Expert Judgment and Financial Decision Making

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Abstract

The purpose of this paper is to consider expertise in financial decision making based on insights gained from behavioral research on auditors. Five questions have been central to this research: (1) How consistent are experts? (2) Do experts agree? (3) How much information does an expert use? (4) Are experts biased? (5) What do experts think about expertise? Research on each of these questions is reviewed. Next, implications are considered for (a) comparisons between experts and non-experts, (b) contrasts between different domains of expertise, (c) the role of experts in groups, and (d) development and use of expert systems.

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Introduction

Experto credito (Virgil, 19 BC)

No lesson seems to be so deeply inculcated by the experience of life as that you never should trust experts (Lord Salisbury, 1877)

These quotes illustrate two points: The issue of expert competence has been of interest to writers for nearly two thousand years. And there has been over two thousand years of disagreement about whether experts should be trusted or not.

The purpose of this paper is to explore these two issues from the perspective of behavioral research on auditing. Let me make it clear from the outset, however, that I am neither an accountant nor a financial expert. Rather, I am a behavioral researcher with an interest in asking questions about the psychology of expertise. What I want to do in this paper is to explore some partial answers to several critical questions.

The Definition of Expertise

In any consideration of expertise, it is essential to define what is meant by the term *expert*. Unfortunately, efforts by researchers to provide widely accepted definitions have proved elusive. There are now almost as many definitions of *expert* as there are scholars in the field (Shanteau, 1993). And there are equally many definitions of the other stages below expert, such as *novice* (Hoffman, et al, 1995).

As a starting point for definitions, I consulted Webster's (1979) dictionary. *Expert* means "having, involving, or displaying special skill or knowledge derived from training or experience." For comparison, *novice* is defined as "a person admitted to probationary membership in a religious community." Lastly, *naive* means "a deficiency in worldly wisdom or informed judgment."

Two comments are appropriate about these definitions. The first is that *expert* and *experience* come from the same Latin root, *experiri*. This suggests to become an expert, a person must have and be able to use relevant experience. The second comment is that expertise describes a continuum ranging from *top expert* at one end to *naive* at the other. There are likely many degrees of expertise between.

These generic definitions from Webster's dictionary are consistent with distinctions I have advocated elsewhere (Shanteau, 1987). I believe only those who are the best at what they do deserve to be called *expert*. Unfortunately, many studies of so-called "experts" have in fact used novices (according to Webster's definitions). Even some functioning expert systems mistakenly have been based on novices rather than real experts (Levitt, 1991). And many "expert-novice" comparisons reported in the literature are really "novice-naive" comparisons.

No matter how defined theoretically, it is necessary to operationalize expertise in any research study. Often the proposal is made to use objective (validity) standards to define who is and who is not an expert. The idea is to use the validity of the expert's judgments as a measure of expertise. Unfortunately, such standards seldom exist for the domains where experts work – that is why experts are needed in the first place. It is experts who define what the standards are, not the other way around.

The approach used in my research laboratory is to let those working in a domain identify the experts. There are always some people who are considered by their peers to be the best at what they do. In some fields, such as auditing, this may be reflected by job titles or other forms of recognition. For other professions, such as management, this comes from consensual acclimation. In either case, "experts" are those who have been recognized by others within their profession as having the highest level of skills. With this background, let me now turn to five questions that have been behind my research on experts.

How Consistent are Experts?

Einhorn (1974) argued that internal consistency (or "stability" as it is often termed in the accounting literature) is a necessary condition for expertise. If a decision maker is inconsistent, then he/she lacks the ability to be an expert. In the abstract, this argument makes sense. But the question is how much consistency is enough?

Research on experts from other domains has generally found relatively low levels of internal consistency. In an analysis of clinical psychologists, for instance, Oskamp (1962) found a correlation of .44 (where 1.00 is perfect) between repeated judgments of the same cases. That is, when these psychologists were unknowingly shown identical patient profiles, they often made different judgments.

Comparable results have been reported in other analyses of medical expertise. For instance, Einhorn reported a consistency correlation of .50 for medical pathologists. Also, Hoffman, Slovic and Rorer (1968) found values of around .40 in several studies of physicians. Similar levels of internal consistency have been reported for other types of experts, such as licensed grain judges (Trumbo, Adams, Milner, & Schipper, 1962), parole officers (Carroll & Payne, 1976) and court judges (Ebbesen & Konecni, 1975).

What about auditors? In a study of 63 auditors, Ashton (1974) reported a mean correlation of .81 between two presentations of 32 internal control cases. Joyce (1976) observed a mean value of .86 for 35 auditors in a study of audit time estimates. Analyses of materiality judgments by audit partners revealed consistency correlations of .90 (Messier, 1983) and .83 (Ettenson, Shanteau & Krogstad, 1987).

Comments: How internally consistent are auditors? The answer depends on one's perspective. If an absolute standard of perfection is adopted, then expert auditors leave something to be desired (e.g., Wright, 1988). After all, even consistency values as high as .90 are still less than perfect. However, if a comparative perspective is taken, then auditors are doing quite well relative to experts in other fields.

My own view is that expert auditors show impressively high levels of internal consistency. That is not to say that expert auditors cannot do better. Indeed, Phelps (1977) found a consistency level of .96 for expert livestock judges – the highest level of consistency I have seen in the literature. Nonetheless, I do not think that the internal consistency results for auditors provide much grounds for criticism.

In summary, are expert auditors consistent? I believe they are about as consistent as they can be. However, internal consistency is only a necessary (not a sufficient) condition for expertise. To be an expert requires more than just consistency.

Do Experts Agree?

Besides internal consistency, Einhorn (1974) also argued that experts should agree with each other. This property has been labeled "between-subject reliability" by psychologists and "consensus" by accounting researchers (Wright, 1988). Either way, the idea is the same – different experts looking at the same case should arrive at the same judgment.

The evidence, however, suggests that experts in other domains frequently disagree. Einhorn (1974) reported an average between-expert correlation of .55 for medical pathologists. Slovic (1969) and Goldberg and Werts (1966) reported average between-correlation values less than .40 for stock brokers and clinical psychologists, respectively. Despite the impressively high internal consistency value found for livestock judges of .96, Phelps (1977) observed an average between-judge correlation of only .50.

Results for expert auditors are noticeably higher. Kida (1980) asked 27 audit partners to judge 40 profiles based on five accounting ratios; the average interjudge correlation was .76. Similarly, Ashton (1974) had 63 practicing auditors evaluate the strength of internal controls for 32 cases; the average correlation between judges was .70. Finally, Libby, Artman, and Willingham (1985) observed an average intercorrelation of .68 for 12 auditors making control reliance ratings.

Reliability has been observed to increase as a function of experience. In a study of materiality judgments, Ettenson, Shanteau, and Krogstad (1987) compared 10 audit partners with 10 audit seniors and 11 accounting students; the mean intercorrelation for the three groups was .83, .76, and .66, respectively. Similarly, Messier (1983) reported that partners with more than 15 years experience had greater consensus than partners with less experience. However, no difference in reliability was observed by Hamilton and Wright (1982) for internal control assessments by three groups of auditors varying in experience; the average across the groups was .72.

Comments: These results suggest two conclusions: First, the agreement between auditors is higher than for experts in other domains. Second, there is some evidence that greater experience may lead to increased consensus between auditors. Before making too much of these results, however, it is important to recognize the wide range of tasks and types of auditors used in these studies. It is difficult to compare across studies based on such different procedures and definitions.

It should be noted that consensus is no substitute for an accuracy measure (Wright, 1988). But in many auditing settings, the only criterion available is the opinion of an expert. Thus, consensus is frequently used as an admittedly poor substitute for the "correct answer."

How Much Information Does an Expert Use?

It makes sense that experts should make use of more information than non-experts (Phelps & Shanteau, 1978). Researchers have interpreted this truism to imply that more cues should be needed to describe expert judgment than non-expert judgment. That is, greater cue usage is equated with greater expertise and lesser cue usage with less expertise. Shanteau (1992) labeled this the *Information-Use Hypothesis*.

The evidence, however, is that judgments of both experts and non-experts can be described by a relatively small number of cues. Hoffman, Slovic, and Rorer (1968) reported that the judgments of medical pathologists could be described by two to six cues. Stockbrokers' judgments were found to depend on six or seven cues (Slovic, 1969). Einhorn (1974) reported that decisions by medical experts were based on one to four cues. Analyses of grain judges showed they were not relying on all the pertinent cues (Wallace, 1923; Trumbo, Adams, Milner, & Schipper, 1962).

In each of these studies, the judgments of experts could be described by relatively few cues. Yet in each case, more (often much more) information was available. This suggests that experts may make important decisions without adequate attention to all the available information. If so, it should not be surprising to find that expert decisions are seriously flawed (Dawes, 1988).

Such evidence led Reilly and Doherty (1989, p. 123) to conclude: "A robust finding in research on human judgment is that relatively few cues account for virtually all of the systematic variance." This contradicts the Information-Use Hypothesis, and suggests that experts are limited in the same way as naive subjects (Goldberg, 1968).

One possible explanation for the limited use of relevant information by experts is that they may be influenced by irrelevant cues. Clearly, experts should focus on information that is the most relevant or diagnostic. However, considerable evidence suggests that irrelevant cues inappropriately influence both expert and naive judges (Gaeth & Shanteau, 1984). In a literature review, Gaeth and Shanteau (1981) found over 250 reports showing an impact of irrelevant information on human judgment.

Do these conclusions extend to auditors and accountants? Ettenson, Shanteau, and Krogstad (1987) had 10 partners and 11 managers evaluate the materiality of a proposed account adjustment for 16 cases. For comparison 11 accounting students performed the same task. Analyses revealed 3.3 significant cues (out of 8) for partners, 2.7 for managers, and 2.6 for students; the difference was not significant. A more detailed analysis did reveal a difference in the pattern of cue weights. The two groups of professional auditors relied primarily on one cue; other cues were seen as less relevant. Students, in contrast, had a broad spread of weights across many cues. Therefore, although the number of significant cues did not differentiate between experts and novices, the pattern of cue weights did.

Bamber, Tubbs, Gaeth, & Ramsey (1991) compared 94 experienced auditors and 97 inexperienced auditors. Both groups were asked to review two audit cases and to revise their probability assessment after receiving two additional pieces of information. The added information was either relevant or irrelevant to the audit task. Both groups responded with appropriate probability revisions for relevant information. However, irrelevant information produced a sizable shift for inexperienced auditors (+3.1), but not for experienced auditors (-1.2). Thus, inexperienced auditors were not able to ignore the irrelevant information.

Comments: The evidence from studies of experts in auditing and elsewhere is clear: Judgments of experts and novices are based on limited amounts of information. The results reveal a tendency for novices to rely on as many (or more) cues as experts. These findings definitely do not support the Information-Use Hypothesis – the judgments of experts are not based on more information than non-experts.

Experts do differ from non-experts, however, in *what* information is used (as opposed to *how much*). What distinguishes experts is their ability to discriminate what is diagnostic from what is not. Both experts and non-experts make use of multiple, but limited sources of information. What non-experts lack is the ability to separate relevant from irrelevant sources of information. Thus, it is the type of information used (relevant versus irrelevant) not the amount that distinguishes between experts and others.

The problem for non-experts is that information relevance is task dependent. What is relevant in one task may be irrelevant in another. Only a skilled expert can determine what is relevant in a given situation. That is precisely why they are considered experts.

Thus, the ability to evaluate the task is central to expertise.

Are Experts Biased?

In the early 1970's, Tversky and Kahneman (1971, 1973, 1974) developed a research paradigm that has dominated the judgment and decision making literature since. They argued through a series of demonstrations that humans use cognitive heuristics or mental shortcuts that reduce the complexity of making probabilistic or frequency judgments. The *representativeness* heuristic, for instance, states that uncertainty judgments are based on similarity rather than on probabilities. "In general, these heuristics are quite useful, but sometimes they lead to server and systematic errors" (Tversky & Kahneman, 1974).

As evidence for the heuristic-and-biases approach, they developed many illustrations that showed undergraduates deviate from normative or statistically-correct standards. In support of *representativeness*, they showed that students often ignore base rates or background information when making judgments.

Consider the following word problem (Tversky & Kahneman, 1974): "Disk is a 30 year old man. He is married with no children. A man of high ability and high motivation, he promises to be quite successful in his field. His is well liked by his colleagues." The description was intended to be noninformative of Dick's occupation. When asked whether he is was more likely to be an engineer or a lawyer, students judged the probability as being .5 regardless of whether the stated proportion of engineers was given as .7 or .3. In other words, subjects ignored the base rate.

Do these results extend to experts? Tversky and Kahneman (1974) argue that heuristics and biases are universal *cognitive illusions*: "there is much evidence that experts are not immune to the cognitive illusions that affect other people" (Kahneman, 1991). Using a medical version of the "lawyers and engineers" problem with nurses, Bennett (1980) reported that nurses tended to ignore base rates in favor of case-specific information. This supports the conclusion that even professionals produce biased judgments because representativeness leads them to ignore base rates.

For experts to ignore base rates is a very serious error; they are overlooking past knowledge and experience. To concentrate only on case-specific information is equivalent to making decisions without using past experience. Therefore, when an expert ignores base rates, there is good reason to question his/her competence.

Do auditors ignore base rates? Many researchers have tried hard to draw that conclusion. Using a variation of the lawyer-engineer problem, Joyce and Biddle (1981) reported that 132 auditors underutilized base rates in judging management fraud. They also found that professionals did better than student subjects. In a follow-up study, however, Holt (1987) concluded that it was the wording of the problems, rather than use of base rates, that led to the Joyce and Biddle results.

When tasks familiar to auditors are used, base rates seem to influence judgments. Kida (1984) evaluated the use of data by 73 audit partners and managers. The results revealed that "most auditors attended to both base rates and indicant (case-specific) data" (Smith & Kida, 1991, p. 475). Thus, "auditors' behaviors correspond more closely to normative principles than the behaviors of naive student subjects. This increased attention to base rates by auditors seems to be present primarily for tasks that appear to be familiar to them" (Smith & Kida, 1991, p. 480)

Comments: After a recent review of the accounting literature on heuristics and biases (Shanteau, 1989), I came to several conclusions: First, accounting researchers had difficulty translating the Tversky and Kahneman word problems into quantitative auditing problems. As Biddle and Joyce (1982, p. 187) noted, "our failure to observe behavior consistent with (heuristics and biases) may be due, at least in part, to problems with our experiment." This difficulty in devising appropriate tasks suggests that heuristics and biases have limited applicability in real-world auditing contexts.

Second, the results reported in many auditing studies of heuristics and biases are often close to normative (e.g., Kinney & Uecker, 1982). Even for studies that find results consistent with heuristics and biases, the effects are generally smaller than those reported by Tversky and Kahneman (e.g., Uecker & Kinney, 1977). Biddle and Joyce (1979, p. 31) say that "superior performance by auditors may be attributable, in part, to their acquisition of professional skills in evaluating sample evidence."

Third, despite their own results, many auditing researchers have argued for heuristics and biases. When Biddle and Joyce (1982, p. 189) failed to find evidence of one heuristic, they concluded that "some as yet unidentified heuristic was at work." This reflects a tendency in auditing to define success of a study by observing biased behavior. Normatively appropriate behavior does not get the same attention. This "bias" toward emphasizing poor decision behavior has also been reported in the psychological literature (Christensen-Szalanski & Beach, 1984).

What Do Experts Think About Expertise?

In the studies described thus far, researchers have studied the decisions made by experts in various situations. Most of these studies compared expert with non-expert behavior. The purpose was to find out if experts are different from others. But experts are seldom asked what they think about expertise.

I am involved in an ongoing study (along with Abdolmohammadi) sponsored by Deloitte and Touche to determine what top auditors define as "expertise." As part of a multi-phase study, 114 of the firm's top audit specialists in the USA were asked to list as many characteristics as they felt relevant to describe a top industry specialist; they also ranked the importance of these characteristics using a 5-category scale.

After combining similar items (e.g., "confidence" and "self -confidence"), the total list contained 90 characteristics. Based on analysis of semantic meaning, the list was then reduced to 26; e.g., "analytical skills" and "trend recognition" are semantically similar and were recoded as "analytical thinker." Different members of the research team working independently produced nearly identical results. In addition, different methods for scoring the results yielded nearly identical orderings.

The results for the most frequently mentioned items are listed in Table 1. As can be seen, interpersonal skills (such as "good presenter" and "works well with others") are listed most often. These are followed by psychological traits (such as "persistent" and "active"), The other groupings (in order) were: knowledge, cognitive abilities, task/business awareness, and decision strategies.

The importance placed on interpersonal skills and psychological traits was surprising. There is no mention of such characteristics in prior literature on expertise. It had been expected that knowledge and cognitive abilities would be considered as most important (e.g., Abdolmohammadi & Shanteau, 1992). However, it appears that nontechnical aspects of experts, such as the ability to relate to others, is considered crucial to be an effective auditor.

Since we first started talking about these results, informal confirmations have come from other sources. I have been told that current studies of military commanders and medical doctors are also finding that broad behavior patterns are more important than technical skill in identifying top experts. This may be, therefore, an emerging pattern.

Comments: The results of asking expert auditors to define "expertise" are notable for several reasons. First, the characteristics identified primarily reflect interpersonal and psychological traits; in contrast, technical skills were mentioned less. However, it should be acknowledged that many experts who participated in this research were also in management positions. Thus, they may have focused more on interpersonal skills when describing expertise. Nonetheless, it is clear these experts felt that strong interpersonal skills are essential to achieving top positions in auditing.

Second, the wide range of characteristics identified by these top auditors imply there is no simple formula to becoming an expert. The pattern emerging from this research suggests many behavioral ingredients. Knowledge and experience are obviously important. But interpersonal and other psychological traits are seen as more important. Technical skills, while not ignored, were not as frequently listed. These findings imply that strategies of educating students that emphasize technical training may be misplaced. If the goal is to produce experts, then greater effort is needed to develop interpersonal/psychological skills.

Some Final Observations

The admittedly incomplete answers to these five questions paint a sometimes complex, but still interesting picture of what it means to be an expert. This picture is even more intriguing because auditing experts are both similar to and different from other types of experts. In these concluding comments, I wish to focus on four issues. The first concerns the various ways that experts differ from non-experts. The second involves similarities and differences between auditing and other types of experts. The third reflects the importance of groups or teams of experts in professional settings. Lastly, I want to comment on implications for the development of expert systems.

Experts vs. Non-Experts. The studies discussed in this paper illustrate that experts differ from non-experts in a variety of ways. Before listing these ways, it is worth noting that expertise is in Chase's terms "spectac ularly narrow." The special abilities seen in experts emerge only in their particular domain. Outside that domain, they behave the same as non-experts – there is no evidence of expertise generalizing to other areas (Shanteau, 1988; Shanteau & Stewart, 1992).

Poets and artists like to emphasize the exalted status of human reasoning. As Shakespeare put it in Hamlet: "What a piece of work is a man! How noble in reason! How infinite in faculty!...In action how like an angel! In apprehension how like a god!"

Unfortunately, the truth falls fall short of these elegant phrases. Psychologists have discovered that people are quite limited in their ability to select and store information

(Miller, 1965). We operate within severe limitations on memory and attention (Newell & Simon, 1972). As Simon (1957) puts it, humans operate with a 'bounded rationality" because of cognitive limitations. We build simplified models of the world that allows us to 'behave rationally with respect to this model, (but) such behavior is not even approximately optimal with respect to the real world" (p. 198).

Experts cannot escape these limitations. In Simon's terms, however, they have learned how to build better models. This allow them to avoid many of the pitfalls associated with cognitive limitations. By concentrating on only what is relevant, for instance, experts are able to avoid problems associated with information overload. The information experts do use is more likely to be diagnostic about a particular problem. In turn, this leads to higher reliability and consistency in their judgments.

However, there is more to being an expert than simply dealing with cognitive limitations. As shown in the Abdolmohammadi and Shanteau study, it is also necessary to know how to behave like an expert. These behavior patterns reflect, in part, what Goffman (1959) calls self-presentation: the creation and maintenance of a public image. To be accepted as an expert, it is essential to have others believe than you are one.

Auditors vs. Other Types of Experts. In a major review of the literature on auditing expertise, Bédard and Chi (1993) state there are many common elements of expertise: 'the invariants of expertise identified in other domains hold up well in auditing." Of course, the essence of science is the search for constancies. It makes sense to look for parallels between auditors and other types of experts.

In any field, however, expertise will depend on both general and specific factors. The generalizable factors shared with other fields are the focus of most psychologists. Yet there are also factors unique, and these often have been overlooked by both psychologists and accounting researchers. Much of the psychological research on expertise has focused on chess masters. Finding parallels between chess players and auditors is provocative. But there are major differences as well, e.g., chess is a game played against a single opponent. It is not clear that such a board game is parallel to auditing. I would recommend extreme caution before generalizing from experts in other domains to experts in auditing (Shanteau, 1993).

In support this contention, the studies cited above show that auditors are often different from and sometimes better than other experts. For instance, auditors have higher internal reliability and greater consensus, show greater use of base rate information, and avoid many of the biases prevalent in other areas.

That is not to say that auditing judgment is above reproach. In almost all the studies cited, performance was less than perfect. Although the consensus between auditors is generally quite good, for example, there are still sizable disagreements. Thus, there is much room for improvement (Shanteau, Grier, Johnson, & Berner, 1991).

Elsewhere (Shanteau, 1992), I have pointed out a relationship between domains where good performance has been observed (e.g., weather forecasting) and where poor performance has been observed (e.g., clinical psychology). One explanation for this difference is that good-performance domains generally involve decisions about objects or things, i.e., the stimuli are relatively constant. In contrast, poor-performance is observed when human behavior is being evaluated, i.e., the stimuli are changeable.

This suggests that when a domain involves evaluating human behavior, the task becomes more difficult for experts. Traditionally, auditors have been asked to deal with fairly static problems, such as evaluating internal controls. Recently, there has been a tendency for auditors to evaluate more subjective problems, such as fraud detection. As auditing become more like clinical psychology, I believe the performance of expert auditors will decline.

Thus, the superior performance seen in previous studies may not continue if auditors are asked to perform new tasks. The more auditors have to rely on fallible data (such as human behavior), the less capable they will appear to be. This is not a reflection on the skill of the auditors. Rather, it is due to more difficult tasks.

Teams of Experts. Most of the research in the literature has focused on individual expertise. That is, most studies have looked at the behavior of experts working alone on a task. In my expertise, however, experts in professional settings are more likely to work in groups or teams. This can be seen, for example, in medical settings; doctors often consult with each other in making difficult decisions. And medical teams – made up of doctors, nurses, and other medical personnel – deal with most medical emergencies (e.g., Schwartz & Griffin, 1986).

Similarly, auditors seldom work in isolation. Instead, they are much more likely to form a group when conducting a large or complex audit. Even when a single auditor has overall responsibility for an engagement, there is usually input from a wide variety of colleagues and subordinates. Thus, to understand how experts actually work requires an investigation of how expert teams function.

Unfortunately, there is relatively little know about the behavior of groups of experts (Klein, et al, 1993). An important unanswered question, for instance, is what can be done to improve the performance of experts in team settings? There are many anecdotal accounts of amazing accomplishments by teams – the recent movie about the *Apollo 13* provides one notable illustration. However, there are also many examples of disastrous performance by teams, e.g., the decisions surrounding the Bay of Pigs fiasco provide one illustration. The critical question is why do some teams perform well and others don't?

Although there has been little research on expert teams, there has been a great deal of work done on leadership and organizational structure (e.g., Fiedler, 1967). Most of the work on leadership, however, has focused on hierarchical work settings, e.g., involving managers and workers. Little is said in this literature about teams of technical experts such as auditors. This is an area where more work is needed.

Any research on expert teams should address an unstudied distinction between *homogeneous* and *heterogeneous* group composition. Homogeneous groups consist of experts with more or less interchangeable skills, e.g., a team of certified accountants. In contrast, heterogeneous groups are composed of experts with different skills, e.g., an auditor working together with a lawyer and a manager. Teams of experts are needed in both cases, but how they work together is likely to be quite different. Also, some experts may be able to work well in one type of team and not the other.

For many reasons, team expertise is difficult to study. It is hard enough to get single experts to participate in a research project. It is far more difficult to get a group of experts together for research purposes. Nevertheless, investigations are being conducted of team expertise, e.g., see Orasanu and Salas (1993). Such research has the potential of altering our understanding of the role that experts play in actual work settings.

Implications for Expert Systems. On the basis of ideas from artificial intelligence, computer scientists have been developing procedures for simulating expertise. These expert systems are based on eliciting the "knowledge structure" and "infe rence engines" (decision rules) used by experts. The systems are intended to deal with the kinds of problems that experts solve by operating as "intelligent assistants." Some of the better known examples include *MYCIN* (Shortcliffe, 1976) for diagnosing bacterial infections and *PROSPECTOR* (Duda, Gashnig, & Hart, 1979) for evaluating geological sites. There are now hundreds of functioning expert systems, with thousands more under development (Reddy, 1988).

However, it was not long after developing the first expert systems that a "knowledge acquisition bottleneck" appeared (Cullen & Bryman, 1988). The ability to construct expert systems was limited until better ways are developed to access the knowledge and decision rules of experts. Discussion of the bottleneck has now become standard in many papers on expert systems (e.g., Hart, 1989).

With some notable exceptions (e.g., Mumpower, Renn, Phillips, & Uppuluri, 1987), there has been little effort to connect the development of expert systems to research on decision making. Given the hundreds of studies on experts, it would appear that judgment and decision research should be able to help in the development of expert systems (Shanteau & Stewart, 1992). There has been little connection to date.

One reason is decision making literature tends to emphasize the deficiencies of experts (Chan, 1982). What expert systems developers want to know, however, is what experts *can do*, not what they *can't do*. Even so, there is considerable potential for application of decision research to the development of expert systems.

I believe the psychological characteristics and strategies outlined here are major components of expertise. Without them, an expert could not function and would not be recognized as a top performer. However, if these characteristics and strategies can be incorporated into expert systems, then it should improve the operation and acceptance of these systems. It may help, for instance, to know how experts respond to stress and to incorporate that into an expert system (Shanteau & Dino, 1991).

Can an expert system be built that incorporates these properties? Not enough is know yet to answer this question. However, the following at least would seem necessary: First, expertise must be looked at from the point of view of the expert, not something to be defined within the constraints of available hardware and software. Second, experts cannot be expected to explain everything they do; much of the way experts behave is not subject to simple explanation. Third, more emphasis should be placed on what is known about the psychology of expertise in building expert systems; characteristics such as *confidence* and *communication skill* must be incorporated into expert systems. Lastly, different methods for building expert systems may be necessary to reflect the various domains in which experts work; just as experts differ, so must the methods used to simulate them differ.

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Table 1

Internal Consistency Values for Experts

Domain	*Consistency*	*Author(s)*
Clinical Psychologists	.44	Oskamp (1962)
Medical Pathologists	.50	Einhorn (1974)
Physicians	< .40	Hoffman, et al (1968)
Auditors: Internal Control	.81	Ashton (1974)
Auditors: Materiality	.90	Messier (1983)
Auditors: Audit Time	.86	Joyce (1976)
Auditors: Materiality	.83	Ettenson, et al (1987)
Livestock Judges	.96	Phelps (1977)

Table 2

Reliability (Consensus) of Experts

Domain	Consensus	Author(s)
Medical Pathologists	.55	Einhorn (1974)
Stockbrokers	.32	Slovic (1969)
Clinical Psychologists	< .40	Goldberg, et al (1966)
Auditors: Accounts Ratios	.76	Kida (1980)
Auditors: Internal Controls	.70	Ashton (1974)
Auditors: Control Reliance	.68	Libby, et al (1985)
Audit Students: Materiality	.66	Ettenson, et al (1987)
Audit Seniors: Materiality	.76	Ettenson, et al (1987)
Audit Partners: Materiality	.83	Ettenson, et al (1987)
Livestock Judges	.50	Phelps (1977)

Table 3

Characteristics of Experts Listed by Top Auditors

Attribute	Frequency Score	Frequency (Rank)	Weighed Score	Weighed (Rank)
Good Presenter	126	(1)	540	(1)
Knowledgeable	93	(2)	430	(2)
Works with Others	74	(3)	324	(3)
Persistent	67	(4)	283	(4)
Active	65	(5)	271	(6)
Respected	64	(6)	279	(5)
Technical Skills	61	(7)	258	(7)
Leadership	54	(8)	227	(10)
Creative	53	(9)	236	(8)
Experienced	53	(9)	228	(9)
Marketing Skills	44	(11)	188	(11)
Intelligent	43	(12)	179	(12)
Analytic Thinker	38	(13)	73	(21)
Business Oriented	26	(14)	121	(14)
Broad Minded	24	(15)	95	(16)
Good Decision Maker	23	(16)	99	(15)
Manages Risk	22	(17)	85	(18)
Confident	22	(18)	94	(17)
Flexible	21	(19)	175	(13)

Table 4

Categories of Characteristics Listed by Experts

Attribute	Frequency		Weighed	
	Score	(Rank)	Score	(Rank)
Interpersonal Skills	408	(1)	1740	(1)
Psychological Traits	258	(2)	1161	(2)
Knowledge/Experience	146	(3)	658	(3)
Cognitive Abilities	134	(4)	488	(4)
Task/Business	99	(5)	429	(5)
Decision Strategies	74	(6)	305	(6)