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Instruction, Induction, Generation, and Evaluation of Strategies for Solving Search Problems[1]

Alan A. Hartley and Joan Wilson Anderson[2]

Two experiments found that older adults can execute efficient strategies for search problems when instructed in their use. They continue to use these strategies after instruction and transfer their use to similar problems. The results did not support the contention that older adults can be led to discover efficient strategies by manipulation of salient stimulus features such as color. It seemed likely that age differences in search performance were due to deficiencies in strategy production. A third experiment directly examined the generation and evaluation of strategies by younger and older adults. Age differences were localized in optimal strategies; older adults were less likely to generate or use optimal strategies and rated them as less informative than did younger adults.

Key Words: Aging, Problem solving, Cognitive training, 20-questions problems

OLDER adults generally use less efficient strategies than younger adults in solving problems (Giambra & Arenberg, 1980; Rabbitt, 1977). When efficient strategies are explained or modeled, however, older adults are able to adopt them (Denney & Denney, 1974; Denney et al., 1979; Labouvie-Vief & Gonda, 1976). One interpretation of this finding is that older adults either have efficient strategies available or they have the cognitive resources necessary to construct them. They may fail to use efficient strategies spontaneously because they do not consider them, or they may consider them but fail to realize their value or judge them too difficult to use.

If strategies are available or can be constructed, it may not be necessary to demonstrate efficient problem solving strategies to older adults. If a problem could be presented in such a way that cues to efficient strategies were included, older adults might be led to discover and adopt such strategies. Denney (1980) has reported results from a 20-questions task that support this hypothesis. In one condition the problem was to determine which one of 42 pictures of common objects the experimenter had in mind by asking questions that could be answered yes or no. Older adults asked substantially less informative questions than younger adults. When playing cards were used instead of pictures, older adults did significantly better. With the playing cards, presumably, salient features such as color, suit, face or nonface card, and value elicited questions that produced efficient search.

The problems used in the present experiments were also versions of the 20-questions task. There were several reasons for using the 20-questions task. First, older adults reliably ask more questions of lower effectiveness than do younger or middle-aged adults (Denney & Denney, 1973; Denney, 1974a, 1974b; Denney, 1979; Denney, 1980; Denney & Denney, 1974; Denney & Palmer, 1981; Hartley & Anderson, 1983a, 1983b; Kesler et al., 1976). Second, there is evidence that older adults can achieve improvements on this task (Denney & Denney, 1974; Denney, 1980). Third, the task is a simple one, compared with other commonly studied problems such as chess, river-crossing problems, or analogies. The rules are neither numerous nor complex, and there are not large numbers of heterogeneous problem elements to monitor and manipulate. Almost all individuals faced with a 20-questions problem are able to select and implement a search algorithm for locating the item in question; what varies is the efficiency of the algorithms. Thus, the use of inefficient strategies can be attributed either to failure to generate efficient approaches or to failure to realize their value, rather than to being overwhelmed by the complexity of

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[2]Scripps College, Claremont, CA 91711. Address correspondence to Alan Hartley.

the problem and, as a result, unable to generate any organized strategy.

The first two experiments, then, tested the hypothesis that older adults can be induced by the problem presentation to adopt efficient strategies in search problems. In addition, two questions concerning transfer were addressed: If efficient strategies are adopted, are they still used when the cues to efficient searching are removed? Do these strategies generalize to conceptually related but superficially different versions of the task? If the efficient strategies represent a change in the problem solver rather than a transient effect of the task demands, their use should transfer.

EXPERIMENT 1

METHOD

The number and characteristics of the participants in this and subsequent experiments are given in Table 1. Each participant solved eight problems. The first six were essentially identical: The individual was shown an 8 × 8 array of squares, resembling a checkerboard, but without the alternating colors. The individual squares were 2.6 cm on a side. The array was drawn in black ink; it was mounted on a 21.7 × 27.9 cm white sheet and covered with plastic. The participant was instructed that the experimenter had one of the squares in mind, that the task was to discover which it was by asking as few questions as possible, and that only questions that could be answered yes or no would be permitted. No limit was placed on the number of questions that could be asked. The solution squares were chosen by means of a random number table for each task and each participant.

All participants began with the basic task, as described above, as a pretest. The pretest was followed by four training problems that differed for the three experimental conditions. After the pretest, participants in the first condition, termed the rule condition, had an optimal strategy for problems of this type explained. In general the optimal strategy is, with each question, to split in half the set of all squares that have not been ruled out, select one of the halves, and ask if the solution square is in that half. After the strategy was explained, participants in the rule condition completed four more problems using the same display as the pretest.

For participants in the second group, termed the color group, the second problem had squares on the left half of the display that were light blue in hue; those on the right were yellow in hue. For the third problem, the quadrants of the array were light blue, dark blue, yellow, and orange. For the fourth problem, the array was subdivided into 2 × 4 sections colored light blue, dark blue, purple, pink, yellow, orange, dark green, and kelly green. For the fifth problem, each of the 2 × 4 sections from the fourth problem was further divided into two 2 × 2 sections by mounting different colored metallic stars on the squares of each section. The intention was not only to provide a salient dimension that separated the stimuli into clusters, but also to attempt to suggest the optimal strategy of using each question to ask about half of the shrinking pool of possible solutions.

Participants in the third group, the control condition, simply repeated the basic 8 × 8 array, on a uniform, white display, without additional instruction, for the second through the fifth problems.

For all participants, the sixth problem was a posttest identical to the pretest. No special explanation was given; for all groups the posttest was introduced as follows: "OK, that was good. Now we'll do another one." To evaluate transfer beyond the basic task, two additional tasks were administered. The first transfer task resembled the basic task with the difference that the array contained 256 squares arranged in 16 rows and columns. This will be termed the large array problem. This problem was introduced as being "just like the other ones, only larger." The second transfer task, the eighth problem, used the array of 42 drawings of common objects previously studied by others (e.g., Denney & Denney, 1973; Denney, 1974a; Denney, 1980;

Table 1. Participant Characteristics

Experiment	Number		Mean age	Age range	Mean education	Mean health
	Women	Men				
1	27	9	70.4	55–83	14.19	8.03
2	30	20	71.1	54–86	13.86	8.00
3 Older	34	14	69.3	61–86	14.14	8.04
3 Younger	33	15	20.7	17–28	14.00	8.58

Note. Health was rated on a 10-point scale on which 10 was excellent.

Denney & Denney, 1974; Denney & Palmer, 1981; Mosher & Hornsby, 1966). This will be termed the object problem. The instructions for the object problem were those used by Denney (1980).

At the conclusion of the eight problems, participants were asked to give their year of birth, extent of education, and self-rating of health. Following that, any questions they had were answered.

No young comparison group was included in this study because, in prior studies, the questioning strategies of young adults were so efficient that there would have been little room for improvement. Further, the concern was whether improvement could be induced in the performance of older adults.

RESULTS

The fundamental dependent measure was the average amount of information gained with each question. Procedures for calculating the amount of information gained by a question are given by Hartley and Anderson (1983a) and Kesler et al. (1976). The information gained with a question can range from 0 bits (the question gained no new information) to 1 bit (the question reduced uncertainty about the solution as much as theoretically possible by eliminating half of the remaining alternatives). The average information gained was determined by finding the information gained by each question and averaging over questions. The means for each condition and problem are given in Table 2. Analysis of variance showed that the conditions did not differ at the pretest, $F(2, 33) = .25$, $p > .05$. Further analyses were based on the amount of change from the pretest to each later problem. Analysis of variance was used to compare the amount of change in the three treatment groups. One-tailed, planned comparisons were used to compare the rule and color groups with the practice-only control group. These contrasts showed that improvement in the rule group was significantly greater than in the control group on the last training problem, $t(33) = 2.40$, $p < .05$, on the posttest, $t(33) = 3.18$, $p < .01$, and on the large array problem, $t(33) = 2.61$, $p < .05$. Despite the improvement, the rule group with an average information gain of .73 bits of information per question on the last training problem was well below the 1.00 bits the optimal strategy should provide. The difference between rule and control groups was not significant on the object problem, $t(33) = 1.67$, $p > .05$. Contrasting the color and control groups showed no significant differences: for the last training problem, $t(33) = 1.17$, $p > .05$; for the posttest, $t(33) = 1.38$, $p > .05$; for the large array problem, $t(33) = 1.44$, $p > .05$; and, for the object problem, $t(33) = .78$, $p > .05$.

DISCUSSION

The performance of the rule group confirms earlier findings that older adults given direct instruction can adopt and use more efficient strategies than they used spontaneously. Their mastery of the strategy that was taught, however, was not complete. The improvement carried over to the large array which was similar in appearance to the preceding problems but not to the object display which was superficially different though formally similar. A limitation in the procedure for the rule condition was that the optimal rule was explained only before the first training problem and not before the subsequent training problems. Moreover, the individual was not corrected for failure to use the rule that had been explained. Perhaps both mastery and transfer of the rule could be improved by expanding the training. The results of the color condition failed to show that older adults can be induced to use more efficient strategies by means of the problem presentation alone, without direct training or modeling of efficient problem solving. The procedure used

Table 2. Average Information Gain Per Question: Experiment 1

	Problem				
Condition	8 × 8 Pretest	8 × 8 Last training	8 × 8 Posttest	16 × 16 Array	6 × 7 Object array
Rule (n = 12)	.42 (.08)	.73 (.07)	.70 (.06)	.57 (.07)	.58 (.09)
Color (n = 12)	.52 (.09)	.69 (.06)	.64 (.09)	.57 (.09)	.60 (.09)
Control (n = 12)	.46 (.10)	.50 (.09)	.46 (.09)	.41 (.10)	.48 (.09)

Note. Standard errors are in parentheses.

color to define progressively smaller divisions of the board, but it did this on successive problems Perhaps this did not convey the dynamic changes over successive questions on the same problem necessitated by the most efficient strategies.

EXPERIMENT 2

The second experiment was conducted to remove the uncertainties introduced by the procedures in the first experiment, to increase the likelihood of mastering the most efficient rules in both the rule and color conditions.

METHOD

The procedures were generally the same as in the first experiment, though the number of training problems was increased from four to six and an additional transfer task was added. Potential participants who used the optimally efficient strategy on the pretest did not complete the experiment; they were shifted to another, unrelated experiment. This was intended to reduce ceiling effects that would preclude demonstration of positive transfer.

In the rule condition, the optimally efficient rule was explained after the pretest and before the first training problem; it was reexplained before each subsequent training problem. If the participant asked a question that deviated from the strategy that was being taught, that question was recorded but the individual was then corrected. To emphasize the efficiency of the strategy, all squares that had been eliminated were covered. In addition, participants were limited to six questions, the number required by the most efficient strategy.

In the color condition, the training displays used bright hues with the squares outlined in black. On the first problem, each 1 × 8 row was in a different color; in the second, the 64 squares were divided into 2 × 4 blocks, each in a different color; and in the third, each 1 × 8 column was in a different color. The intent of these first three training problems was to use color to convey the idea that the array could be divided into chunks larger than single squares. To emphasize that different divisions were possible the spatial arrangement of the colors was changed on successive problems. The fourth problem then extended the idea of using chunks larger than single squares toward the optimal strategy; it introduced changes in the division of the display after each question: Four displays were used, one with two 4 × 8 blocks in different colors, the second with four 4 × 4 blocks in different colors, the third with eight 2 × 4 blocks in different colors, and the fourth with 16 2 × 2 blocks in different colors. The first display was placed before the individual to start the problem. After each question, the display was replaced with the next one. The experimenter emphasized that the solution square had not changed. The colors were arranged so that subdivisions of a particular area on one display (e.g., an 8 × 8 red area) were replaced by similar colors on the new display (e.g., 4 × 8 red and pink areas). To further reduce possible confusion, areas that had been eliminated by prior questions were covered on successive displays. The display was not changed for questions after the fourth. The procedure introduced on the fourth training problem was continued for the fifth and sixth problems.

Again, there was a control condition in which individuals simply solved six problems identical to the pretest. In both the control and color conditions, there was no limit on the number of questions.

The sequence of problems, then, was a 64-square pretest, six training problems, followed by a posttest identical to the pretest. Neither instructions nor colored displays were given in any of the conditions on the posttest. The 256-square and object arrays transfer tasks used in the first experiment then were given. These were followed by a new transfer problem, in which the participant was asked to guess the selling price of a fictitious house in the local community. The price was described as somewhere between $100,000 and $300,000. The task was to guess the price to the nearest one thousand dollars, using questions that could be answered yes or no (e.g., "Is it more than $200,000?" or "Is it $185,000?"). This task is equivalent to a board-guessing task with 200 squares, although it is superficially quite different.

RESULTS

As in the first experiment, analyses were carried out on the average amount of information gained with each question. The means for each condition and each problem are shown in Table 3. The conditions did not differ at the pretest, $F(2, 46) = 1.01$, $p > .05$. Again analysis of variance with planned contrasts was used to compare the three groups. The improvement over the pretest was significantly greater in the rule group than in the control group for the last training problem, $t(47) = 4.27$, $p < .001$; for the posttest, $t(47) = 4.29$, $p < .001$; for the large array problem, $t(47) = 3.34$, $p < .01$; and for the object problem, $t(47) = 2.96$, $p < .01$. The difference was not significant for the house price problem, $t(47) = 1.00$, $p > .05$. On the last

Table 3. Average Information Gain Per Question: Experiment 2

Condition	Problem					
	8 × 8 Pretest	8 × 8 Last training	8 × 8 Posttest	16 × 16 Array	6 × 7 Object array	House price
Rule (n = 18)	.48 (.05)	.94 (.06)	.87 (.07)	.77 (.09)	.74 (.07)	.42 (.09)
Color (n = 16)	.60 (.06)	.77 (.07)	.69 (.07)	.70 (.07)	.62 (.08)	.45 (.06)
Control (n = 16)	.60 (.05)	.69 (.06)	.69 (.07)	.58 (.09)	.61 (.07)	.36 (.10)

Note. Standard errors are in parentheses.

training problem, each question by the rule group gained an average of .94 bits of information out of the possible 1.00. The changes from the pretest were not significantly greater for the color than for the control groups: for the last training problem, t (47) = 1.11, $p > .05$; for the posttest, t (47) = .01, $p > .05$; for the large array, t (47) = 1.28, $p > .05$; for the object problem, t (47) = .17, $p > .05$; and for the house price problem, t (47) = 1.02, $p > .05$.

Discussion

As hoped, the expanded training in the rule condition resulted in even greater mastery and transfer than in the first experiment. It appears that changes in the surface structure of the problem eliminate transfer; the improvement did not extend to the house-price task. Participants used efficient strategies for the 256-cell display of squares and when there were objects in the cells, but not when there was no array at all in the house task. The caution must be observed that the changes in the task were confounded with the time and intervening tasks since training.

The color-display training again showed no greater improvement than the control group that received only practice. These findings fail to support the hypothesis that providing stimuli with salient dimensions will elicit more efficient questions that can produce improvements in problem solving.

EXPERIMENT 3

It could be argued that age differences in solving problems, including the present search problems, are due to (a) failure of older adults to generate efficient strategies, (b) failure of older adults to assess accurately the value of efficient strategies that have been generated, or (c) inability of older adults to execute efficient strategies. The mastery of the optimal strategy by the instructed groups in Experiments 1 and 2, however, rules out the third possibility that older adults cannot execute efficient rules in these problems. That the instructed groups generalized the strategies to problems other than those they were trained on indicates that older adults can recognize the value of an efficient strategy. The transfer was not perfect, however, and declined noticeably as the similarity between training and transfer problems decreased. This suggests that the evaluations may not be accurate, consistent with the second possibility. The failure of both the color and the control groups to discover efficient strategies is consistent with the remaining explanation, impaired strategy generation by older adults. It seems likely that a production deficiency, a failure to generate effective problem solving strategies, is an important source of the age differences in performance that have been observed. The third experiment was designed to test that hypothesis.

Two central hypotheses were tested: (a) Older adults generate less informative strategies than younger adults, and (b) when presented with strategies, older adults judge the informativeness of strategies less accurately than younger adults. The basic design included three conditions: (a) participants were asked to generate strategies for a 20-questions problem, (b) they were given strategies and asked to rate their informativeness, or (c) they served in a control group.

The basic design was elaborated to allow additional questions to be answered. The first question was whether being asked to generate or being exposed to strategies would affect subsequent problem solving performance. To answer this question, all participants were given a 20-questions problem to solve following the strategy manipulation. If older adults have efficient strategies available then being asked to generate strategies may prompt them to access and use more efficient strategies than they

would otherwise. Further, if individuals can recognize strategies as informative when they are presented, the strategy-rating condition could show even greater improvement than the strategy-generation conditions. If age differences in problem solving performance are due to failure of older adults to access available strategies, there should be a greater improvement in older adults than in younger adults in both the strategy-generation and strategy-rating conditions, and the age differences should be narrowed relative to the control condition. The second question was whether solving a problem would affect strategy generation or evaluation. To answer this, participants who were not in the control condition repeated the strategy generation or rating task they had done previously after solving the problem. It is plausible that strategies will be discovered or refined or evaluations adjusted as a side effect of actually solving a problem. The third question derived from Experiments 1 and 2. Did exposure to the problems with the sequence of colors in fact have no effect on the generation of strategies? To answer this question directly, a second strategy generation condition was added in which the problem presented after the initial strategy generation used the colored displays.

Younger adults were included in this experiment, unlike the preceding ones, because the focus of the study was whether deficiencies in strategy production can account for the observed age differences in problem solving. The ceiling on performance that made it uninformative to study improvement in problem solving in younger adults would not affect the generation or rating of strategies.

METHOD

Twelve younger and 12 older adults were assigned to each of four conditions: (a) generate strategies, then solve a standard problem with an 8 × 8 array of squares; (b) generate strategies, then solve a problem with an 8 × 8 array divided by colors; (c) evaluate presented strategies, then solve a standard problem; and (d) a problem-only control.

In all conditions, the requirements of the 20-questions problem were explained. In the strategy-generation conditions the participant was then asked to think of and to describe as many ways as he or she could that a person could use to solve the problem. It was explained that the ways of solving the problem need not all be good ones or ones the individual would use. Rather, all those that the individual thought of should be described even if some were not particularly good. The experimenter recorded each strategy. Any ambiguity was probed by asking the participant to demonstrate on an 8 × 8 array of white squares which squares were referred to by successive questions. The strategy was further clarified by asking the participant to explain what would be done if the answer to the question were "yes" and what would be done if the answer were "no."

In the strategy-rating condition, the participant was presented with written descriptions of the seven strategies that had been observed most frequently in previous studies. Each description was read aloud by the experimenter, and the areas on the matrix that would be ruled out or might still contain the target square were indicated on the display. The experimenter then explained that the next step was to rate "how good" a method of solving the problem each generated strategy would be. A 6-point scale was used, represented by a line with five divisions and with the phrases "definitely a good way" and "definitely not a good way." After all the strategies had been described, each was read again and a rating obtained.

The next step for all groups was to solve a problem in which the task was to determine which square in an 8 × 8 matrix the experimenter had in mind. For all but the strategy-generation group given the colored display, the matrix was outlined in black on a white background and was identical to that used in the pretests of Experiments 1 and 2. For the colored display, the displays used for the fourth problem of the color group in Experiment 2 were used. These used colors to divide the 64 squares into successively smaller blocks. Following solution of the problem, participants in the strategy-generation and strategy-rating conditions repeated the same task they had done before solving the problem. At the conclusion of the experimental tasks, participants were asked their year of birth, educational attainment, and general health.

RESULTS

Strategy generation. — Counts were made of the number of strategies generated prior to problem solution and the number of new strategies added following problem solution. There was no significant difference between younger and older adults in the number generated prior to the problem, $t(46) = 1.01$, $p > .05$; the younger adults generated an average of 4.38 strategies, the older adults, 3.95. The number of strategies added after problem solution was unaffected by age group, condition (stan-

dard or colored display), or the interaction of those variables, all Fs < 1. Younger adults added .67 new strategies; older adults added .55. The specific strategies that were generated were each assigned to one of 13 classifications. Seven of the classifications were as follows: (a) halving or (b) quartering the remaining area, (c) decreasing perimeters, (d) rows or (e) columns, and one square at a time, (f) systematically or (g) unsystematically. The remaining six were generally variants of the basic strategies. Chi-squared tests were carried out for each strategy, comparing the age groups on the frequency with which that strategy was generated. The only difference prior to problem solution was in the optimal halving strategy. Older adults were significantly less likely to generate it (25% did) than were younger adults (67%) did), χ^2 (1, corrected for continuity) = 6.80, $p < .01$. The numbers of strategies added after solution were too small to allow analysis.

The strategies were examined to find that which would have produced the highest average information gain per question, the measure of problem solving performance in the previous experiments. The average information gain in bits that would have been produced by the most informative strategy was the dependent variable for analysis. Older adults generated significantly less informative strategies (M = .71 bits per question) than did younger adults (M = .91), t (46) = 3.01, $p < .005$. The same result held after problem solution, F (1, 44) = 10.69, $p < .005$, ω^2 = .19. There were no effects of condition (colored or uncolored problem) or of the interaction of age group and condition, both Fs < 1. Further analysis showed that the average information gain in actually solving the problem did not differ from the information value of the most informative strategy generated. This was true for both the older adults, t (23) = .86, $p > .05$ (actual average information gain was .75 bits per question), and for the younger adults, t (23) = .46, $p > .05$ (actual average, .93).

Strategy rating. — For each individual Spearman's rank-order correlation was calculated between the actual and rated informativeness of the seven strategies that were presented. An analysis of variance was carried out with the correlation coefficient as the dependent measure, and age group and pre- or postproblem solution as independent variables. The correlations were significantly lower for older adults (M = .70; range = .22–.89) than for younger adults (M = .88; range = .51–.99), F (1, 22) = 11.08, $p < .005$, ω^2 = .34. The correlation coefficients were subjected to z-transformation before analysis. The values on the rating scale were reversed so that accurate relative judgments would produce positive correlations. There was no significant improvement as a result of solving the problem and no interaction of age and pre- or postsolution, both Fs < 1. Tests for differences between younger and older adults in their ratings of the individual strategies showed a significant difference only for the optimal halving strategy. Older adults rated the strategy as less informative (M = 1.83) than did younger adults (M = 1.17), t (22) = 2.10, $p < .05$.

The changes in ratings from before to after problem solution also were examined. Younger adults rated the quartering strategy as significantly less informative after solving the problem (M = 2.75) than they did before (M = 1.83), t (11) = 4.00, $p < .001$. The older adults did not change their rating (1.46 vs. 1.47). The difference between the age groups in the change was significant, t (22) = 2.93, $p < .01$. Older adults rated the row strategy as less informative after solving the problem (M = 4.33) than they had before (M = 3.67), t (11) = 2.35, $p < .05$. The younger adults also gave lower ratings after solving (3.67 to 4.08), but the change was not significant, t (11) = 1.33, $p > .05$. The change was not significantly different in the two groups, t (22) = –.59, $p > .05$. No other changes were significant.

Problem solving performance. — For analysis of performance, the dependent variable was the average information gain, and the independent variables were age group and condition (strategy-standard, strategy-color, rating, or control). There were significant effects of age, F (1, 88) = 42.04, $p < .001$, ω^2 = .29, and condition, F (3, 88) = 4.37, $p < .01$, ω^2 = .09. The interaction of those two variables was not significant, F (3, 88) = 1.35, $p > .05$, ω^2 = .03. As described earlier, the older adults asked less informative questions (M = .75 bits) than the younger adults (M = .93). Planned, one-tailed comparisons showed that the control condition (M = .74) was significantly below the strategy generation conditions with the standard problem (M = .80) and with the color problem (M = .84), which did not differ from each other. The strategy rating condition (M = .90) was significantly higher than all others.

DISCUSSION

The experiment was designed to test the hypoth-

eses that older adults are less likely to generate informative problem solving strategies and that they are less accurate in judging the informativeness of strategies. The results from the strategy generation conditions confirm that older adults produce less informative strategies than do younger adults. The results from the rating conditions show that, when a range of strategies is furnished, older adults are less accurate at judging the relative effectiveness of strategies.

In order to evaluate the carryover effects of being asked to generate or of being presented with strategies, the groups were compared on performance on the problem. Individuals in the evaluation conditions, in which strategies were provided, performed better at the problem than those asked to generate strategies. Both rating and generation groups performed better than control conditions in which there was no task other than solving the problem. Thus being asked to access strategies for problem solution or being given access to them produces significant improvement in the strategies used. There was, however, no differential improvement for older adults. Completing the problem had little effect on the subsequent generation or evaluation of strategies. In agreement with the results of Experiments 1 and 2, the condition that received colored displays did not differ from the strategy generation condition that received a standard problem display, without color.

This experiment provides converging evidence that optimal strategies are the focus of the performance differences between younger and older adults: Older adults are less likely than younger adults to generate optimal strategies; they give lower ratings to an optimal strategy when it is presented; and they are less likely to use an optimal strategy or its derivatives in solving a problem. The correlations between actual and judged informativeness show that older adults behave as if they were somewhat aware that the more remaining squares ruled out by a question, the better the strategy that dictated that question. Yet they do not consistently apply this rule because the optimal, halving strategy is given a lower rating than a quartering strategy that is 20% less informative. Our speculation is that older adults fail to generalize the principle fully. They may judge that there is a point of diminishing returns, with too large a "bite" being less helpful in locating the target than a smaller "bite." They may believe that asking about half of the squares exceeds the point of diminishing returns. Thus, they would give it a lower rating than another strategy such as quartering, that did not pass the point of diminishing returns.

GENERAL DISCUSSION

Three experiments failed to find evidence that would support the hypothesis that problem solving performance in older adults can be improved by manipulating the salient stimulus dimension of color. Experiment 3 did show that older adults can produce and use more efficient strategies even when they are not directly instructed in efficient strategies and when no opportunities are provided for them to mimic the experimenter. Older adults do have or can access more efficient strategies for search tasks than they normally use even when those strategies are not explicitly provided. Experiment 3 also gave some indication of the limits of generalization of these conclusions. Asking individuals to generate strategies aided younger as well as older adults; the age differences were not narrowed. The older adults remained less likely to generate optimally efficient strategies and underestimated their relative value when presented with them.

Demonstrations that the performance of older adults can be improved establish the plasticity of their cognitive performance. An assumption that has been made, though not always explicitly, is that older adults are less likely to perform up to their capacity than younger adults, perhaps because of experimental factors (Baltes et al., 1980). But it is likely that younger adults, too, perform below capacity on many tasks, selecting less than optimal strategies or failing to exploit fully the strategies they select. It is important to consider the possibility that plasticity may be the same or even greater in younger adults than in older adults (Denney, 1982). Cognitive intervention studies that have included younger adult comparison groups have found greater improvement in younger groups (Harber & Hartley, 1983; Heglin, 1956; Hoyer et al., 1978–1979) or no age differences (Experiment 3 in the present study; Hybertson et al., 1982; Rebok, 1981; Young, 1966). Assertions that cognitive plasticity are greater or less in later adulthood are probably too simplistic. It would be more productive to hypothesize more broadly that different abilities are differently affected by training in persons of different age and experience.

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