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The Cognitive Ecology of Problem Solving

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Discussions of perception or memory seldom begin by defining a percept or a memory. Discussions of problem solving, however, almost always begin by attempting to define a problem. Yet the term "problem" is in the everyday vocabulary of virtually every adult. When a term that is commonly used must be explicitly defined, usually it is because the meaning that is intended differs from the common usage. The difference may be connotative. For example, the term "relativity" has almost completely different connotations for the theoretical physicist and for the layperson. The difference may also be denotative. For example, the term "flu" denotes different sets of disorders for the epidemiologist and for the layperson. It seems unlikely that two concepts would denote the same things but have different connotations. It is likely, then, but not assured, that the scientific and the lay concepts of a problem denote different things. It is an open question whether or not the two concepts have similar connotations. If the connotations are similar, then we must ask if the problems we, as scientists, study are sufficiently similar to the problems people experience that we can generalize what we learn about how problems are solved and how to assist the process. If the connotations are not similar, the questions are more serious: If our problems are not like people's problems, to what aspect of human experience do they generalize? What fields of scientific inquiry do address problems that people experience?

There are two plausible goals for the study of everyday problem solving: to understand real-world problem-solving performance and to predict real-world problem-solving performance. If the goal is to understand real-world problem solving, the tasks chosen must have external validity. They must adequately represent problems that are actually encountered. In addition, it must be possible to identify factors that contribute to performance either through experimental manip-

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ulations of the problems or through correlations of problem-solving performance with performance on other tasks that are reliable, valid indicators of basic abilities or processes. If the goal is to predict real-world problem solving, the tasks chosen must have predictive validity. They must correlate well with some measures of real-world performance. The tasks should be easy to administer; they should translate easily to the laboratory or testing situation. The tasks do not have to be representative; that is, they do not have to have face validity. For example, the Raven Progressive Matrices and subtests of the WAIS do not resemble problems that most people face in their everyday lives, but they do predict real-world performance. The two goals are not inconsistent. If contributing processes can be identified, then problem solving performance can both be understood and be predicted. At the same time, valid, easily administered tests that do predict real-world performance are of considerable value even if they are not representative or do not allow clear identification of underlying processes. Denney describes several examples of such tests in the next chapter.

This chapter examines the first goal: understanding real-world problem solving. It is particularly concerned with issues of representativeness and what has been called ecological validity (Hartley, Harker, & Walsh, 1980). In addition, because there is considerable evidence that there are differences across the adult life span in solving problems, as reviewed by Botwinick (1978), Giambra and Arenberg (1980), and Rabbitt (1977), it will be important to ask whether or not age is an important qualifier to the conclusions that are reached. The first section discusses the problems people actually face and reviews the paradigms used in scientific investigations to represent problems, including studies of age differences and changes in problem solving. The second section explores the extent to which the lay and scientific domains overlap and finds that there is little overlap. The final section describes an exploratory study of problems representative of those people report facing in everyday life.

In the next chapter, Denney devotes more attention to the second goal – predicting real-world problem-solving performance – in the context of a broad discussion of task validity and performance stability. The evidence for the contributions of age and experience is then synthesized into a comprehensive developmental model of problem-solving performance. Suggestions for future research are drawn from review of prior work and from the model.

Problems and problem solving

The natural ecology of problems

The most straightforward way to learn what constitutes a problem in everyday life is to ask. Therefore, 96 individuals ranging in age from 18 to 89 years were asked to "think of someone you know who is good at solving problems" and to "describe what kinds of problems this person is good at solving." The most frequent categories of responses are given in Table 18.1. The modal response, given by 52% of all respondents, was that the person was good at dealing with social and interpersonal problems, often involving emotional conflict. Technical, scientific, or mathematical problems were also mentioned frequently, most often by middle-aged adults. In addition, older adults mentioned financial or home-repair problems. Most commonly, then, the term ''problem'' referred to difficulties in human relationships, but it also comprised other situations at school, at work, or in professional activities for younger and middle-aged individuals, or situations in the home for older individuals. The age-group differences likely reflect age differences in the situations in which individuals find themselves. To generalize from the specific responses that were given, ''problem'' connotes for the layperson a situation in which there are one or more goals to be achieved, and it is not immediately clear what steps to take to achieve those goals.

To explore the denotative definition of ''problem,'' the individuals surveyed were given the following description that defined a problem broadly without using the term:

> Everyone encounters situations in which they have to figure something out. These situations may be big challenges or they may be little challenges, but they are all situations in which you don't know exactly what to do right away. Sometimes it takes just a few seconds of thought to figure out what to do; sometimes it can take much longer.

They were asked to think of and describe particular incidents of such challenging situations in several facets of everyday life: (a) work, professional activities, or school; (b) hobby, volunteer work, sports, or recreational activities; (c) around home; (d) in interacting with or dealing with other people; (e) in puzzles, board games, or card games. The responses are summarized in Table 18.1.

To generalize, there were again clear age differences, but for adults of all ages reporting on their own experiences, a problem was most likely to be a difficult personal choice or a difficulty in interpersonal relations. Less often, it was a difficulty in managing the routine or special demands of school, home, or the workplace. Rarely, it was a challenge of mathematics, science, or formalized games or puzzles. For younger adults, but not older adults, it was the challenge of acquiring the skills of a sport.

In addition to probing for the everyday concept of ''problem,'' it was also of interest to explore people's understanding of the processes of problem solving. Consequently, once respondents had identified someone who was good at problem solving and described the problems that person was good at, they were also asked to explain ''what you think makes him or her good at'' solving problems. The most common answers at all ages were that good problem solvers were good listeners who could look at a problem from many ''angles'' or ''viewpoints.'' Good problems solvers were also persistent, patient people who could concentrate well and who had substantial experience. Other traits mentioned at least once were intelligence, common sense, logic, and level-headedness.

Table 18.1. *Frequently reported problem types (percentages of respondents reporting)*

Problem type	Younger (18–25 years)	Middle (26–64 years)	Older (65–89 years)	Total sample
"Good problem solver"				
Interpersonal	56	33	53	52
Technical/scientific	44	67	20	38
Finance/home management	–[a]	–	27	11
Self				
Work or school				
Time management	47	–	–	25
Low grades	20	–	–	10
Interpersonal	–	73	–	13
Work-related				
Technical/logistical	–	18	36	13
New responsibilities	–	–	45	13
Hobby, volunteer, recreation				
Learning skills	82	33	–	33
Sports participation	–	–	24	12
Time management	–	33	–	5
Interpersonal	–	22	29	18
Home				
Family	100	64	26	60
Friends/others	–	–	9	5
Home repair/maintenance	–	27	48	26
Other people				
Friends	92	9	32	52
Family	–	36	21	15
Co-workers	–	45	5	9
Others	–	9	22	11
Puzzles and games				
Board games	30	40	33	33
Card games	10	10	33	20
Crosswords	–	–	40	20

[a]No response.

The respondents to this survey generally were well educated as well as intellectually and physically active. They tended to be retired from, engaged in, or headed toward professional, relatively well paid employment (or were from families in which the main income earner was professional). No claim is made that the sample was representative of the wider population. It is likely, though, that if any individuals face problems resembling those studied in the laboratory, this sample included them.

The general conclusions from this survey are supported by converging evidence from three very different lines of research. In the first, Kanner, Coyne, Schaefer, and Lazarus (1981) constructed instruments to elicit the hassles and uplifts experienced in everyday life. Hassles are ''irritants that can range from minor annoyances to fairly major pressure, problems, or difficulties'' (pp. 24–29); uplifts are ''events that make you feel good. They can be sources of peace, satisfaction, or joy'' (pp. 30–35). It is clear that the classes of hassles and uplifts include but are broader than the class of problems. Hassles can include problems in getting along with fellow workers and having too many things to do, but they also include such things as the weather and nightmares. Uplifts include using skills to solve a problem, but also being lucky. Among the most frequently mentioned hassles and uplifts were relationships with family and friends, time management, health, job responsibilities, and others closely similar to the problems reported by the survey respondents in our study. Kanner and associates (1981) also found differences between college students and middle-aged individuals. The students reported problems of time management and meeting academic standards; the middle-aged adults reported problems of home and financial management. These findings are similar to those presented in Table 18.1.

The second line of research, by Sternberg, Conway, Ketron, and Bernstein (1981), found that the strongest factor in lay judgments of intelligence comprised a cluster of behaviors labeled ''practical problem solving.'' The cluster included many items similar to those ascribed to good problem solvers in our survey (e.g., reasons logically, sees all aspects of a problem, keeps an open mind, gets to the heart of problems, listens to all sides of an argument) (Sternberg et al., 1981, p. 45).

The final line of research was carried out by Charlesworth (1979), who took an ethological approach to the study of intelligence. He observed two 22-month-old children for 16 hours each in order to determine the kinds of problems to which intelligence is applied in real life. He defined a problem as an instance in which ongoing behavior was disrupted by someone or something or in which there was a deficit, a need, or a want for something that was not available. He found that 89% of the problems were social or interpersonal, 6% were physical, and 4% were cognitive. Of course, these were infants, not adults, and observations of infants make the presence of cognitive problems difficult to infer. Nonetheless, Charlesworth's findings are consistent with the assertion that most problems are interpersonal.

The laboratory ecology of problems

There is reasonable consistency in the connotative definitions of ''problem'' with which most discussions of problem solving commence (Anderson, 1980; Glass, Holyoak, & Santa, 1979; Mayer, 1983). A problem is characterized as having some givens (an initial state), a goal or goals to be achieved, and a set of operations that will transform the current state. The critical features are, first, that there is (or may be) a sequence of operations that will transform the initial state into the goal state and, second, that the problem solver does not initially know what that sequence is. The agreement on the definition may reflect general adoption by researchers in problem solving of the information-processing metaphor. Earlier researchers proposed more restrictive definitions consistent with their own paradigms, such as those of the Gestalt psychologists (Duncker, 1945) and the associationists (Maltzman, 1955).

The scientific concept of a problem is denotatively defined by the problems that are studied. There is no agreed-on taxonomy of problems or problem-solving processes, and reviews of the literature reflect this. The review may be organized around the particular problem or paradigm (Giambra & Arenberg, 1980; Rabbitt, 1977) or, still focused on the problem but at a somewhat deeper level, organized around whether or not the initial state or the final state or both are well defined (Glass et al., 1979). The review may be historical, organized around the broad point of view within which the problems were introduced or extensively studied (Mayer, 1983). Finally, the organization may be based on the processes or abilities that are called for to solve the problems (Greeno, 1978). Although none of the approaches that have been taken is completely satisfactory, the one that will be used here is organization by the presumed processes, following Greeno (1978). The general format of the review will be a summary of work on a particular problem or class of problems with younger adults, followed by a description of efforts to extend the findings to include later states in the adult life span. For problems that have received considerable attention, such as concept identification, no attempt will be made to give an exhaustive list of studies. Rather, a few exemplary studies will be listed. Kausler (1982) provides a particularly thorough review of age differences in problem solving.

Induction problems. The first class of problems comprises those that require the problem solver to induce the structure, that is, to understand. These include analogy problems such as those studied by Mulholland, Pellegrino, and Glaser (1980), Rumelhart and Abrahamson (1973), and Sternberg and Gardner (1983). The problem solver must extract the relevant features and induce the relationship on which the analogy is based; errors increase as the complexity of the relationship increases, presumably because holding and manipulating the information in working memory increases the load on general processing resources. In an unpublished study, Hartley used the same stimuli as Mulholland and associates (1980) and found not only that older adults made more errors but also that the age differences increased as the number of transformations that had to be held in working memory increased. Series extrapolation or completion problems are very similar to analogies. Again, as the complexity of the information that must be held in working memory increases, so do errors (Holtzman, Glaser, & Pellegrino, 1976; Kotovsky & Simon, 1973; Simon & Kotovsky, 1963). Hartley also used the same stimuli as the earlier investigators and found that age differences were larger on series that imposed a more severe burden on working memory. One set of problems in analogical reasoning that has been used extensively in studies of age differences is the Raven Progressive Matrices Test (Raven, 1974). Although age differences are reliable and well documented (Cunningham, Clayton, & Overton, 1975), the test has been used more for its psychometric properties than to explore processes of problem solving [but see the theoretical assault by Hunt (1974)].

One class of inductive-reasoning problems that has been extensively investigated comprises concept learning or acquisition tasks. These tasks are well understood, and powerful models have been developed to describe the strategies individuals adopt both with simple versions of the task (Trabasso & Bower, 1968) and with complex versions (Bourne, 1966; Bruner, Goodnow, & Austin, 1956). Older adults reliably performed less well than did younger adults (Giambra & Arenberg, 1980; Rabbitt, 1977), although there were suggestions that the age differences might be reducible through training (Sanders, Sterns, Smith, & Sanders, 1975). The differences were particularly large when the amount of irrelevant information was large (Hoyer, Rebok, & Sved, 1979) or when the relevant information was not salient (Hartley, 1981; West, Odom, & Aschkenasy, 1978). Problems in deductive logic might also be included under this rubric. For example, Dickstein (1978) and Johnson-Laird and Steedman (1978) investigated evaluation of syllogisms. Wright (1981) and Light, Zelinski, and Moore (1982) found age differences on linear syllogisms or linear-order problems that they attributed to limitations of working memory in older adults.

Transformation problems. The second category of problems comprises those that require transformation of the initial state. The difficulty in these problems is thought to result from two burdens on memory. One is that of holding subgoals in mind while selecting and executing moves; the other is that of mentally transforming the current state to determine whether or not goals or subgoals can be achieved. Such problems include the "towers of Hanoi" or pyramid puzzle (Egan & Greeno, 1974; Karat, 1982; Simon, 1975) and the missionaries–cannibals or Hobbits–Orcs problem (Greeno, 1974; Jeffries, Polson, Razran, & Atwood, 1977; Thomas, 1974). Age differences on the towers-of-Hanoi problem have been found in unpublished studies by Charness and by Hartley. Hartley also found that older adults performed less well than did younger adults on an isomorph of the missionaries–cannibals problem. On both the towers-of-Hanoi and missionaries–cannibals, Hartley found that older adults made more moves that violated the rules or regressed to previous problem states, as would be expected if working memory were more taxed in older adults. Performance is also a function of working memory load in mental arithmetic tasks (Hitch, 1978), and Wright (1981) has reported results generally consistent with the interpretation that age differences increase as memory load increases.

Water-jug tasks also can be considered transformation problems. In these problems, the individual must discover a sequence of transfers that will result in a specified quantity. After several trials that require the same sequence, many individuals will fail to realize when a much simpler sequence will do (Luchins, 1942). This failure is more pronounced in older adults than in younger adults (Heglin, 1956).

Finally, Greeno (1978) includes the proving of geometry theorems in the category of transformation tasks (Newell & Simon, 1972). Age differences in theorem proving have not been investigated. Algebra word problems (Mayer, 1982) and physics problems (Larkin, McDermott, Simon, & Simon, 1980) have also received considerable attention, perhaps because of the difficulty they pose for students. Again, the performance of older adults on these problems has not been assessed.

There is another group of transformation tasks that has been widely used with children and to some extent with older adults, but seldom with young adults (Chance, Overcast, & Dollinger, 1978). These are tasks used by Piaget or those in the Piagetian tradition to assess stages of cognitive development. A number of investigators have used these tasks to evaluate the hypothesis that decline in abilities in adulthood may mirror the acquisition of abilities in childhood; see Papalia and Bielby (1974) for a review of this work. The results are generally consistent with the hypothesis, but they have been criticized for possible confounds such as problem difficulty (Rabbitt, 1977) and extraexperimental factors (Hornblum & Overton, 1976).

Arrangement problems. The third class of problems comprises those requiring arrangement. The anagram is a type of arrangement problem that was widely studied by researchers influenced by the associationist tradition (Mayzner & Tresselt, 1966). The relative frequency of occurrence of the solution or of the anagram and its components could be varied, providing an easy operationalization of the habit family hierarchy. Hayslip and Sterns (1979) found no age differences in the numbers of anagrams solved. The numbers solved were positively correlated with measures of both fluid intelligence and crystallized intelligence within young, middle-aged, and older groups. See Horn and Cattell (1967) for a discussion of the fluid–crystallized distinction. The matchstick and card-trick problems studied by Katona (1940) were arrangement problems. It appeared that persons prompted to discover general problem structures and to think productively showed better long-term retention and transfer, though this conclusion was questioned (Hilgard, Irvine, & Whipple, 1953). The cryptarithmetic problems studied by Newell and Simon (1972) also involved arrangement, though both these and Katona's tasks might better be thought of as involving constraint satisfaction or constraint propagation. None of these tasks has been replicated with older adults.

One very simple type of problem that could be classified as an arrangement or constraint problem and that has been extensively studied with older adults includes variants of the 20-question game in which one of many possible objects must be identified by asking questions that can be answered yes or no (Denney, 1974; Denney & Denney, 1974). In an early study with children (Mosher & Hornsby, 1966), and in studies conducted by Denney and her colleagues, the task was to identify one pictured object from among 42 objects in a six-by-seven array. The reliable finding was that older adults were more likely than younger adults to ask hypothesis-testing questions (e.g., "Is it this one?") and less likely to ask constraint-seeking questions (e.g., "Is it living?").

Within the class of arrangement problems, Greeno (1978) distinguishes those that also involve inducing structure. Such problems include the insight or recentering problems popularized by the Gestalt psychologists, such as the candle problem, the two-string problem, the hat-rack problem, the horses-and-riders problem, and the nine-dot problem. These and related problems are described and illustrated by Scheerer (1963). These problems have not been studied with older adults, but given their lower likelihood of recentering in the water-jugs task (Heglin, 1956), it seems likely that there would be age differences in solving these set, or functional-fixity, problems. Arrangement problems also include design and invention tasks, such as the composition of a musical fugue (Reitman, 1965). Planning in general has been subjected to theoretical investigation, but that work has been more within the tradition of artificial intelligence than the psychological study of problem solving (Sacerdoti, 1975). An exception is a study by Meyer and Rebok (1985), who examined planning for a simple task of sorting a shuffled deck of playing cards and found that older adults produced less fully elaborated plans that were more likely to be insufficient.

Decision making and expert judgment. There are two additional areas of research that do not fit comfortably within Greeno's taxonomy (1978). Neither paradigm is usually considered problem solving, but both appear relevant to everyday problem solving as described by our survey respondents. These two areas are decision making and expert judgment.

Early studies of decision making examined choices of monetary gambles to determine if choices conformed to the prescriptions of economic theory, as reviewed by Payne (1973, 1982). More recent studies have examined decisions in a number of domains (often consumer commodities, because it is relatively easy to specify and manipulate component attributes) and have identified a variety of decision strategies (Einhorn, 1970; Jacoby, Szybillo, & Busato-Schach, 1977; Lussier & Olshavsky, 1979; Payne, 1976; Svenson, 1979). The strategy that is adopted for information search and decision making is a function of the importance of the decision and the pressures under which it must be made. In an unpublished study, Hartley, Anderson, and White compared the information-search patterns of young, middle-aged, and older adults and inferred the decision rule that was used. Older adults were more likely to organize their searches around the different objects under consideration (in this case, small appliances), whereas younger adults were more likely to organize their searches around the attributes of the objects.

Decisions under uncertainty or risk might also be included in this category; the volume edited by Kahneman, Slovic, and Tversky (1982) reprints many of the relevant studies. When people are asked to judge the likelihood or relative likelihood of events (e.g., "Which is more likely, that someone will die of spider bite or lightning strike?"), the judgments are distorted by failure to take base-rate information into account and by heuristics that lead to biased judgment. One such heuristic is representativeness; a representative outcome (such as heads-tails-heads-tails in flipping a coin) is judged more likely than a nonrepresentative outcome (such as heads-heads-heads-heads). Another heuristic is availability; it is more likely that one will have heard or read reports in the news media about a death due to lightning strike than a death due to spider bite, and the differential familiarity is used as the basis for judgment. The occurrence of these biases in judgments by older adults has not been determined. There have been several studies directed at the hypothesis that there is a conservative bias in the decisions of older adults (Okun, 1976). A conservative bias has been found in responses to the Choice Dilemmas Questionnaire, but it may be an artifact of the instrument.

The final area is expert judgment. Much of this work has been concerned with implementing expert systems on the computer. An example is Shortliffe's successful system for diagnosing and prescribing for infectious diseases (MYCIN) that was constructed by representing the knowledge of experienced specialists in internal medicine and developing a natural-language-like interface for querying the knowledge base (Shortliffe, 1976). Other investigations of expertise have been more in the psychological tradition, although computer models of human thought and behavior have played central roles. One of these was chess playing (Chase & Simon, 1973; Newell & Simon, 1972); the other was learning to use a computer text editor (Card, Moran, & Newell, 1983). The general finding was that, with experience, the individual builds a "vocabulary" of situations that occur in his or her field of expertise and appropriate responses to them. The individual learns how best to structure the situation or represent the information in a particular domain. The result is that situations that would pose very difficult or impossible problems for novices no longer even meet the definition of a problem for experts; the solution or the way to get the solution is immediately available.

Charness (1981a, 1981b) studied expert chess players ranging from young adulthood to late middle age. Although he found a decline with age in memory ability, he found that skill at rapidly sizing up a situation and selecting the best move improved. Hartley, Hartley, and Johnson (1984) monitored younger and older adults as they acquired expertise in the use of a computer text editor. Age differences in recalled knowledge were significant, but small – much smaller than differences in standard measures of memory from comparable samples. Older adults, however, performed significantly less well in applying acquired knowledge to editing tasks. Some of the differences simply reflected slowing of responses in older adults. Other differences in errors and number of steps required to achieve a goal suggested that older adults maintained a less complete and accurate model of the current state of the edited text.

Matching laboratory to life

Are laboratory paradigms representative of real-world problem solving? The connotative definitions of problems in everyday life and in the laboratory match reasonably well. There are, however, substantial differences in the specific situations and events that are denoted as problems. This can be made apparent by contrasting two different mappings: first, from the laboratory to the real world; second, from the real world to the laboratory.

From the laboratory to the real world

The matching can be approached by selecting laboratory tasks and seeking real-world analogues. With this approach, laboratory tasks match rather well with real-world problems for the simple reason that the real-world problems have been imported into the laboratory. Problems in formal systems of thought, such as algebra, geometry, and physics problems, have been studied in the laboratory. Similarly, puzzles such as the towers-of-Hanoi and games such as chess and even 20-questions were entertaining laypersons long before they were entertaining researchers and perplexing their subjects.

The study of expert problem solving has also been imported from the real world, though it is clear that there are enormous numbers of domains of expertise that have not been examined in the laboratory. Technical expertise appears to be an important source of problems for younger and middle-aged adults. Newell and Simon (1972) believe that the same general problem-solving processes underlie most domains of expertise. Nonetheless, because it is possible that there are domain-specific processes, just as there is domain-specific knowledge, it will be important not to jump to premature conclusions. Just as important, researchers have barely begun to explore age differences, and it is unwarranted to assume without empirical test that age differences in the acquisition and application of cognitive skill are independent of the domain of expertise.

One class of tasks that originated in the laboratory (e.g., tasks such as concept identification) is a good analogue for inductive-reasoning tasks in the real world, such as scientific investigations. Perhaps because of the name given to the paradigm, these tasks have unfortunately been dismissed as invalid representations of the acquisition of semantic concepts (Medin & Schaffer, 1978; Rosch, 1978).

From the real world to the laboratory

If the matching is approached by selecting the everyday experiences of people of all ages in the real world and attempting to find laboratory analogues, the laboratory study of problems and problem solving is virtually irrelevant. Personal and interpersonal choices and dilemmas are reported to be ubiquitous and important problems. Their study has most often been the province of personality psychologists and clinicians, not cognitive psychologists.

The problems most commonly mentioned by our survey respondents concerned interpersonal relations. Do these situations satisfy the scientific connotative definition of a problem? Consider the problem of a friend making inconsiderate demands for one's time and attention. That is the initial state. There is also a goal state – a situation without the demands. It is, however, very likely that one will know a course of action. In fact, one might well conceive of several courses of action in such situations – talk to the friend, avoid the friend for a time, end the friendship, or continue to endure the demands. What one does not know immediately is which course of action is most likely to achieve the goal without incurring unacceptable costs. It might be argued that this does not meet the definition of problem solving because one has a choice to make rather than a problem to solve. But if one does not know which sequence of operations to select, then the final component of the connotative definition of a problem has been satisfied. The choice is a problem because each alternative has both positive and negative implications. The implications vary on many dimensions, and it is not clear how to make them commensurable. Further, one cannot be certain of the outcome of any alternative one chooses. These situations are modeled better by the choice and decision paradigms than by any of the conventional problem-solving paradigms. Techniques are available for assessing utility and subjectively determining likelihoods, and procedures have been developed to monitor the information that is considered. The fact that previous investigations often have used consumer goods as the objects to be chosen need not prevent the development of scenarios involving interpersonal decisions. It is an open question whether or not the cognitive processes that have been revealed by these methods are sufficient to account for decisions with interpersonal content. An even more important question is whether or not there are age differences in the processes, because very little is known about decision making in older adults. Systematic study of the processes of choice has not been extended to older adults even in the domain of consumer behavior; see Phillips and Sternthal (1977) for a review of the issues and statements of hypotheses.

There was an interesting difference between the problems our respondents mentioned when asked to describe the kinds of problems at which good problem solvers were good and those they mentioned when describing challenging situations they themselves had experienced. In several instances, the good problem solvers were singled out as adepts at solving technical problems or problems related to their work that were not interpersonal problems. Yet there were very few cases in which individuals described such problems as challenges for themselves. If we speculate about the daily lives of people such as these survey respondents, it seems likely that they would have faced a variety of challenges that they could plausibly have called problems. One who sews might have to ease a bloused sleeve into a shoulder. A lawyer might have to develop a theory of what occurred consistent with the client's statements. A computer engineer might have to design an operating system that will fit into a 64K chip. If these situations are common, why were they only occasionally described as problems, and then only for others, not for the respondent?

It seems likely that the layperson makes a distinction very similar to one made by cognitive psychologists between problem solving and exercising cognitive skill. Fitting an operating system into 64K is a complex design problem, but if one has faced that task a number of times, one will already be aware of the different approaches that can be taken and the questions that will need to be addressed – of algorithms for subtasks such as handling a priority queue of actions for the system to take, of heuristics for other tasks such as memory support for both computation and video display. There are decisions to be made, but even the decisions reflect the sophisticated representation of the problem that the skilled designer has available. In most cases that representation is created even as the individual is listening to the problem specifications.

Turning to an example from a very different domain, Sherlock Holmes, in *The Red-Headed League,* has determined that a crime is planned, that it very likely involves tunneling, and even the probable identity of the criminal well before the befuddled pawnbroker, Jabez Wilson, has completed his description of the events that have transpired. There are a few points to be resolved – such as the target of the tunnel – but Holmes knows precisely how to collect the needed information at the outset of the problem. Both the design engineer and Sherlock Holmes are more appropriately described as exercising a cognitive skill than solving a problem (Anderson, 1980; Card et al., 1983). Both have a substantial body of relevant knowledge. The knowledge is more than specific instances; it incorporates a set of rules or a vocabulary (Simon & Gilmartin, 1973) that allows the person to parse the situation and formulate an appropriate course of action. Exercise of a cognitive skill shares with problem solving an initial state, a goal state, and a sequence of operations that will transform the initial state into the goal state. There is a problem to be solved rather than a skill to be applied, however, only when the individual does not know what the sequence of operations is or how to find that sequence. One respondent said that he found bridge enjoyable, but that it posed no real problems; it is likely that he was making a distinction between exercising a cognitive skill and solving a problem.

In the early stages of acquiring a skill, individuals clearly engaged in problem solving. The expert vocabulary is either nonexistent or in primitive form, and the problem representations often are inadequate or inappropriate. Holmes's roommate, Watson, also sees the red-headed pawnbroker and hears his story, but despite his efforts to carry out a Holmesian analysis, he infers far less than the great consulting detective. As novices solve more problems in a domain, they gain expertise, and it becomes less appropriate to describe their efforts as problem solving. If laypersons make the same distinction, they will describe the situations they encounter as problems only when they are novices. Most people will not remain novices for long; they will either become more expert or abandon the field. It is not surprising, then, that so few people described such situations as problems for themselves. Why would they describe them as problems for others, for the good problem solvers? For the same reason that Watson marveled at Holmes's deductions: because a situation that is easily comprehensible to an expert may seem a difficult problem to one without the skill to deal with it.

Applications of cognitive skill by experts range from situations that simply require recall of an appropriate response to situations in which a problem must be solved. A skilled chess player playing a standard opening can select the next move from a thoroughly memorized table of openings. In other cases there are uncertainties, but the problem solver knows what the alternatives are and how to choose among them. For example, a rheumatologist described the process of diagnosing a famous football player with the symptoms of skin rash, areas of dead skin, and arthritis of the hands (Weisman, 1985). He knew that the combination of these three symptoms narrowed the diagnosis to one of three possibilities. The available information did not allow a choice among the three, but he knew that simply observing the individual over several months would provide disambiguating evidence. It did. Increasingly severe muscle weakness eliminated two of the possibilities, leaving the third as the most probable cause. There were points at which the physician did not know the solution, but at every point he knew how to proceed to arrive at an eventual solution. At the other extreme from simple recall are situations in which an expert is faced with a true problem. This occurs when expertise fails and the individual has an inappropriate representation of the problem. For example, this occurs to Sherlock Holmes in *The Adventure of the Lion's Mane*. He incorrectly represents the information as evidence of a murder when in fact the individual has died from an accidental jellyfish sting. Only after being blocked and recentering his thinking does Holmes find the solution that might have been obvious to one less accustomed to dealing with criminal behavior. Thus, expert applications of cognitive skill range from simple recall to actual problem solving. The frequency of occurrence, though, varies systematically over the range. Most situations require only recall; only a few require that a problem be solved. The important conclusion is that the study of problem solving is only one component of the study of expertise.

Studies of expertise, as reviewed by Charness (Chapter 24, this volume), address the classes of tasks in which cognitive skill is truly exercised. Those studies typically have imported into the laboratory a real-world domain such as bridge (Charness, 1979), chess (Charness, 1981a, 1981b, 1981c; Newell & Simon, 1972), or word processing (Card et al., 1983; Hartley et al., 1984; Mikaye & Norman, 1979). Relatively few domains have been investigated. Studies of expertise at bridge, chess, and word processing have been extended to the later life span, but such investigations have been uncommon.

Matches and mismatches

If we tally the matches and mismatches, scientific and everyday problems match principally for games and puzzles. Yet these compose only a small subset of the problems faced in everyday life. The obvious conclusion is that we must direct our research attention toward paradigms that capture everyday problems. Calling for more representative research, though, is both simplistic and misleading. Simply importing everyday problems into the laboratory is not enough. If the goal is to understand the processes by which problems are solved, the attention must be directed to the strategies that are selected, the contributions of abilities and personal characteristics, and the ways in which those things change or remain stable with age. Representative tasks are important because the processes of solving everyday problems may well differ from the processes of solving the games and puzzles that have been studied in the laboratory. What we already have available in the laboratory are the tools to begin the enterprise. We can co-opt decision paradigms and use them to explore representative choice scenarios. We can adopt the techniques for studying expert judgment, expanding the domains to which they have been applied. We can use individual-difference approaches to gain leverage on problems that do not lend themselves to manipulation or intervention. And we can make more use of hypothesis-formulating approaches, such as think-aloud protocol analysis, to explore everyday problems in vivo. We must explicitly address the contributions of knowledge and experience to the problem-solving process.

Exploratory study

From our review of problems faced by laypersons and the problem-solving literature it was concluded that research should be directed toward problems that are representative of those faced in everyday life, particularly toward discovering the antecedents of performance on those problems. There have been few studies that have met those criteria. Consequently, a preliminary investigation of problem solving using tasks modeled on the problems reported in the survey was designed and carried out. The goals were to explore possible paradigms, to draw parallels to research using standard problems, and to produce hypotheses for future research. The general approach was to select representative or ecologically valid problem-solving situations and to include them in a battery of other measures to explore cognitive abilities, health, and current activities. These tasks were given to 44 individuals ranging in age from 19 to 84 years. Thus, it was possible to investigate relations between problem-solving performance and age, as well as other personal characteristics, and also between performance and cognitive abilities. In addition, to extend the study of laypersons' conceptions of problem solving begun with the survey described earlier, relations were explored between performance and self-report measures of problem-solving experience and style.

Problem-solving tasks

The tasks were selected to simulate situations that require choosing a course of action either to meet a person's own needs or to meet the expressed needs of someone else. The situations included a health-related choice, consumer advice to others, and personal advice to others.

Medicare-supplement insurance choice. In this task, the participant's problem was to gather information about four different Medicare-supplement insurance policies that varied on eight features. The goal was to select the best of the four policies. The different policies were identified simply as A, B, C, and D. The participant gained information by specifying a policy and a feature. An interactive computer program provided the information, for example, ''The annual premium for policy C is $495.'' The information remained available until the next question was asked. The participant continued to gather information until ready to make a decision. At that point, the program asked for the policy that had been selected and called a research assistant, who asked the participant to explain why that policy had been chosen.

Two simple measures are available that reflect the decision process: (1) the number of questions asked and (2) the proportion of those questions that are redundant, repeating an earlier question. The sequence of questions can also reveal the individual's information-gathering strategy. The questions can be organized around the different policies, gaining information about several features of one policy, then another, and then another; this can be inferred from a sequence in which a high proportion of the questions concern the same policy as the preceding question, but a different feature. Alternatively, strategies that involve comparing the different policies on one feature, then on another feature, and then another can be inferred from sequences in which a high proportion of the questions concern the same feature as the preceding question, but a different policy. Unsystematic strategies can be inferred from sequences in which a high proportion of questions change both policy and feature from the preceding question. It is possible to make very specific identifications of the decision rules used by examining the type of question-to-question transition and the depth of search (Svenson, 1979). That was not done here; the analysis focused on the general characteristics of the search process (Payne, 1976).

Automobile purchase. In this task, the participant was given a written description of an individual who wished to purchase an automobile. Descriptions of six possible automobiles were also provided. The participant was to rank-order the six cars according to how well each met the described needs of the individual. The task was repeated with descriptions of four different buyers. Again, the task simulated a consumer choice. In this case the choice was for another person, whereas the choice of an insurance policy was based on one's own standards. The descriptions of buyers and of automobiles were constructed so that an overall measure of goodness of fit between car and buyer could be computed. The dependent measure was the nonparametric correlation between the ranks given for the six automobiles and the computed values, averaged over the four descriptions of buyers.

Personal advice. Two requests for advice were taken from published letters to a syndicated advice columnist. One asked for advice in a situation in which the mother of a bride had stricken members of the groom's family from the list of wedding invitees. The other described an elderly man in failing health who was becoming increasingly dependent on his son's former wife. The man's own family had assumed no responsibility for his care, and the former wife was seeking advice on how to ask her former husband, with whom she did not communicate, to provide help for his father. The participants' task was to read each item and to suggest any courses of action they would recommend to the writer (the columnist's response was not provided). After the participant finished providing suggestions, he or she was asked to recall the contents of that letter. Verbatim recall was not required – only the gist of the message. The first three suggestions were rated for their appropriateness, probable effectiveness, and ingenuity or unusualness. The recall was scored for the number of idea units correctly recalled from the requests.

Measures of cognitive ability

These measures fell into two categories. The first included measures of basic cognitive abilities. The second category included tasks that assess cognitive performance but that are not pure measures of a particular ability. Rather, these tasks probably require higher-level combinations of basic cognitive abilities.

The measures of basic abilities were primarily memory tasks. This choice was made because both Charness and Hartley, in unpublished studies, found that measures of memory were powerful predictors of individual differences in performance on standard problem-solving tasks. Memory is also given a central role in theoretical analyses of problem solving (Simon, 1975; Simon & Gilmartin, 1973; Simon & Kotovsky, 1963). Measures of short-term memory and working memory included the forward and backward digit span from the Wechsler Adult Intelligence Scale–Revised (WAIS-R). The reading-span measure of Daneman and Carpenter (1980) was also included. The final measure was the recency component of the free recall of four 12-word lists. For two of the lists, recall was immediate; for the other two, 30 sec of counting backward by threes preceded recall. The recency component was operationally defined as the number of items recalled from the last third of the list in immediate recall less the number recalled from the last third in delayed recall. To assess longer-term memory, the number of words correctly recalled on delayed-recall trials was tallied. Finally, to assess very long term, lexical memory, the Quick Word Test (Borgatta & Corsini, 1964) was administered.

The higher-level cognitive tasks all required that critical information be extracted from a complex stimulus. The tasks used were the Group Embedded Figures Test (Witkin, Oltman, Raskin, & Karp, 1971), the Picture Completion subtest from the WAIS-R, and a shortened version of the Davis Reading Test. The Embedded Figures Test (EFT) requires that simple line figures be located within more complex figures. Pilot research had shown that the EFT was a powerful predictor of performance at a variety of problem-solving tasks. The Picture Completion task requires that the missing element be identified in pictures of common scenes. Again, in pilot research this was found to be a significant predictor of problem-solving performance. The Davis Reading Test is a commonly

Table 18.2. *Items on the questionnaire for problem-solving style*

1.	I compromise.	18.	I am smart.
2.	I have patience	19.	I am logical.
3.	I am open-minded.	20.	I am disciplined.
4.	I am persistent.	21.	I am analytical.
5.	I am organized.	22.	I am level-headed and rational.
6.	I set priorities.	23.	I draw on past experience.
7.	I decide between alternative solutions.	24.	I am creative.
8.	I can leave a difficult problem and come back to it.	25.	I consult others.
9.	I use common sense.	26.	I have a positive self-image.
10.	I treat problems as a challenge.	27.	I break the problem into pieces.
11.	I remain unbiased and objective.	28.	I concentrate on the problem and solve it piece by piece.
12.	I consider all the options.	29.	I remain calm.
13.	I am sympathetic.	30.	I approach the problem from different angles.
14.	I consider conflicting ideas.	31.	I have a good memory.
15.	I listen carefully.	32.	I remain unemotional.
16.	I look at the pros and cons.	33.	I am motivated to solve the problem.
17.	I have a good attitude.		

used test of reading comprehension. Information must be extracted from a short passage in order to answer questions about it. The questions concern both directly stated facts and inferences that can be drawn.

The three tasks selected tap the ability to locate critical information in abstract visual displays, in meaningful visual displays, and in verbal materials. Skill at these tasks probably is dependent on a variety of basic abilities – attention and search, short-term memory, symbol decoding – as well as general cultural knowledge.

Self-report measures of problem solving

The responses to the survey described previously were used to create two instruments that each participant completed. The first concerned problem-solving style. Thirty-three items were constructed that described the characteristics and approaches to problems attributed to good problem solvers by respondents. The participant was asked to rate how descriptive each item was of him or her using a five-point scale from "definitely like me" to "definitely not like me." The items are listed in Table 18.2. The measure derived from these items was termed "problem-solving style." The second instrument concerned types of problems the person actually faced. Twenty-five items were constructed from the challenges that the survey respondents reported facing. Two responses were requested for each item: first, how frequently this sort of problem had been encountered (using a five-point scale from "very often" to "very seldom"; second, how good the individual was at solving this kind of problem (using a five-point scale from

Table 18.3. *Items on the questionnaire for problem-solving skill/frequency*

1. Budgeting time	14. Card games, board games, puzzles
2. Doing well at work or school	15. Managing investments
3. Making a decision	16. Relations with employer/employee
4. Priority conflicts	17. Auto repair
5. Choosing between work and social activity	18. Home improvements or repair
6. Handling family responsibilities	19. Technical problems
7. Doing well at a sport or hobby	20. Math or science problems
8. Your own health	21. Financial affairs
9. Health of someone close to you	22. Fitting into a new situation
10. Independence from family or relatives	23. Boredom
11. Relations within your family	24. An emergency
12. Dealing with inconsiderate friends	25. Dealing with business and professional people
13. Relations with the opposite sex	

"very good" to "not very good"). The items on this instrument are listed in Table 18.3. The measure derived from the first set of responses was termed "problem-solving frequency"; that derived from the second set was termed "problem-solving skill."

The three sets of item responses were subjected to reliability analysis. Coefficient d was .90 for problem-solving style, .82 for problem-solving frequency, and .89 for problem-solving skill. Because the reliabilities were acceptably high, single scores were obtained by averaging the responses within each of the three sets. Intercorrelations of the scores showed that problem-solving style and problem-solving skill were strongly related (r = .64), providing some evidence of concurrent validity; individuals who reported being good problem solvers had the qualities attributed to good problem solvers. Problem-solving frequency was uncorrelated with either style, (r = .15) or skill (r = −.08), indicating that that scale assessed a different aspect of self-perceptions concerning problem solving.

Health and activities measures

It also seemed desirable to assess the participant's health and current level of activity, because it could be argued that age differences in performance are really attributable to poorer health and limited activity.

Health status was assessed by asking about the presence and severity of any current problems in eight areas: blood pressure, systemic infections, heart disease, pulmonary disease, vision, hearing, other. The eight responses were combined into a single index of health status.

To assess activity level, a questionnaire was constructed asking the individual how frequently he or she engaged in a variety of common physical, intellectual, recreational, and social activities. There were nine possible responses ranging

Table 18.4. *Items from the activity questionnaire*

1. I engage in recreational sports such as golf, swimming, tennis, jogging, walking, dancing, or fishing.
2. I travel away from my home in California (other than for daily activities).
3. I travel outside California in the USA or in a foreign country.
4. I do volunteer work for a political organization or for a hospital, church, school, or similar organization.
5. I work crossword puzzles, acrostics, or anagrams.
6. I repair a car.
7. I do woodworking, carpentry, or furniture refinishing.
8. I play word games such as Scrabble.
9. I attend films (travel films, commercial movies, etc.).
10. I watch television.
11. I read books or magazines as part of my job, career, or formal education.
12. I read books or magazines for leisure.
13. I give a public address.
14. I engage in business activities, such as investments or real estate transactions, not related to my job or career.
15. I engage in sewing, knitting, or needlework.
16. I engage in painting, sculpting, ceramics, drawing, etc.
17. I engage in creative writing, writing poems, writing newspaper articles, etc.
18. I write a letter.
19. I play a musical instrument.
20. I act or participate in a theatrical activity.
21. I go to a concert or to the theater.
22. I attend an educational course (including nonacademic courses such as yoga or cooking).

from ''never'' to ''daily.'' The items are listed in Table 18.4. To obtain an overall activity level for an individual a z score was calculated for each item, and the z scores were averaged for all 22 items.

Procedure

Forty-four persons were recruited for the study from nearby senior-citizens' centers, college campuses, and the general community. Their ages ranged from 19 to 84 years. Eleven were 25 years of age or younger; 15 were between 26 and 64 years; 18 were 65 years or older. Education ranged from 10 years to 21 years. The self-report measures were completed at home; the other tasks were completed in the laboratory during one session lasting from 2 to 4 hours. Participants were paid $20.00 for their participation.

Results

Age and performance. The correlations between chronological age and problem-solving performance are given in Table 18.5. Correlations between age and cognitive and self-report measures are also given. There were no significant correlations between age and performance on the insurance-purchase task. Age did not affect the organization of the search or the frequency of redundant questions. In the automobile-purchase task, the fit between the participant's rank-

Table 18.5. *Correlations with chronological age*

Problem-solving measures	
Insurance-policy-choice task	
Number of questions	−.260
Proportion same-policy transitions	−.048
Proportion same-feature transitions	−.158
Proportion different-policy/different-feature transitions	.100
Proportion redundant questions	.058
Automobile-purchase task	
Nonparametric correlation	−.473[a]
Personal-advice task	
Number of suggestions	−.298[b]
Appropriateness of suggestions	.197
Probable effectiveness of suggestions	.235
Unusualness of suggestions	.101
Number of idea units recalled	−.383[c]
Cognitive measures	
Measures of basic abilities	
Forward digit span (WAIS-R)	−.366[c]
Backward digit span (WAIS-R)	−.447[c]
Reading span	−.563[a]
Recency in free recall	−.272
Delayed free recall	−.546[a]
Quick Vocabulary Test	−.194
Measures of complex abilities	
Embedded Figures Test	−.838[a]
Picture Completion (WAIS-R)	−.707[a]
Davis Reading Test	−.703[a]
Personal characteristics	
Self-report problem-solving scales	
Problem-solving style	.015
Problem-solving frequency	.542[a]
Problem-solving skill	.009
Health index	−.070
General activity index	−.123

[a] $p < .001$.
[b] $p < .05$.
[c] $p < .01$.

ordering of the automobiles and the objectively determined ordering declined with increasing age. In the personal-advice task, there was no correlation between age and the quality of the suggestions – their appropriateness, effectiveness, or unusualness. The number of idea units recalled from the letters declined with age, however, and there was a tendency for older adults to offer fewer suggestions. Denney and Palmer (1981) have also examined age differences in suggested courses of action for everyday problems. They found a nonlinear relation in which the rated quality of the suggestions was higher in the middle years and lower for both young and elderly respondents. To search for nonlinear relations between age and performance in the present tasks, the sample was split approximately into thirds by age, and analyses of variance were carried out with the age group as the independent variable. Post hoc comparisons were done using the Newman-Keuls test with the overall *d* set at .05. The only variables for which the results of analyses of variance diverged from those of the linear-correlation analyses were measures of the quality of solution on the personal-advice task. There were significant age-group differences for appropriateness [F (2, 41) = 3.59, $p < .05$] and unusualness [F (2, 41) = 3.61, $p < .05$]. The differences for effectiveness fell short of significance [$F(2, 41) = 2.90$, $p = .07$]. In each case, the ratings were somewhat higher for the older group than for the younger group, but both were higher than the middle group. These differences were significant for appropriateness and unusualness.

In contrast to the varied relations between age and problem performance, there were strong linear correlations between age and most of the cognitive-ability measures. Only vocabulary scores and the recency component of free recall were not significantly correlated with age. Age was unrelated to either problem-solving style or problem-solving skill, but self-reported frequency of encountering problems did increase with age.

Predicting problem-solving performance. A hierarchical regression approach was employed to explore the extent to which individual differences in problem solving could be predicted by cognitive abilities and other characteristics. At the first step in the regression, predictors that tapped basic abilities were entered in a block. These included forward and backward digit span, reading span, and recency in free recall (short-term and working memory), delayed free recall (longer-term memory), and vocabulary (long-term lexical memory). At the second step, the higher-level cognitive measures were entered. This provided an indication of the contribution of the integrated ability to draw out critical information beyond contributions of memory alone. At the third step, the computed measures of health and general activity were entered. If current health status and life style account for variance in problem solving not explained by cognitive status, these variables should significantly improve the prediction equation. Finally, chronological age was entered at the last step. If age makes a significant contribution, this indicates that there are other important variables covarying with age that have yet to be identified.

There were five criterion measures from the insurance-policy-choice task. For three of them there were no significant predictors, and the prediction equations never achieved significance – the number of questions, the proportion of redundant questions, and the proportion of same-policy question transitions. The regression analyses for the other two measures – proportion of same-feature question transitions and proportion of different-policy/different-feature transitions – are summarized in Table 18.6. In both cases, the block of basic cognitive abilities led to a significant prediction equation, but the higher cognitive abilities,

Table 18.6. *Hierarchical regressions of abilities and characteristics on problem-solving performance*

Criterion	Predictor	R^2	F(change)	F(equation)
Insurance-policy-choice task				
Proportion same-feature transitions	Basic cognitive	.294	2.574[a]	2.574[a]
	Complex cognitive	.365	1.252	2.168[a]
	Health & activity	.413	1.331	2.050
	Age	.425	0.621	1.909
Proportion different-policy/ different-feature transitions	Basic cognitive	.288	2.491[a]	2.491[a]
	Complex cognitive	.335	0.805	1.903
	Health & activity	.373	0.959	1.727
	Age	.398	1.325	1.710
Personal-advice task				
Appropriateness of suggestions	Basic cognitive	.393	3.987[b]	3.987[b]
	Complex cognitive	.411	0.359	2.639[b]
	Health & activity	.477	2.020	2.656[b]
	Age	.499	1.322	2.569[b]
Probable effectiveness of suggestions	Basic cognitive	.465	5.352[c]	5.353[c]
	Complex cognitive	.487	0.487	3.582[b]
	Health & activity	.508	0.688	3.002[b]
	Age	.517	0.599	2.767[a]
Unusualness of suggestions	Basic cognitive	.355	3.396[b]	3.396[c]
	Complex cognitive	.369	0.243	2.206[a]
	Health & activity	.391	0.594	1.870
	Age	.412	1.092	1.810
Number of idea units recalled	Basic cognitive	.319	2.893[a]	2.893[a]
	Complex cognitive	.333	0.233	1.887
	Health & activity	.426	2.607	2.164[a]
	Age	.434	0.384	1.977

[a] $p < .05$
[b] $p < .01$.
[c] $p < .001$.

health and activity, and age made no significant contribution. For same-feature transitions, the most powerful predictors were forward digit span, recency, and delayed free recall; for different-alternative/different-feature transitions, backward digit span was the most powerful predictor.

There was one criterion measure for the automobile-purchase task: the nonparametric correlation between the participant's rank order and the objectively derived rank order. The overall equation never achieved significance, although higher cognitive measures, health and activity, and age all made contributions that bordered on significance ($p < .10$).

There were five criterion measures for the personal-advice task: the number of suggestions, the rated appropriateness, effectiveness, and unusualness of the first three solutions offered, and the number of idea units recalled from the request for advice. The regressions are summarized in Table 18.6. For the number of suggestions, there were no significant predictors, and the equation was not significant. For the remaining criteria, the basic cognitive abilities produced significant prediction equations. Though the higher abilities and other characteristics did not significantly increase the variance accounted for, the equations remained significant throughout the analyses. The strongest predictors of both appropriateness and effectiveness were vocabulary, backward digit span, and reading span; reading span was the strongest predictor of unusualness; delayed free recall was the strongest predictor of the number of idea units recalled.

The predictive validities of the self-report measures of problem solving were also explored. The approach used was to enter all three self-report measures as predictors in a regression equation and then remove predictors successively. In addition to the criterion measures from problem solving, analyses were also carried out using the EFT, Picture Completion, and Davis Reading Test scores as criteria. The findings were not complex; simple correlation coefficients suffice to convey them. Those who rated themselves as relatively good at solving problems made less appropriate suggestions in the personal-advice task ($r = -.30$), but asked fewer redundant questions in the insurance-policy-choice task ($r = -.34$). The self-report measure of the frequency with which problems were encountered was the best predictor. Those who reported encountering more problems did better on the automobile-choice task ($r = .41$), the EFT ($r = .44$), the Picture Completion task ($r = .41$), and the Davis Reading Test ($r = .45$).

Discussion

It is important to reemphasize that the interpretation of these results is intended to generate hypotheses for further research rather than to provide conclusive tests of a priori hypotheses. The tasks were chosen to represent problems faced in everyday life, but, even so, there were numerous limitations. First, these three tasks are by no means a systematic sampling from all possible problems. Second, for any particular problem, there are many ways to reconstitute it in the laboratory and many ways that performance can be assessed. Third, even within a particular approach, the specific aspects of the scenario could well affect performance. For example, the processes involved in selecting an insurance policy may differ from those in selecting an over-the-counter headache remedy or selecting a nursing home for an aged parent, although all involve health-related choices. Fourth, the sample was not large; middle-aged adults were underrepresented; the subjects were relatively well educated. Despite these qualifications, there are several interesting results that suggest directions for further work.

Age and performance. The most striking finding was that the relations of age to performance were different for the three different problems. This pattern is in sharp contrast to virtually every standard laboratory problem-solving task reviewed earlier, for which there were clear age differences. In the insurance-policy-choice task, there was no relation. In the automobile-purchase task, there was a strong negative relation. In the personal-advice task, recall was negatively related to age, but the quality of solutions followed an inverse-U relation, with younger and older adults best.

The insurance-policy-choice task showed that younger and older adults performed similarly. Would they in all such problems? Medicare is more familiar and more important to the average older adult than to the average younger adult. What if a domain were selected that was more familiar and important to younger adults than to older adults? Alternatively, cognitive capabilities might be important. The amount of information available was small (32 pieces). If the number of policies or their features were increased, would that tax the more limited cognitive resources of older adults and produce age differences in performance? If the importance of information gathering were not emphasized by the task, as it was here, would age differences appear? For example, the individual might simply read a prose passage describing each policy. Regression techniques could be used with a single individual's ratings of policies to determine which pieces of information affected judgments. In general, the way in which information is organized and the form in which it is presented may affect differently the search strategies of individuals of different ages.

The automobile-purchase task showed clear effects of age. Here the information was presented in connected prose. Perhaps younger adults could see the underlying structure of relevant information, but the older adults could not. Would a matrix-like representation, such as that used in the insurance-policy-choice task, have prompted older adults to be more thorough and systematic? Successful performance requires that one notice and weigh a number of pieces of information, information that is embedded in other, extraneous information. The age differences on the EFT, Picture Completion task, and Davis Reading Test show that this is particularly difficult for older adults.

The relevant information in the personal-advice task, too, was buried in connected prose; yet the older adults produced the highest-quality suggestions. Perhaps when the schema is a highly familiar one, older adults are at least as likely as younger adults to activate the schema and use it to guide the extraction of information. If that is the case, asking for personal advice in areas with which older adults are unfamiliar should disrupt the pattern of superiority found here. In contrast, Denney (Chapter 19, this volume) reports finding that older adults perform less well even on problems selected as appropriate for their age group.

The older adults did recall less of the prose passage requesting the advice. Others have found poorer prose recall by older adults (Zelinski, Light, & Gilewski, 1984; Chapters 11 and 12, this volume). Yet, clearly, the older adults were not insensitive to the important information, because their suggestions were rated the highest in quality. Again, perhaps the familiar schema was extracted and guided problem solving even though specific details of the story were lost.

Could the unusual pattern of age differences found in this study simply be the result of an anomalous sample? Probably not. Measures of cognitive ability showed the declines with age that are commonly reported. It appears more likely that these problems were fundamentally different from standard laboratory problems.

Predicting problem-solving performance. Could the problems themselves be anomalous, calling on an idiosyncratic or variable set of abilities or strategies? Again, probably not. Individual differences in performance on many aspects of the problems were predictable. Measures of memory were significant predictors of the organization of search in the insurance-policy-choice task and of the quality of suggestions and recall in the personal-advice task. In unpublished studies, both Charness and Hartley found that measures of memory (particularly working memory) were significant predictors of problem-solving performance. In contrast, other problem-solving measures – the number of questions and frequency of redundant questions in insurance choice, the automobile-purchase task, and the number of suggestions in the personal-advice task – were not predicted. Hartley's unpublished study also found that the EFT score was correlated with performance on a variety of problems. Here, the EFT, together with other tests of more complex cognitive functioning, did not contribute significantly (though there was a tendency in that direction on the automobile-purchase task). Most important, personal characteristics (health, activity, age) did not contribute significantly when the contributions of cognitive abilities had already been taken into account.

These results raise a number of questions. Is it the case that the ability to pull critical, relevant information from a context of irrelevant information (measured by the EFT, the Picture Completion task, and the Davis Reading Test) is important in the type of problems conventionally studied in the laboratory, but not in many of the problems encountered in everyday life? Are the schemata of everyday problems so easy to pick out that individual differences are small and unsystematic?

Self-report measures of problem solving. The self-report measures of problem solving were reliable, but were uneven in predicting actual problem-solving performance. Only problem-solving frequency seemed promising. It may be that those who encounter more problems gain greater skill in solving them. An alternative explanation is that certain people are more likely to see a situation as a challenge – a problem to be solved – whereas others fail to see any challenge or simply respond in well-learned, stereotyped ways. If this explanation is correct, there should be a correlation between problem-solving frequency and "need for cognition" (Cacioppo & Petty, 1982), a measure of how attracted an individual is to cognitive challenges. Neither the extent to which one's self-description coincided with the characteristics attributed to good problem solvers nor the skill at problem solving attributed to oneself predicted performance. Thus, there is consensus on what makes someone a good problem solver, but that leaves us with three possibilities: (a) the consensus is wrong, or (b) it is right, but there are other, untapped characteristics that are necessary for good problem solving, or (c) such people are good at solving problems other than those investigated here. Each of these possibilities can be subjected to empirical test.

Conclusions

It has been argued that representative problems should be studied not simply because they are ecologically valid but rather because it is possible that the strategies and processes and the relations to basic abilities and personal characteristics such as age may be different from those for the domain of problems studied in the laboratory. The outcomes of this study indicate that that is a very likely possibility. The relationships of age and abilities to performance differed in nontrivial ways from those found with conventional problem-solving tasks. The study raised many questions, but it answered the principal question it was designed to address: Is it of value to study representative problems? Modeling the natural ecology of problems in the laboratory should be a fruitful exercise.

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