in making decisions. Presumably, experts should use all relevant information. Many studies, however, have reported that expert judgments are based on surprisingly little

information. Court judges, for instance, have been observed to use only one to three factors in sentencing defendants (Ebbesen & Konecni, 1975); medical pathologists have been reported to be equally limited (Einhorn, 1974).

One reason for the limited use of relevant information is that experts are often influenced by irrelevant information. Soil judges, for example, have been observed to be influenced by irrelevant materials in soils (Gaeth & Shanteau, 1984). Similar findings have been reported in studies of nurses (Shanteau, Grier, Johnson, & Berner, 1981) and personnel selection (Nagy, 1981). This implies that decisions are made without an adequate differentiation between what is relevant and what is irrelevant. If so, it should not be surprising that expert decisions are often inaccurate, unreliable, and biased.

One frequent explanation for this low level of performance is that experts reportedly rely on heuristics (mental rules of thumb) in making judgments. These heuristics often lead to biases or judgmental errors. Similar biases have been observed for both novice and expert decision makers (Kahneman, Slovic, & Tversky, 1982). "Numerous studies show that people – including experts – have great difficulty judging probabilities, making predictions, and otherwise attempting to cope with uncertainty. Frequently these difficulties can be traced to the use of judgmental heuristics" (Slovic, Fischhoff, & Lichtenstein, 1985).

Altogether, previous decision making research has painted a bleak picture of the abilities of experts. It is difficult to find studies cited in the literature that have anything positive to say about experts (Christensen-Szalanski & Beach, 1984).

Experts as Viewed in Cognitive Science Research

A quite different view of experts has emerged from research in cognitive psychology (Anderson, 1981). Studies within this tradition have revealed novice-expert differences in nearly every aspect of cognitive functioning, from memory and learning to problem solving and reasoning. Chess masters, for instance, have been found to perceive patterns of play more effectively (deGroot, 1965) and to have superior memory for chess positions (Chase & Simon, 1973). Analyses of experts in mathematics, physics, and computer programming produced similar demonstrations of expert skill (Mayer, 1983).

Three general themes have emerged from this body of research. First, expertise is domain specific. Any special skills of an expert are lost outside his/her area of expertise. An expert's cognitive processes are tailored to the unique characteristics of a particular problem area. For instance, novices have been found to reason backwards from the unknowns to the givens. Experts, in contrast, reason forwards using stored "functional units" from the givens to the goal (Larkin, 1979). This forward reasoning ability only develops in specific domains. Thus, the thinking of experts becomes "domain adapted" (Slatter, 1987).

Second, the thinking of experts relies more on automated processes (Shiffrin & Schneider, 1977). Automated processes are often parallel and function independently, somewhat like visual perception or pattern recognition. Controlled processes, on the other hand, are linear and sequential, more like deductive reasoning. With practice, some control processes may become automatized over

time (Larkin, McDermott, Simon, & Simon, 1980). As they gain experience, experts come to rely less on deductive thinking and more on pattern-recognition like thinking.

Third, expert thinking is reflected by and can be studied through verbal protocols. By asking experts to think aloud, qualitatively rich accounts of an expert's reasoning becomes available (Ericsson & Simon, 1980). Protocol analysis is commonly used to provide raw data for the construction of expert systems. A verbal protocol of an expert, for example, can be used to infer (1) factual relationships and (2) production rules. In expert systems, these corresponds to (1) the knowledge base and (2) the inference engine (Slatter, 1987).

In total, the cognitive science view is that experts within their domains are skilled, competent, and think in qualitatively different ways from novices (Anderson, 1981; Chi, Glaser, & Farr, 1988). This skill provides a sufficient basis for building expert systems (Coombs, 1984).

A Third View of Experts

My research on expert decision makers began in the mid-1970's with analyses of livestock judges (Phelps & Shanteau, 1978; Shanteau & Phelps, 1977). Based on previous decision research, my expectation was that these judges would be as limited as other experts had been reported to be. Indeed, this research showed that the decisions of livestock judges were sometimes unreliable and did not always match up to standards. Nonetheless, livestock judges were careful, skilled, and knowledgeable decision makers. Despite the evidence of cognitive limitations, these experts seemed able to make effective judgments. Since then, my emphasis has been on exploring the factors that lead to competent performance in experts. The research question has been: Under what conditions do experts do well and under what conditions do they do poorly?

My research on this question has examined a variety of experts: auditors, personnel selectors, registered nurses, soil judges, and business managers. Although this research has led to many insights about experts (e.g., Ettenson, Shanteau, & Krogstad, 1987; Krogstad, Ettenson, & Shanteau, 1984), it is not the goal here to review specific research findings. Rather, the present paper reflects observations and insights gained about experts while conducting these studies.

My view is that experts are neither as deficient as suggested in the decision making literature nor as special as implied by the cognitive science perspective. Instead, the skills and abilities that emerge (or don't emerge) in experts depend on the situation in which they work. Experts sometimes perform competently and make difficult decisions well, as is true for weather forecasters (Murphy & Winkler, 1977). Other experts seem incapable of performing much above the level of novices, as is reportedly the case for clinical psychologists (Oskamp, 1962).

The relationship between topic area and decision performance is illustrated in Table 1. The left side of the table lists judgment domains in which good performance has been observed. The right side lists domains in which poor or deficient performance has been reported. Except for physicians (shown on both sides), the literature in each field is clear about the level of competence. The ques-

tion then is: What is in common about the tasks listed on each side?

My original answer (Shanteau, 1987) was that domains where good performance has been observed involve decisions about objects or things. Thus, the experts are being asked to evaluate and make decisions about something that is relatively constant. Where poor performance is observed, the decisions involve human behavior. Thus, experts are being asked to evaluate and decide about what is, in effect, a moving target.

Other insights have been offered about this table. Dawes (1987), for instance, observed that predictability is different for the two sides: human behavior is inherently less predictable than physical stimuli. Dawes also noted that the level of competence expected by clients (or the public) varies for the two sides. Clinical psychologists, for example, are expected to always be correct, whereas weather forecasters are allowed to make an occasional mistake. Paradoxically, in the less predictable behavior domains, experts often are held to a higher standard of performance.

One final distinction involves opportunity to improve based on feedback. With left-side domains, there are more chances to learn from past decisions. Based on previous successes and failures, an expert can better his/her decisions. With right-side domains, in contrast, there appear to be fewer chances to learn. Thus, opportunity to improve is less.

In summary, my alternative third view holds that the performance of experts is not uniformly good or bad. Rather, the level of performance depends on the problem type and the task constraints. Any conclusions about the skills of experts must take domain into account.

Psychological Characteristics of Experts

From studying and interacting with experts, my students and I observed that experts in various domains often display similar psychological characteristics. These appear to reflect what Goffman (1959) described as "self presentation" – the creation and maintenance of a public image. Beyond that, these characteristics are part of a decision style common to many experts. This section contains a description of several of these psychological traits (also, see Shanteau, 1984, 1987, 1989).

Without exception, every expert we have studied has an extensive and up-to-date content knowledge. They know a lot and pride themselves in staying up with the latest developments in their field. One recently retired agronomy expert commented that he felt unqualified to help on a research project because he had not kept up in the past few months (Gaeth, 1980). This was despite his having been a leading expert for nearly 40 years!

The two prevailing views of experts offer differing perspectives on knowledge. In decision making, role of knowledge is seldom mentioned in discussions of processing limitations of experts. The cognitive science literature, in contrast, focuses almost exclusively on expert knowledge in various forms. My alternative view is that knowledge is a necessary, but not sufficient condition for expertise. The rest of this section examines nine other characteristics of experts.

First, experts have highly developed perceptual/attention abilities. They can extract information that non-experts either overlook or are unable to extract. When

Phelps (1977) presented already detailed information to novice livestock judges, they made decisions that were nearly as good as experts. The difference was that expert livestock judges could see patterns of information that novices could not.

Second, experts have a sense of what is irrelevant when making decisions. The assessment of relevance can be quite difficult and experts have been observed to use irrelevant information to their detriment. Nonetheless, expert soil judges are better than novices in distinguishing relevant from irrelevant materials (Shanteau & Gaeth, 1981). When trained to make explicit distinctions between relevant and irrelevant, the decisions of novice soil judges were found to improve (Gaeth & Shanteau, 1984).

Third, experts have an ability to simplify complex problems. As one medical specialists commented, "an expert is someone who can make sense out of chaos." In part, this is related to the superior pattern recognition abilities reported for game-playing experts, such as chess masters (deGroot, 1965). There is more involved, however. Professional personnel selectors, for example, have an enhanced ability to get at the crux of an issue (Shanteau & Nagy, 1984). This allows experts to deal more effectively with the cognitive limitations experienced by all humans.

Fourth, experts can communicate their expertise to others. An expert's credibility depends on the ability to convince others of that expertise. As one manager put it, "an expert is anyone who can persuade someone else that he (she) is an expert" (Dino & Shanteau, 1984). In fact, experts who are unable to communicate their expertise are viewed as inferior. This can be self-fulfilling because poor communicators are not given the opportunity to make decisions and to show their skills.

Fifth, experts handle adversity better than non-experts. Even when things are not going well, experts continue to make effective decisions. Novices have yet to learn the saying of professional musicians: "If you are going to make a mistake, make a good one and get on with it." That is, there is no point in worrying about past errors; you have to keep functioning (Shanteau, 1987). This may account for the superior ability of experts to work under stressful conditions (Dino, Shanteau, Binkley, & Spenser, 1984).

Sixth, both experts and novices can follow established strategies when the decision problems are straightforward. Experts, however, are better at identifying and adapting to exceptions. Shanteau & Phelps (1977) found that expert livestock judges were likelier to have single-case deviations in their decision patterns. When exceptions are encountered, experts could generate meaningful special-situation strategies. In contrast, novices often persist in following well-established rules, even when inappropriate.

Seven, almost all experts show strong self-confidence in their decision making. One widely-respected agricultural judge when confronted with an inconsistent decision about which of two animals was best-of-show said: "There must have been two grand champions." That is, the source of any inconsistency resides elsewhere besides the expert (Shanteau & Phelps, 1977). Although this might be viewed as arrogance, it comes across more as a highly-developed faith in one's own abilities. Experts really do believe in themselves and their capacity to make good decisions.

Eight, experts know how and when to adapt their decision strategies to changing task conditions. A well-regarded agricultural judge noted that one of the biggest difficulties in teaching students is "their persistence in using inflexible and outdated standards" (Phelps, 1977). Expert decision makers, in contrast, recognize that conditions change and that they may need to adapt their strategies accordingly. Of course, changing strategies prematurely can be just as bad as being resistant to change. The key is to know when to adapt and when not to.

Finally, experts have a strong sense of responsibility and a willingness to stand behind their recommendations. Experts make it clear to others – "this is what I have decided." Of course, experts must live at times with decisions that are shown later to be incorrect. However, the sense of responsibility helps expert nurses, for instance, avoid letting bad outcomes disrupt later decisions. Novice nurses, in contrast, often have difficulty continuing after a decision turns out poorly.

Psychological Strategies of Experts

In our studies of experts, we have observed the use of various formal and informal decision strategies. Although many of these strategies are domain or problem specific, several have been found in common use. These strategies have the effect of helping experts overcome cognitive limitations. Five such strategies are described here.

First, experts are willing to make continuous adjustments in initial decisions. They use feedback in dynamic environments to avoid adherence to rigid decision strategies (also see Hogarth, 1981). Blind commitment to initial choices is characteristic of non-experts. The best decision makers have learned that making improvements is more important than being consistent.

Second, experts get help from others to make better decisions. They seldom work in isolation, but either operate in a group or seek out feedback from others. This leads to consultation with colleagues and subordinates to gain added insights, especially for tough cases. Group interaction has been reported by Sniezek and Henry (1987) to increase judgmental accuracy and confidence. Experts seem aware that isolation from associates can lead to inferior decisions.

Third, experts often make use of formal or informal decision aids. These aids help avoid the biasing effects associated with judgment heuristics. Livestock judges, for instance keep written records of prior decisions (Shanteau & Phelps, 1977); this has the effect of reducing hindsight biases resulting from memory errors (Fischhoff, 1975). Edwards and von Winterfeldt (1986) argue that experts, of necessity, will adopt whatever aids are needed to assist their decision making. The "unaided expert" may be an oxymoron.

Fourth, although experts may make small errors, they try to avoid making large mistakes. They operate as though coming close is generally good enough. The focus is not on being exactly right, but on avoiding making bad decisions. Experts often use a dual strategy of first making a "ball park" estimate, and then conducting a more careful analysis. By concentrating on getting close, experts avoid making sizable errors. The loss function for experts apparently is flat around the maximum, but falls off rap-

idly for larger deviations (Shanteau, 1989).

Finally, experts follow some sort of divide-and-conquer strategy. They break large problems into simpler parts, work on the parts, and then put the pieces back together. The specifics depend on the domain, but all the types of experts we have studied have developed ways of separating complex decisions into manageable parts. Interesting, although this approach is prescribed in decision analysis (e.g., Gardiner & Edwards, 1975), experts appear to have developed this strategy on their own.

Implications for Expert Systems

Using techniques from artificial intelligence, expert systems are increasingly being proposed to aid or even replace skilled decision makers. According to Kolodner (1984), the goal is to build systems which "contain all or most of the compiled knowledge an expert has." Some argue that eventually expert systems will provide "replacements for humans" (Cebrzynski, 1987).

However, getting experts to interact with these systems has proved difficult (Michie, 1982). There are several potentially valuable expert systems, such as MYCIN, which are either unused or misused by the very people the systems were designed to help (Ham, 1984). Other examples involve extended efforts to develop expert systems that had to be abandoned, in part because of questions about the cooperativeness of experts (Rose, 1988).

At the same time, there has been debate about whether computer systems can mimic experts successfully (e.g., Graubard, 1988). Most investigators see great potential for expert systems (Barrett & Beerel, 1988: Slatter, 1987), although others question whether that potential can ever be realized (Dreyfus & Dreyfus, 1986; Haugeland, 1985).

The analyses of experts here may contribute to a greater understanding of when and where expert systems are likely to be useful. Domain knowledge and experience are clearly necessary for expertise; having the facts and relevant experience are essential for any expert (Naylor, 1987). Nonetheless, knowledge is not sufficient for expertise. By concentrating on knowledge and production rules, other aspects of expertise might be overlooked by cognitive scientists and builders of expert systems.

There is something more to experts, something the writer Tom Wolfe (1979) described as the "Right Stuff." According to Wolfe' s account of test pilots, "the idea was to prove...that you might be able to join the special few at the very top, that elite who had the capacity to bring tears to men' s eyes, the very Brotherhood of the Right Stuff itself."

What is the "Right Stuff?" Chuck Yeager (1985) answers as follows: "The question annoys me because it implies that a guy who has ' the right stuff' was born that way.... All I know is I worked my tail off to learn how to fly, and worked at it all the way." Beyond these descriptions, both Wolfe and Yeager leave the question of defining "Right Stuff" unanswered.

I believe the psychological characteristics and strategies described here are major components of the right stuff. Without these, an expert could not function and would not be recognized as an expert. Others have come to similar conclusions from different perspectives (Benner, 1984).

Can an expert system be built that incorporates these characteristics? Not enough is known yet to answer this question. But the following, at least, would seem necessary to build such a system. First, expertise must be looked at from the perspective of experts, not as something to be defined within the constraints of available hardware and software. Second, experts cannot be expected to explain everything they do; verbal protocols are inefficient (Hoffman, 1987) and may be misleading when capturing expertise. Third, more emphasis should be placed on the psychology of experts when building expert systems; characteristics such as confidence and communication must be incorporated into these systems, not removed from them. Lastly, as suggested by Table 1, different types of expert system may be needed to reflect object expertise (left side) and behavior expertise (right side). The traditional knowledge engineering methods may be well suited for the former, while linear decision models may be better suited for the latter.

Concluding Comments

In his insightful book, Golde (1970) states that "we seem to expect too much and the wrong things of our experts." We expect that experts will "know just what' s wrong and exactly what to do about it," i.e., that experts can find the right answers. The power of professionals, according to Golde, is "much less than we believe.... Miracles are rare and difficult problems cannot be made simply to disappear." Although "an expert does sometimes make decisions, his role is usually much more that of an advisor." A more realistic view of what an expert can do is the following:

> He' ll attempt to uncover the real problem, which is probably different and more complex than I imagined. He ought to develop some alternative courses of action and outline their relative merits or risks. He won' t be able to do everything himself, but he' ll let me know the kinds of decisions or actions I must take. (Golde, 1970).

This view of experts describes what they do and how they perceive themselves. For the most part, such a view has yet to be reflected in the scientific literature on experts.

Author Notes

The research described in this paper was supported in part by grants from the Army Research Institute, the Department of Health and Human Services, and the Bureau of General Research at Kansas State University. I wish to thank Gary Gaeth, Geri Dino, and Richard Ettenson for their insightful contributions during the initial phases of this research. This chapter was prepared while the author was serving as Director of the Decision, Risk, and Management Science Program at the National Science Foundation.

Requests for copies of the cited research can be obtained from: James Shanteau, Department of Psychology, Bluemont Hall, Kansas State University, Manhattan, KS 66506-5302.

References

Anderson, J.R. (1981). Cognitive skills and their acquisition. Hillsdale, N.J.: Erlbaum.

Barrett, M.L., & Beerel, A.C. (1988). Expert systems in business: A practical approach. Chichester, G.B.: Ellis Horwood (Halsted).

Benner, P. (1984). From novice to expert: Excellence and power in clinical nursing practice. Reading, MA: Addison-Wesley.

Carroll, J.S., & Payne, J.W. (1976). The psychology of parole decision process: A joint application of attribution theory and information-processing psychology. In J.S. Carroll & J.W. Payne (Eds.), Cognition and social behavior. Hillsdale, N.J.: Erlbaum.

Cebrzynski, G. (1987, February 27). Experts systems are seen as replacements for humans. Marketing News, 21 (5), 1.

Chan. S. (1982). Expert judgments made under uncertainty: Some evidence and suggestions. Social Science Quarterly, 63, 428-444.

Chase, W.G., & Simon, H.A. (1973). Perception in chess. Cognitive Psychology, 4, 55-81.

Chi, M.T.H., Glaser, R., & Farr, M.J. (1988). The nature of expertise. Hillsdale, N.J.: Erlbaum.

Christensen-Szalanski, J.J.J., & Beach, L.R. (1984). The citation bias: Fad and fashion in the judgment and decision making literature. American Psychologist, 39, 75-78.

Coombs, M.J. (1984). Developments in expert systems. London: Academic Press.

Dawes, R.M. (1987). Personal comm.

deGroot, A.D. (1965). Thought and choice in chess. The Hague: Mouton.

Dino, G.A., & Shanteau, J. (1984). What skills do managers consider important for effective decision making? Paper presented at the Psychonomic Society meeting, San Antonio.

Dino, G.A., Shanteau, J., Binkley, M., & Spenser, A. (1984). The detrimental effects of environmental stress on creativity. (Tech. Rep. 84-2). Manhattan: Kansas State University, Department of Psych.

Dreyfus, H.L., & Dreyfus, S.E. (1986). Mind over machine. N.Y.: The Free Press.

Ebbesen, E., & Konecni, V. (1975). Decision making and information integration in the courts: The setting of bail. Journal of Personality and Social Psychology, 32, 805-821.

Edwards, W., & von Winterfeldt, D. (1986). On cognitive illusions and their implications. Southern California Law Review, 59(2), 401-451.

Einhorn, H. (1974). Expert judgment: Some necessary conditions and an example. Journal of Applied Psychology, 59, 562-571.

Ericsson, K., & Simon, H.A. (1980). Verbal reports as data. Psychological Review, 87, 215-251.

Ettenson, R., Shanteau, J., & Krogstad, J. (1987). Expert judgment: Is more information better? Psychological Reports, 60, 227-238.

Fischhoff, B. (1975). Hindsight • foresight: The effect of outcome knowledge on judgment under uncertainty. Journal of Experimental Psychology: Human Perception and Performance, 1, 288-299.

Foss, J.E., Wright, W.R., & Coles, R.H. (1975). Testing the accuracy of field textures. Soil Science Society of American Proceedings, 39, 800-802.

Gaeth, G.J. (1980). A comparison of lecture and interactive training designed to reduce the influence of interfering materials: An application to soil science. Unpublished Masters' Thesis, Kansas St. Univ.

Gaeth, G.J., & Shanteau, J. (1979). Analysis of the Soil Survey Laboratory data and description for some soils of Kansas. (Tech. Rep. 79-11). KSU, Dept of Psych.

Gaeth, G.J., & Shanteau, J. (1984). Reducing the influence of irrelevant information on experienced decision makers. Organizational Behavior and Human Performance, 33, 263-282.

Gardiner, P.C., & Edwards, W. (1975). Public values: Multi-attribute utility measurement in social decision making. In, M. Kaplan & S. Schwartz (eds.), Human judgment and decision processes. N.Y.: Academic Press.

Goffman, E. (1959). The presentation of self in everyday life. N.Y.: Doubleday.

Golde, R.A. (1970). Can you be sure of your experts? N.Y.: Award Books.

Graubard, S.R. (Ed.). (1988). The artificial intelligence debate: False starts, real foundations. Cambridge, MA: MIT Press.

Ham, M. (1984, January). Playing by the rules. PC World, 34-41.

Haugeland, J. (1985). Artificial intelligence: The very idea. Cambridge, MA: MIT Press.

Hoffman, R.R. (1987, Summer). The problem of extracting the knowledge of experts from the perspective of experimental psychology. AI Magazine, 53-67.

Hogarth, R.M. (1981). Beyond discrete biases: Functional and dysfunctional aspects of judgmental heuristics. Psychological Bulletin, 90, 197-217.

Hughes, H.D. (1917). An interesting corn seed experiment. The Iowa Agriculturalist, 17, 424-425.

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

Kolodner, J.L. (1984). Towards an understanding of the role of experience in the evolution from novice to expert. Developments in Expert Systems, 95-116.

Krogstad, J.L., Ettenson, R.T., & Shanteau, J. (1984). Context and experience in auditor' s materiality judgments. Auditing: A Journal of Practice and Theory, 4, 54-73.

Larkin, J.H. (1979). Information processing and science instruction. In J. Lochhead & J. Clement (Eds.), Cognitive process instruction. Philadelphia: Franklin Institute Press.

Larkin, J.H., McDermott, J., Simon, D.P., & Simon, H.A. (1980). Expert and novice performance in solving physics problems. Science, 208, 1335-1342.

Mayer, R.E. (1983). Thinking, problem solving, cognition. N.Y.: Freeman.

Meehl, P. (1954). Clinical versus statistical prediction: A theoretical analysis and a review of the evidence. Minneapolis: University of Minnesota Press.

Michie, D. (1982). Introductory readings in expert systems. N.Y.: Gordon & Breach

Murphy, A.H., & Winkler, R.L. (1977). Can weather forecasters formulate reliable forecasts of precipitation and temperature? National Weather Digest, 2, 2-9.

Nagy, G.F. (1981). How are personnel selection decisions made? An analysis of decision strategies in a simulated personnel selection task. Unpublished Doctoral Dissertation, Kansas State University.

Naylor, C. (1987). Build your own expert system. (2nd ed.). N.Y.: Halsted Press.

Oskamp, S. (1962). The relationship of clinical experience and training methods to several criteria of clinical prediction. Psychological Monographs, 76.

Phelps, R.H. (1977). Expert livestock judgment: A descriptive analysis of the devel-

opment of expertise. Unpublished Doctoral Dissertation, Kansas State University.

Phelps, R.H., & Shanteau, J. (1978). Livestock judges: How much information can an expert use? Organizational Behavior and Human Performance, 21, 209-219.

Rose, F. (1988, August 12). Thinking machine: An ' electronic clone' of a skilled engineer is very hard to create. The Wall Street Journal, 14.

Shanteau, J. (1984). Some unasked questions about the psychology of expert decision makers. In M.E. El-Hawary (ed.), Proceedings of IEEE Conference on Systems, Man, and Cybernetics. N.Y.: IEEE.

Shanteau, J. (1987). Psychological characteristics of expert decision makers. In J.L. Mumpower, O. Renn, L.D. Phillips, & V.R.R. Uppuluri (eds.), Expert judgment and expert systems. Berlin: Springer-Verlag.

Shanteau, J. (1989). Psychological characteristics and strategies of expert decision makers. In B. Rohrmann, L.R. Beach, C. Vlek, & S.R. Watson (Eds.), Advances in decision research. Amsterdam: North Holland.

Shanteau, J. & Gaeth, G.J. (1981). Evaluation of the field method of soil texture classification: A psychological analysis of accuracy and consistency. (Tech. Rep. 79-1). Kansas State University, Department of Psychology.

Shanteau, J., Grier, M., Johnson, J., & Berner, E. (1981). Improving decision making skills of nurses. In, ORSA-TIMS Proceedings. Houston; ORSA-TIMS.

Shanteau, J. & Nagy, G.F. (1984). Information integration in person perception: Theory and application. In M. Cook (Ed.), Issues in person perception. London: Methuen.

Shanteau, J. & Phelps, R.H. (1977). Judgment and swine: Approaches and issues in applied judgment analysis. In M.F. Kaplan & S. Schwartz (Eds.), Human judgment and decision processes in applied settings. New York: Academic Press.

Shiffrin, R.M. & Schneider, W. (1977). Controlled and automatic human information processing: II. Perceptual learning, automatic attending, and a general theory. Psychological Review, 84, 127-190.

Slatter, P.E. (1987). Building expert systems: Cognitive emulation. Chichester, G.B.: Ellis Horwood.

Slovic, P., Fischhoff, B., & Lichtenstein, S. (1985). Regulation of risk: A psychological perspective. In R. Noll (Ed.), Social science and regulatory policy. Berkeley: University of California Press.

Sniezek, J.A., & Henry, R.A. (1987). Accuracy, confidence, and commitment in consensus group estimates of prices. Unpublished manuscript, University of Illinois.

Soil Survey Laboratory. (1966). Soil survey data and descriptions for some soils of Kansas. (Soil Survey Investigation Report 4). Washington, D.C.: USDA.

Trumbo, D., Adams, C., Milner, M., & Schipper, L. (1962). Reliability and accuracy in the inspection of hard red winter wheat. Cereal Science Today, 7.

Wallace, H.A. (1923). What is in the corn judge' s mind? Journal of the American Society of Agronomy, 15, 300-324.

Wolfe, T. (1979). The right stuff. N.Y.: Farrar Straus Giroux.

Yeager, C. & Janos, L. (1985). Yeager: An autobiography. Toronto: Bantam Books.

Table 1.

Domains in which good decision performance have been observed and in which poor performance has been observed.

Domains With Good Performance	Domains With Poor Performance
Weather Forecasters	Clinical Psychologists
Livestock Judges	Psychiatrists
Soil Judges	Court Judges
Auditors	Student Admissions
Chess Masters	Behavioral Researchers
Physicists	Counselors
Mathematicians	Personnel Selectors
Accountants	Parole Officers
Insurance Analysts	Stock Brokers
Physicians	Physicians