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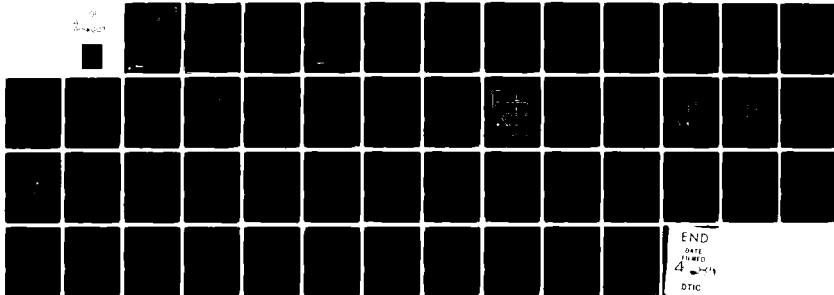
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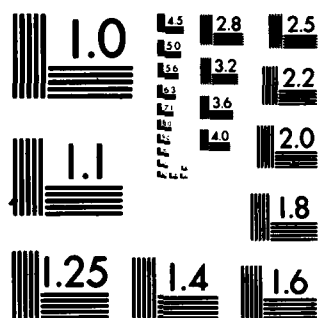
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LEVEL II

PLANNING-CONCEPT MAP-LEARNING
THE GLOBAL STRATEGIES OF HIGH
AND LOW VISUAL-SPATIAL INDIVIDUALS

Cathleen Stasz

December 1980

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Prepared For

The Office of Naval Research

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A RAND NOTE

**PLANNING DURING MAP LEARNING:
THE GLOBAL STRATEGIES OF HIGH
AND LOW VISUAL-SPATIAL INDIVIDUALS**

Cathleen Stasz

December 1980

N-1594-ONR

Prepared For

The Office of Naval Research



PREFACE

This study is the third and last in a series of Rand investigations of the process of map learning. This Note supplements findings previously reported in Stasz and Thorndyke (1980) and Stasz (1980). Rand's map-learning research has been supported by the Personnel and Training Research Programs of the Office of Naval Research, under Contract No. N00014-78-C-0042.

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SUMMARY

➤ This Note investigates the relationship between people's visual-spatial ability and their global strategies for learning maps. The results are based on experiments in which 25 subjects differing in spatial restructuring and visual memory abilities provided verbal protocols while attempting to learn maps. These protocols suggested a number of strategies that subjects used to approach the learning problem. Three strategies structured the learning task of successful map learners by providing algorithms for systematically focusing attention on various subsets of map information. Unsuccessful map learners adopted other or no strategies. Subjects high in visual-spatial ability tended to adopt these attention-focusing strategies, while most low-ability subjects used no systematic strategy. ↗

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This study is a portion of the author's doctoral dissertation submitted to the University of California, Los Angeles. Conversations with Richard J. Shavelson and Morton P. Friedman contributed to the research reported here. The contributions of Perry Thorndyke, whose collaboration made this research possible and who provided helpful comments on an earlier draft of this Note, are also gratefully acknowledged. Finally, the Note greatly benefited from Richard J. Shavelson's thoughtful review.

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I. INTRODUCTION

The learning of a body of information frequently depends on strategies that the learner uses during study. The term strategy refers here to the individual's general approach to the task or overall plan for proceeding. The notion of a strategy or a plan of action is fundamental to the view of learning as an active, intentional process carried out by the learner (Bower, 1975). Researchers have studied strategies for performance on a variety of tasks, including concept learning (Bruner, Goodnow, & Austin, 1956; Johnson, 1978); learning a zoological taxonomy (Pask & Scott, 1972); solving verbal, numerical, and geometrical analogies (Heller, 1979; Corsale & Gitomer, 1979; Mulholland, Pellegrino, & Glaser, 1980); mental arithmetic (Dansereau, 1969); sequence extrapolation (Greeno & Simon, 1974); and the Tower of Hanoi puzzle (Simon, 1975). Much of this research treats strategies as comprising particular combinations and sequences of low-level information processes, such as rehearsing an item in short-term memory or comparing an item in memory to the current stimulus. These lower-level processes, or procedures, may be automatic or learner-controlled (Hunt, 1978; Posner & Snyder, 1975).

Variations in subjects' use of strategies for a specific task are often attributed to ability differences (Cronbach & Snow, 1977). Abilities, as traditionally measured by psychometric tests, reflect stable, individual traits that influence performance skill on tasks requiring the measured ability (Fleishman, 1967). MacLeod, Hunt, and Matthews (1978), for example, found that subjects with high spatial ability used

a pictorial-spatial strategy on a sentence-picture verification task, while lower-ability subjects adopted a linguistic strategy. Frederiksen (1969) found that subjects with different verbal abilities (e.g., associative memory, associative fluency) employed different strategies when learning word lists. Furthermore, many subjects' strategies were not well suited to the task conditions. Finally, individuals differing in field-independence, a cognitive style construct representing restructuring ability (Witkin & Goodenough, 1977), have exhibited strategy differences on a variety of tasks. For example, field-independent individuals adopt an active, hypothesis-testing strategy in concept-attainment tasks (Nebelkopf & Dreyer, 1973) and utilize category clustering in verbal free recall tasks (Meshorer, 1969). In contrast, field-dependent individuals adopt a more passive, spectator role in concept learning by waiting for evidence to accumulate over learning trials before attempting to identify any concept. All of these studies indicate that while ability differences may influence strategy choice, the chosen strategy does not always improve learning.

This Note examines the strategies individuals use to learn geographic maps. The research examines the relationship between map-learning expertise and learner strategies, and the relationship between these strategies and abilities. Our previous studies of map learning (Thorndyke & Stasz, 1980; Stasz & Thorndyke, 1980) have identified 16 procedures that subjects may use to focus attention, encode information, and evaluate their learning progress while studying a map.

Imagery, for example, is an encoding procedure used to memorize configurations of spatial information. In these earlier studies, each individual's unique study style was defined by the subset of the procedures he or she employed.

To compare procedure use with map-learning skill, we determined the proportion of elements correctly reproduced (both spatial location and verbal label correctly specified) on maps subjects drew after each study trial. We found that "good" learners--subjects recalling at least 90 per cent of the map elements--used a certain subset of the procedures more frequently than poor learners (Thorndyke & Stasz, 1980; Stasz & Thorndyke, 1980). Furthermore, the validity of these procedures as underlying map learning was tested in an experiment. Individuals who were taught to use these "effective" procedures significantly improved their map learning over uninstructed individuals and individuals taught to use other, less effective procedures.

Several findings have also suggested that good and poor map learners differ in basic abilities (Stasz & Thorndyke, 1980; Thorndyke & Stasz, 1980). First, subjects' informal reports of their visual imagery ability correlated with their choice of learning procedures and their success on the learning task. Second, poor learners were inaccurate in their evaluations of what they had already learned (Thorndyke & Stasz, 1980; Stasz & Thorndyke, 1980). One possible explanation for this latter finding is that the evaluation procedure may have required subjects to visualize a portion of the learned map and compare it to information on the printed map. Thus, subjects' visual abilities might also underlie their skill at using this procedure (and perhaps others).

Third, when subjects were trained to use six effective learning procedures, high-visual-ability subjects improved tremendously after training, while low-ability subjects improved no more than subjects uninstructed in these procedures. Thus, the success of instruction in using procedures also depended on visual abilities. Finally, pre-selected groups of subjects with high and low visual-spatial ability differed in their use of imagery for encoding spatial information and in their subsequent recall of spatial information on the map. In addition, data on abilities were better predictors of learning performance than data on procedure usage.

Since abilities appear to influence subjects' selection of and success at executing relatively low-level learning procedures, they may influence other aspects of study behavior as well. In particular, abilities may influence subjects' selection of an overall approach to a learning problem (i.e., their global strategy). Such a strategy is a critical component of the map-learning task, since all of the information to be learned is presented simultaneously rather than sequentially. Subjects must decide for themselves what information to learn first and how much time to spend studying each portion of the map. Thus, individuals with spatial restructuring skill may adopt strategies that subdivide the learning task into smaller subtasks. For example, subjects may use a divide-and conquer strategy to partition the map into a set of meaningful regions. They could then focus attention on and learn one region before moving on to learn another region. In a previous study, the best map learner seemed to adopt this type of strategy. In contrast, subjects with low spatial restructuring ability may be simply

overwhelmed by the visual complexity of the stimulus and may study the map haphazardly. The present study focuses on the identification of global learning strategies and their relationship to abilities and performance on the map-learning task.

In the present study, we collected data on subjects' spatial and verbal abilities and observed their study procedures and strategies on map-learning tasks to determine what strategies people of varying abilities use, which procedures are associated with each strategy, and whether strategy use can predict learning rate. Using subjects' ability scores, we also examined whether their abilities influenced their choice of strategies.

II. METHOD

SUBJECTS

Twenty-five subjects were selected from an initial group of 94 UCLA undergraduates, on the basis of performance on a battery of standard psychometric ability tests. The tests measured visual memory, general intelligence, verbal associative memory, and field-independence (Witkin & Goodenough, 1977). For a description of these tests, see Stasz and Thorndyke (1980). The 25 subjects comprised two groups: one scoring high on field-independence and visual memory tests, and the other scoring low on these tests. The two groups had equivalent scores on the tests of general intelligence and verbal associative memory, and no subject differed by more than one standard deviation from the overall sample mean on each of these tests.

PROCEDURE

Subjects were individually tested in the map-learning task. Subjects alternately studied and reproduced two maps. One of these, a map of an imaginary town, is shown in Fig. 1. The other map portrayed an imaginary continent with countries, cities, roads, railroads, rivers, and mountains.

On each trial, subjects studied the map for two minutes and then drew from memory what they could recall from the map. While they studied, subjects verbalized their study behavior, including what they were looking at and the procedures and strategies they were using to learn

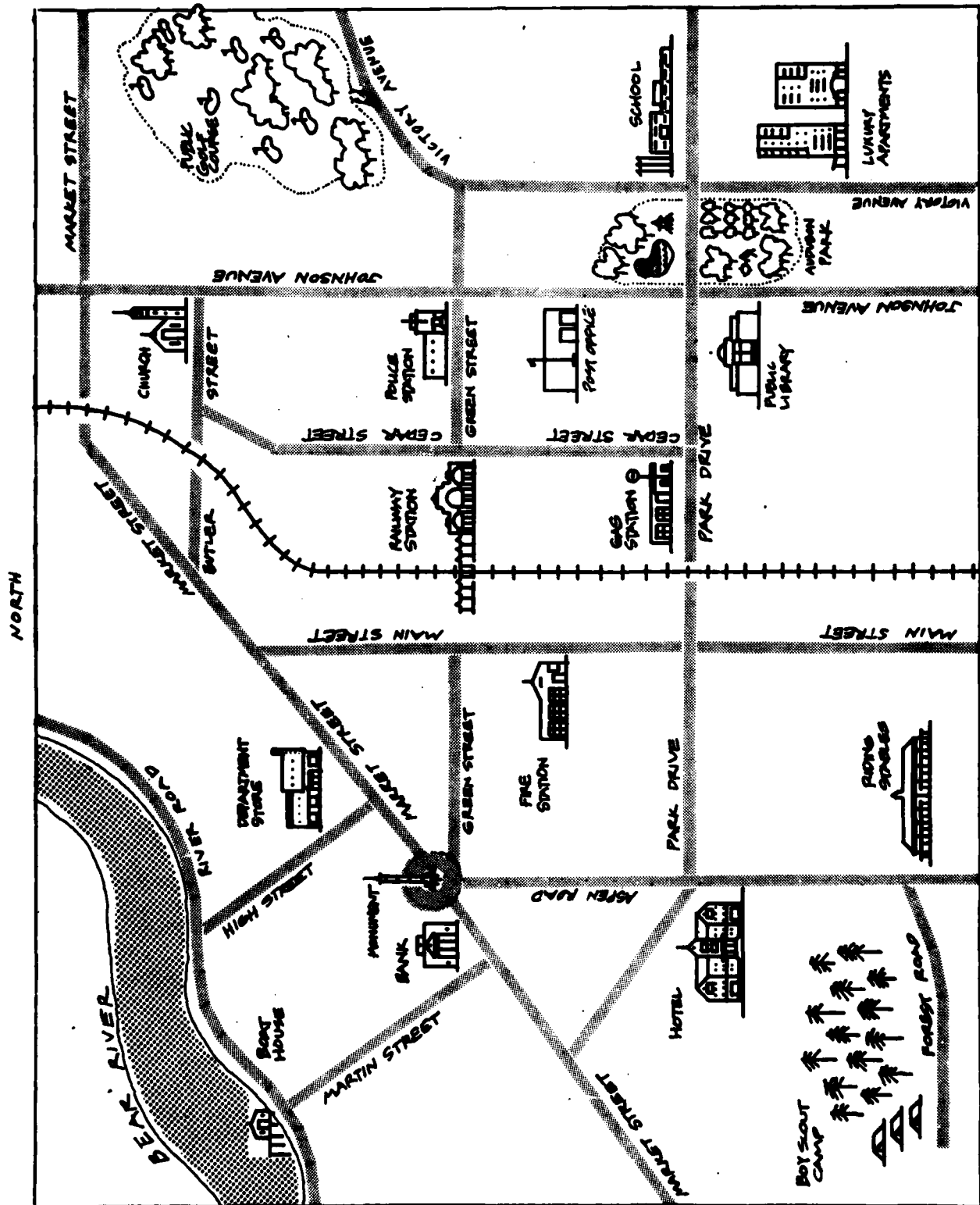


Fig. 1--The town map

the map. After six study-recall trials (or fewer if the subject learned the map perfectly), subjects answered eight location and route-finding questions from memory. For example, subjects studying the town map were asked, "What is the shortest route from the hotel to the police station?" Finally, subjects were interviewed about their learning techniques and approaches. They were asked to describe their overall strategy for learning each map and to provide any additional information about the learning task, such as level of difficulty.

PROTOCOL SCORING

To score the protocols, we defined the subjects' task-related statements and sorted them into previously identified and operationalized procedures (Thorndyke & Stasz, 1980; Stasz & Thorndyke, 1980). Table 1 list the procedures that are important for characterizing the different learning strategies discussed below.[1] This scoring method yielded, for each subject, the frequency of occurrence of each procedure on each of the study trials.

MAP SCORING

Subjects' reproduced maps were scored for accuracy according to the methods detailed in Thorndyke and Stasz (1980). Briefly, each element on the map has two potential attributes: a verbal label and a spatial location. The scoring method yielded three separate scores for each trial: percent of verbal attributes correctly recalled, percent of

[1] Readers interested in the other procedures used for map learning should see Thorndyke and Stasz (1980), or Stasz and Thorndyke (1980).

Table 1

SOME OF THE PROCEDURES USED DURING MAP LEARNING

Name	Function
Spatial partitioning	Define a spatial region of the map
Conceptual partitioning	Define a category of map elements (e.g., roads)
Random sampling	Select successive elements for study randomly
Stochastic sampling	Select for study an element adjacent to the current one
Systematic sampling	Move in a consistent direction to select successive elements
Association	Define a semantic relationship among two or more elements
Evaluation	Decide whether or not the current element has been learned
Planning	Decide on high-level strategy or plan of action for the approaching task

spatial attributes correctly recalled, and percent of total elements recalled (both verbal and spatial elements correct).

III. RESULTS

Data analyses addressed four questions about the global strategies subjects used during study: (1) What strategies do people use to learn maps? (2) What procedures do various strategies require? (3) Do strategies improve learning? (4) Do subjects with different abilities use different strategies?

IDENTIFICATION OF LEARNING STRATEGIES

The study protocols indicated that subjects differed widely in their approach to learning. Some learners adopted a specific strategy and articulated their approach during study. Other subjects with a seemingly systematic approach did not make strategy statements during study but did explain their general strategy in post-experiment interviews. The remainder of the subjects neither articulated a learning strategy nor demonstrated a consistent approach to learning the map information.

Potential strategies which subjects might use were identified in a number of ways. For example, a subject in a previous experiment adopted a "divide-and-conquer" strategy by defining a subset of the map information (e.g., streets) and focusing on elements in that set until all the elements were learned (Thorndyke & Stasz, 1980). Other potential strategies came from the problem-solving literature. Finally, some subjects made general planning statements, which were coded as instances of the planning procedure. Stasz and Thorndyke (1980) found that good learners more frequently stated an overall plan for learning the map than poorer learners.

With these potential strategies in mind, we reviewed each protocol and sorted them into seemingly similar strategy types. Three types of data aided this categorization process: strategy statements appearing in the protocols (i.e., instances of the planning procedure); strategy statements made in post-experiment interviews; and contents of the reproduced maps. Map reproductions served primarily as verifications that subjects were learning according to their stated strategies.

Across all subjects, four general strategies emerged: the "divide and conquer" (DC) strategy, the "global network" (GN) strategy, the "progressive expansion" (PE) strategy, and the "narrative elaboration" (NE) strategy. These strategies are described below.

Divide-and-Conquer Strategy. Subjects using the DC strategy sought to divide the map into smaller, more manageable regions for study. They first used the partitioning procedure to spatially subdivide the map into several sections. As illustrated in Fig. 2, subjects focused their attention on a single area, such as the northwest corner of the map, ignoring information outside of that area. They then adopted a variety of procedures to learn the information in the identified area. Having satisfied themselves that they had learned this information, they then moved on to study a new region. This process continued until all sections of the map had been studied. Thus, they treated each section of the map as a separate sub-problem. The following excerpt from a protocol illustrates how one subject articulated this strategy on his first study trial on the town map.

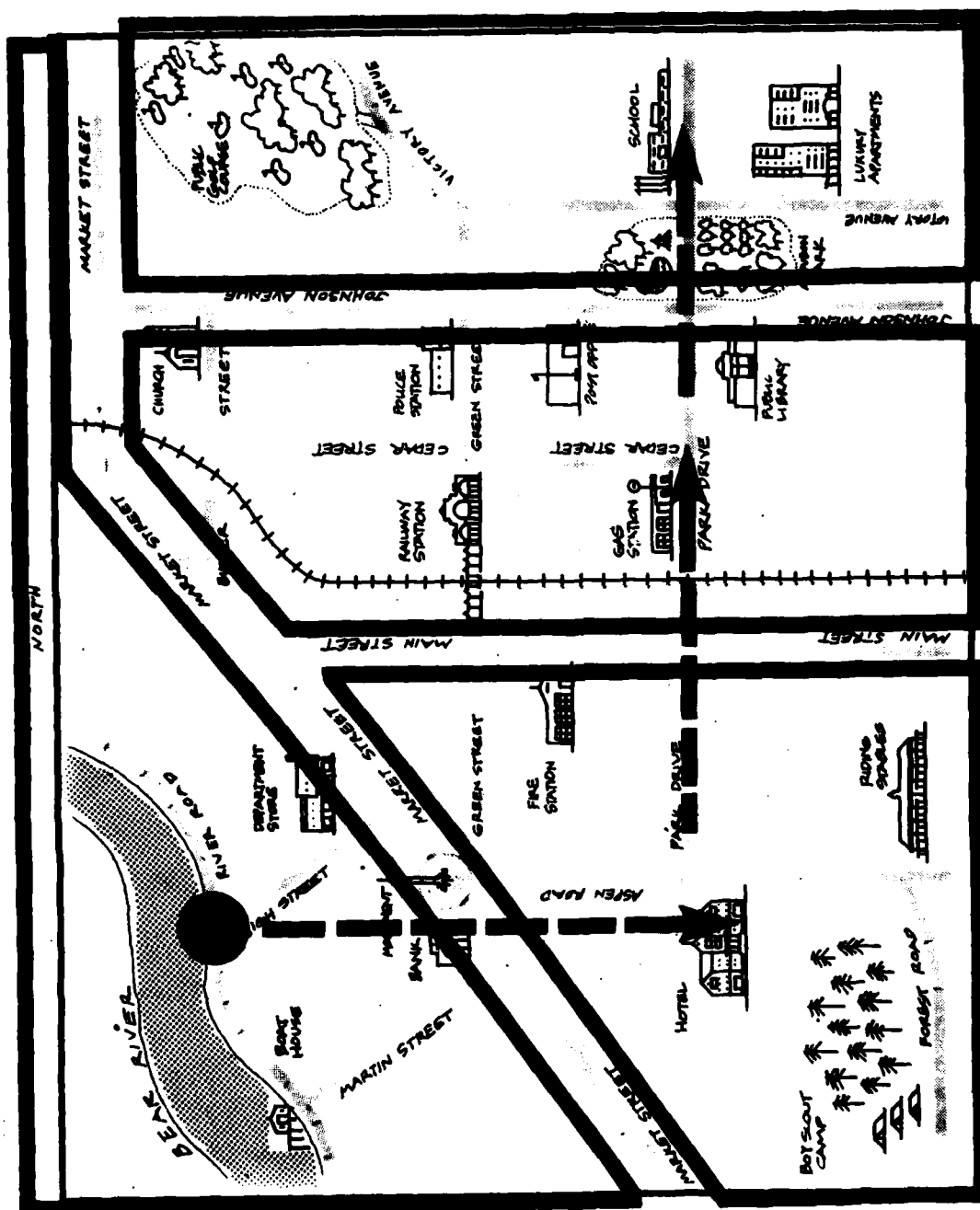


Fig. 2—Divide-and-conquer (DC) strategy

"Okay. First thing is see is I'm ... going to divide the town into five major areas by streets. I notice Market Street running northeast and southwest, about two-thirds of the way and then straightening out and running east and west. And then I'm going to take Main Street and Johnson Avenue as two more major areas that I can look at. That's just ... four areas instead of five. Look at each of those as one separate area. Start up here ... north of Market Street and the Bear River ..."

This subject continued to study the first specified area, using a variety of study procedures, throughout trial 1. Midway into trial 2, he said, "So I'm going to try now to look at what's between Market Street and Main Street." Thus, he switched his attention to the second region he identified. Similar statements indicated regional switches on trials 3 and 4. This subject used the final trials to review each area independently and to integrate the separate areas to maintain feature continuity.

Global Network Strategy. Subjects using the GN strategy first identified a small set of salient features or a type of feature that could provide a spatial framework covering the entire area of the map. These subjects learned the names and locations of these reference points and then learned new elements by relating them to the location of the reference points. They thus developed a network of spatial relations anchored by the initial global framework. Rather than focusing initially on particular geographical areas, as with the DC strategy, these subjects established their initial framework by focusing, for example, on a certain conceptual category of information (such as streets, cities, or particular terrain features) or on a few large, salient map features.

An illustration of this strategy is provided by a subject who initially focused on four large features: the river, the railroad track, the boy scout camp and the golf course:

"The first time I look at the geographical features, like the river, ... there's a railroad right down the middle, there's a golf course right here in the corner, a boy scout camp over here..."

After studying the four large features distributed across the map, this subject noted new element locations relative to these main features on subsequent trials. In effect, the initial elements became starting points for stochastically sampling new information. Stochastic sampling involved shifting the focus of attention from the current element to an adjacent element, but in no systematic or consistent direction. The sequence of foci seems to describe a "random walk" (Feller, 1966) through the map. This sampling procedure is illustrated in Fig. 3. The arrows point to adjacent elements that the subject may choose to sample. Solid arrows indicate actual choices, while broken arrows denote adjacent elements not sampled from that particular starting point.

Progressive Expansion Strategy. The third major strategy, PE, is characterized by subjects' systematic movement of attention across the map. Typically, subjects chose a starting point, such as the right side of the map in Fig. 4, and systematically moved across the map in a slow progression and in a consistent direction. When they encountered a new element, they studied it to learn its name and location. The following excerpt illustrates the PE strategy:

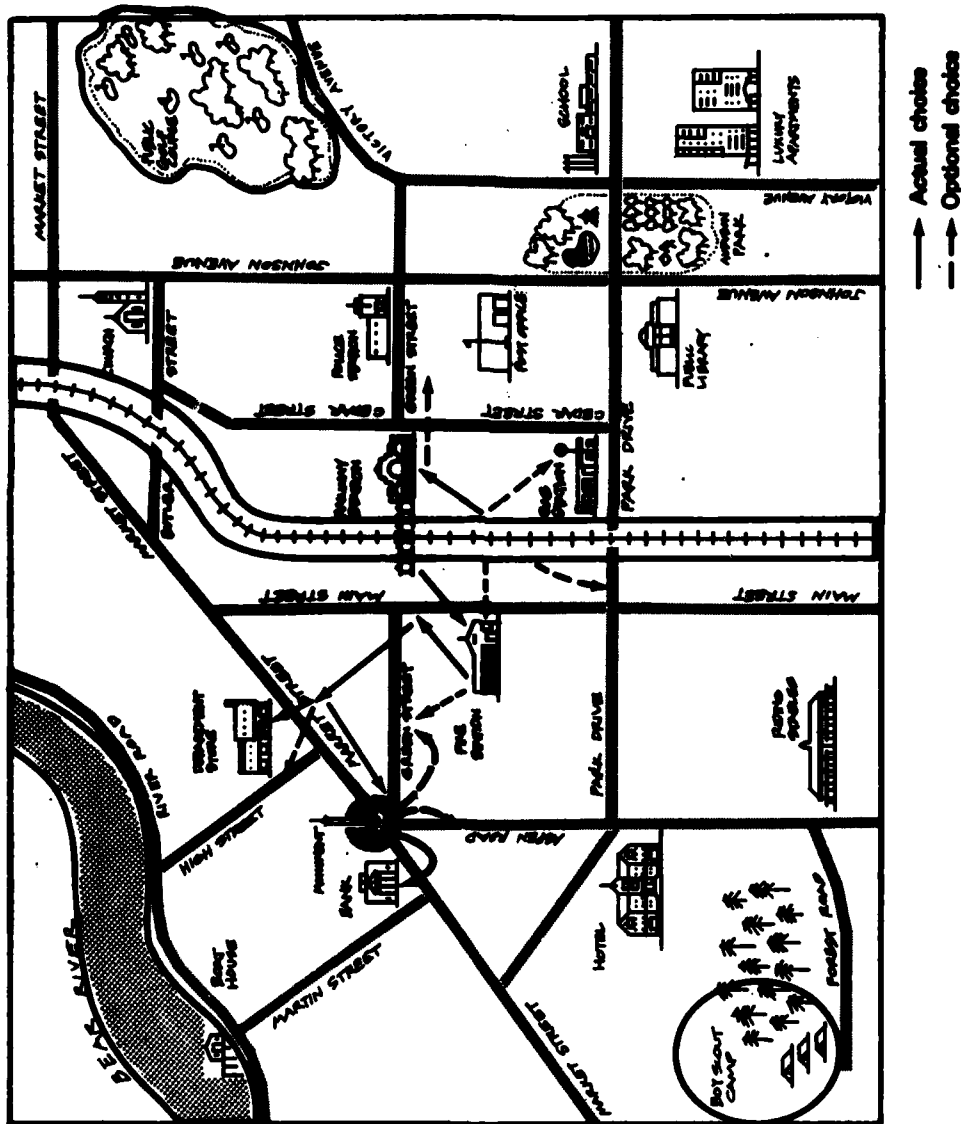


Fig. 3--Global network (GN) strategy

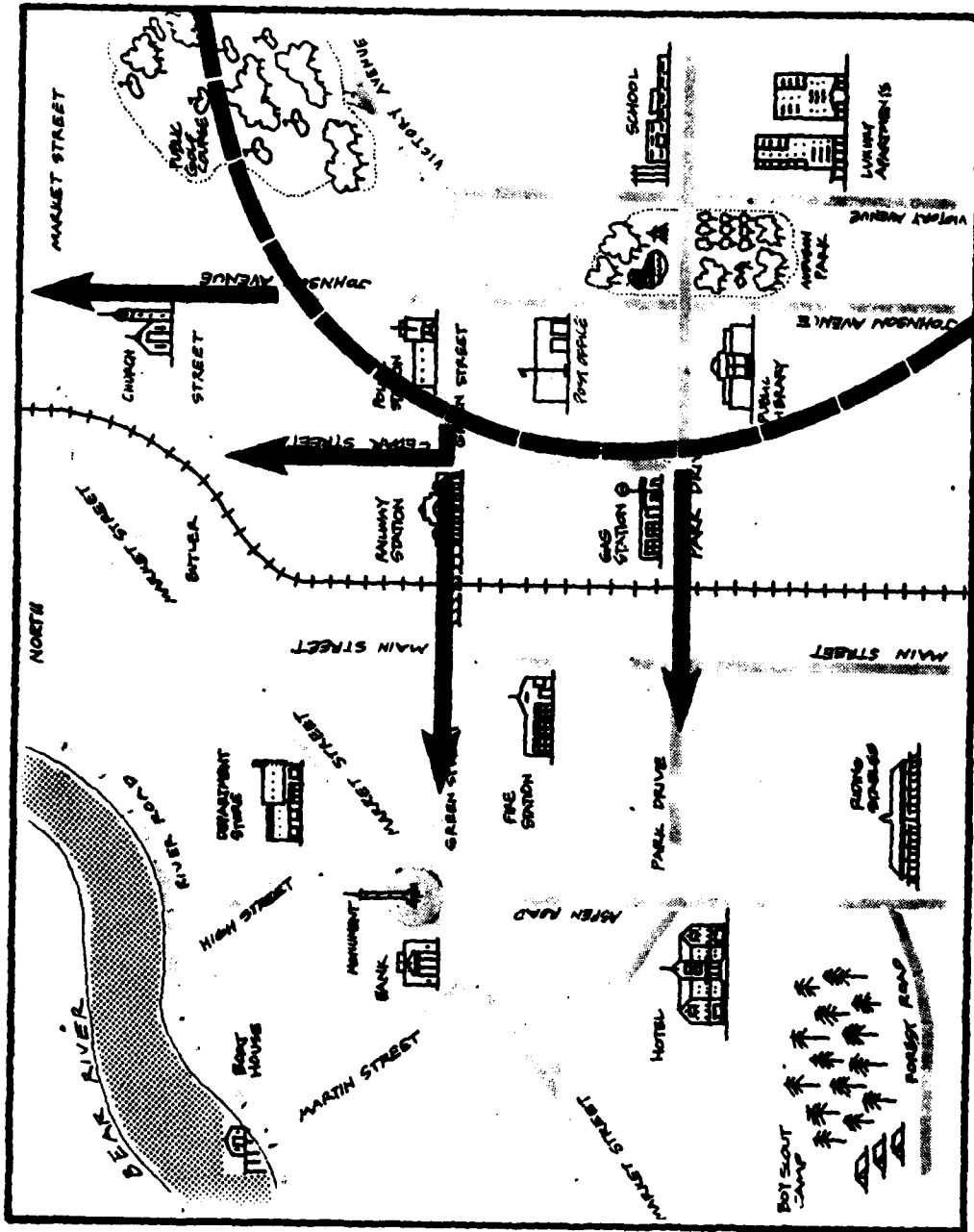


Fig. 4—Progressive expansion (PE) strategy

"I look over the whole thing. Okay. I guess I'll start at one corner, get one little section. I'll start at the right hand corner. Okay. From Green street down." [The subject studies the right side for 2 trials, and in the middle of trial 3 says,] "Okay. Then the next thing after Cedar Street is the railway...then Main Street."

This subject systematically moved across the map from right to left. This progression was clearly reflected in her map reproductions. Elements on the lower right-hand side of the map, south of Green Street, appeared on the first map reproduction, but the left-hand side of the page was blank. Her trial 2 map reproduction included all streets and buildings east of Cedar Street, but no elements west of the railroad track.

Narrative Elaboration Strategy. While the DC, GN, and PE strategies rely on specific attention-focusing procedures, the NE strategy does not. Subjects using the NE strategy attempted to learn the map by creating narratives or categories incorporating adjacent elements. This required the elaboration of verbal attributes by association to or embellishment with some related prior knowledge. Thus, NE strategists learned the configuration of map elements by inventing verbal chains or associations whose ordered set of element names implied spatial relations. For example, one subject noted the cluster of "tree" streets that included Aspen Road, Forest Road, and Park Drive. This subject also generated and rehearsed the following narrative: "Martin went to the river after the market, came back high, and then went to the department store." Thus, he created an association among Martin Street, the river, Market Street, High Street, and the department store (see Fig. 5). This subject primarily used such association procedures to learn both maps (31 percent of all procedure invocations were of this type).

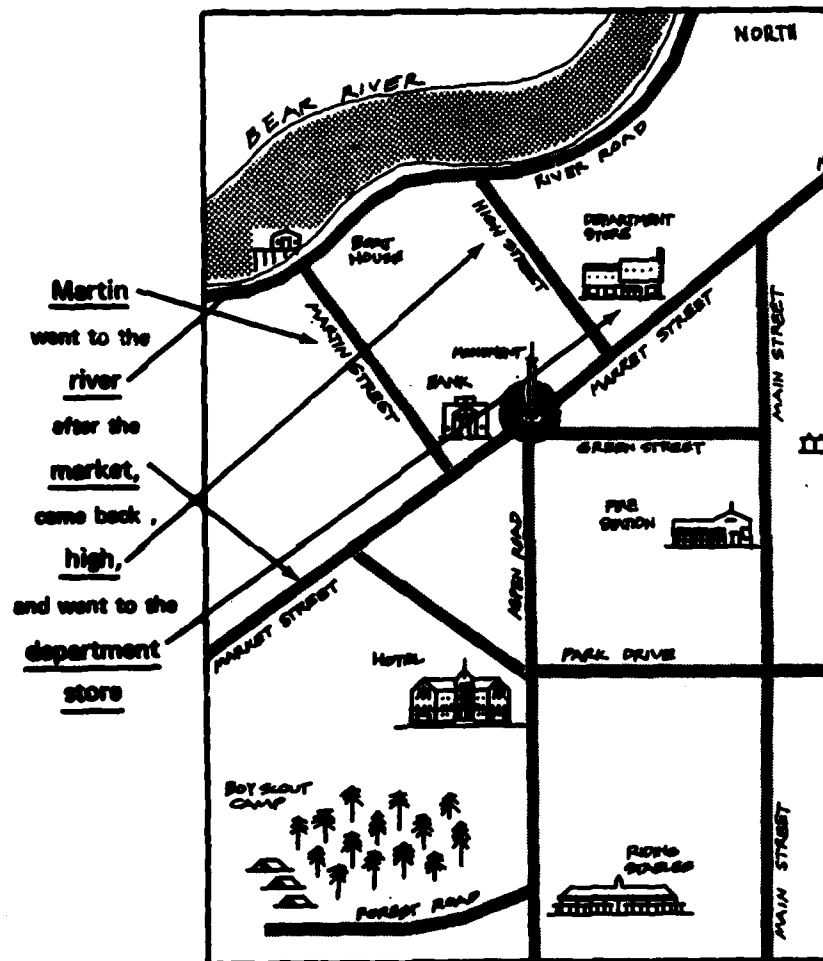


Fig. 5--Narrative elaboration (NE) strategy

One investigator sorted the subjects into groups, based on the strategies they used to learn the maps. A second investigator then sorted a random subset of the protocols. The raters agreed in 90 percent of the cases. The 50 sets of study protocols (two maps for each of 25 subjects) were sorted into five categories: the four strategies described above--DC (N = 7), GN (N = 12), PE (N = 11), NE (N = 2)--and no apparent strategy (N = 17). One subject used a strategy that seemed idiosyncratic to the countries map, and the resulting protocol could not be unambiguously categorized; therefore, we eliminated it from the analysis.

Most subjects consistently used the same strategy for both maps. This was true for three out of four subjects in the DC group, five out of seven subjects in the GN group, five out of six subjects in the PE group, and the single NE subject. Of the remaining subjects, one switched strategies from one map to the next and two adopted a strategy only for the second map.

THE RELATIONSHIP BETWEEN STRATEGIES AND PROCEDURES

Each of the four strategies we have identified suggests the use of certain study procedures. The DC, GN, and PE strategies all require subjects to structure the learning task by adopting some attention-focusing plan. These strategies seem to differ primarily in the particular type of attention-focusing procedures they prescribe. Subjects using the DC strategy, for example, must employ a spatial partitioning procedure to divide the areas into geographic regions. Having selected

a region for study, subjects may use systematic or stochastic sampling to switch their attention among the various elements in the designated region. On the other hand, GN strategists, would be more likely to use conceptual partitioning to establish their initial framework. From each reference point in that framework, subjects would sample elements stochastically. For example, the GN strategist illustrated in Fig. 3 began with the railroad track and sampled elements in the following order: railway station, fire station, Main Street, Market Street, monument, and bank. The PE strategists would use the partitioning procedures less frequently than DC or GN strategists. Since the PE strategy entails systematic movement of the focus of attention across the map, subjects using this strategy would frequently use the systematic sampling procedure. By contrast, the NE strategy requires frequent use of the association procedure but does not entail the use of a particular attention-focusing procedure. Thus, each of these four strategies depends on the use of certain procedures. We sought confirmation for these procedural invocations in the DC, GN, PE, and NE strategies to demonstrate their distinctive characters.

We compared procedures used by subjects in each strategy group. Table 2 presents the mean number of occurrences of five procedures in the protocols of subjects using the various strategies. In computing these means, a subject's score for each procedure was the total number of occurrences of the procedure across the six study trials.

Differences between strategy means on each procedure were tested using the Kruskal-Wallis one-way analysis of variance (Siegel, 1956). Since use of the attention-focusing procedures was of interest primarily

to distinguish among the DC, GN, and PE strategies, the analyses for the partitioning and sampling procedures included only these three groups.

As expected, subjects using different strategies varied in their use of attention-focusing procedures. Significant differences were found for the spatial partitioning ($H = 9.74$, $p < .001$), stochastic sampling ($H = 16.51$, $p < .001$), and systematic sampling procedures ($H = 17.57$, $p < .001$). To determine which between-group means were significantly different, we computed Mann-Whitney U-tests with an alpha level of .05 (Siegel, 1956). The DC strategists spatially partitioned the map more frequently than subjects in the other groups. In contrast, the GN strategists used conceptual partitioning and stochastic sampling more

Table 2

MEAN FREQUENCY OF OCCURRENCE OF LEARNING PROCEDURES IN
PROTOCOLS DEMONSTRATING VARIOUS GLOBAL STUDY STRATEGIES

Procedures	Strategy				
	DC	GN	PE	NE	No Strategy
Spatial partitioning	2.71	0.17	1.00	0.00	0.47
Conceptual partitioning	2.00	2.67	1.09	0.00	0.71
Systematic sampling	3.00	0.58	3.36	0.00	1.18
Stochastic sampling	3.57	5.58	2.54	6.00	4.18
Association	5.14	6.00	11.00	22.00	1.70

frequently than the DC and PE strategists. Subjects in the PE strategy group employed the systematic sampling procedure more frequently than the GN and DC strategists, although only the difference between the first pair of strategies was statistically significant. Subjects in the NE and No-Strategy groups used partitioning and systematic sampling much less frequently than subjects in the other groups, if at all.

To test group differences in the use of the association procedure, we computed a Kruskal-Wallis one-way analysis of variance which included the DC, GN, PE, and NE strategy groups. However, this test revealed that the observed differences were not significant. The fact that the NE group contained only two protocols probably contributed to the failure to obtain significance. It is possible that this strategy is idiosyncratic to one individual, at least for the map-learning problem. However, researchers in verbal learning cite many instances of what we have called the association procedure and have advocated this technique for learning verbal information (e.g., Bower & Clark, 1969; Wittrock, 1974).

These results suggest that the DC, GN, and PE strategies may be differentiated by the frequency with which their prescribed procedures are invoked. Subjects do appear to implement their learning plan in accordance with the general approach suggested by the global strategy they adopt.

THE RELATIONSHIP BETWEEN STRATEGIES AND PERFORMANCE

Since the map information is presented simultaneously and not sequentially, learners must make decisions and take actions to control

the content order of information they study. Thus, it is reasonable to suppose that the adoption of a global strategy is an important part of learning. If so, then subjects who report attention-focusing strategies should be better map learners than subjects who do not. To test this prediction, we compared mean recall scores averaged across trials for subjects using the different strategies. Separate means were computed for recall of complete map elements, spatial attributes, and verbal attributes (see Table 3). Recall of complete map elements and spatial attributes was about 20 percent higher for subjects using the DC, GN, and PE strategies than for subjects using the NE or no strategy. Mean recall of verbal attributes was less variable across groups. Kruskal-Wallis one-way analyses of variance indicated significant differences for each dependent variable ($H = 38.99$, $p < .001$, for complete elements; $H = 36.74$, $p < .001$, for spatial attributes; $H = 16.02$, $p < .01$, for

Table 3
MEAN PERFORMANCE FOR SUBJECTS USING VARIOUS GLOBAL STRATEGIES
(Mean percentage recalled per trial)

Recall Item	Strategy				
	DC	GN	PE	NE	No Strategy
Complete elements	60.7	65.3	61.5	39.0	45.2
Spatial attributes	63.7	71.2	64.2	42.0	49.1
Verbal attributes	79.0	76.9	74.8	76.5	70.6

verbal attributes). Pairwise post-hoc comparisons between means using the Mann-Whitney U-test revealed that recall of complete elements did not differ among the DC, GN, and PE groups, but each of these three groups had significantly higher recall than the NE and No-Strategy groups ($p < .01$). The latter two groups did not differ from each other. Recall of spatial attributes produced the identical pattern of results. For recall of verbal attributes, both the DC and GN groups had significantly higher recall than the No-Strategy group ($p < .05$). Thus, subjects adopting any attention-focusing strategy recalled more complete elements and spatial attributes of the map than the NE strategist or the subjects with no apparent strategy. These results replicate our earlier findings (Thorndyke & Stasz, 1980) that individual differences in map learning depend primarily on the individual's skill at acquiring spatial information rather than on differences in the acquisition of verbal information.

ABILITY DIFFERENCES AND STRATEGY USAGE

To determine the relationships between ability and map recall, we analyzed differences in strategies and learning outcomes between extreme ability groups. Since subjects' performance on tests of field-independence and visual memory were highly correlated ($r = .66$, $p < .01$), most subjects fell into one of two extreme groups: relatively field-independent, high visual memory (HIGHS, $N = 10$) and field-dependent, low visual memory (LOWS, $N = 10$).

Stasz and Thorndyke's (1980) analysis of the performance of these groups indicated that HIGHS recalled significantly more complete ele-

ments and spatial attributes than LOWS. However, the groups did not differ in recall of verbal attributes. These results, coupled with the findings reported above, suggest that HIGHS may adopt attention-focusing strategies more frequently than LOWS. This hypothesis is supported by studies that show that in learning situations field-independent individuals typically adopt active learning approaches, while field-dependent individuals assume a more passive, spectator role (Goodenough, 1976).

To examine strategy differences in the HIGH and LOW ability groups, we sorted the 40 sets of protocols from the 20 subjects into one of the four strategy groups or into the No Strategy group. Table 4 shows that 80 percent of the HIGH subjects' protocols exhibited one of the three attention-focusing strategies. None of the HIGHS used the NE strategy. In contrast, 50 percent of the LOWS subjects' protocols contained no

Table 4

NUMBER OF PROTOCOLS FROM HIGH- AND LOW-ABILITY
SUBJECTS INCORPORATING THE VARIOUS GLOBAL STRATEGIES

Strategy	Ability Group	
	HIGHS	LOWS
DC	2	3
GN	10	1
PE	4	4
NE	0	2
No strategy	4	10

consistent strategy and 10 percent exhibited the NE strategy. To test whether HIGHS and LOWS differed in their use of attention-focusing strategies and the use of no strategy, Fisher's exact test was computed separately for each map. Both tests indicated that the probability of chance differences at least this large in the tendency of the two groups to use a strategy is .08. Therefore, we conclude that these between-group differences are reliable.

IV. DISCUSSION

The analyses performed in this study suggest that both abilities and subject-selected strategies are important sources of individual differences in map learning. We identified four strategies that subjects used in the map-learning problem. Three of these--DC, GN, and PE--are characterized by the use of certain procedures for focusing attention on subsets of the map information. The fourth, NE, is characterized by extensive use of the association procedure, a technique for building relationships among multiple elements on the map.

Analyses of procedure use for each identified strategy indicated that the three attention-focusing strategies can be differentiated reasonably well by the frequency with which subjects use the particular procedures that instantiate them. The NE strategy, however, may be idiosyncratic to the single subject who used it for learning the maps. The fact that different strategies can be characterized by the use of particular procedures is a measure of validity for the proposed strategy distinctions. This demonstration is one of several tests proposed by Johnson (1978) for validating concept-learning strategies. Another test is the consistency with which subjects employ the same strategy over repetitions of the task. This consistency was demonstrated for most of the subjects.

Analyses of strategy use and performance indicated that subjects employing attention-focusing strategies recalled more complete elements and spatial attributes of the map than other subjects. Further, subjects with high visual-spatial ability were more likely to use the

attention-focusing strategies than low-ability subjects. This suggests that visual-spatial abilities may underlie the adoption of these strategies, and it supports the notion that learners can choose strategies that match their skills. However, we cannot assess from these data the relative importance of abilities and strategies for predicting learning success.

These results raise the important question of whether strategy training--particularly strategies for focusing attention--might improve map-learning performance. Given the nature of the map-learning task, the success of subjects who use attention-focusing strategies is not surprising. Moreover, focus of attention seems to be an important determinant of successful learning in other situations. Many studies in educational psychology have attempted to direct the attention of subjects when they are reading or learning from instruction. These instructional treatments have included, for example, adjunct questions inserted into a test or lesson (e.g., Boker, 1974; Felker & Dapra, 1975; Mayer, 1975, 1979; Sagaria & DiVesta, 1978) and providing objectives to learners either before or after they read a text (e.g., Kaplan & Simmons, 1974). Our research and these earlier studies suggest that attention-focusing strategies may facilitate knowledge acquisition across many content domains, and that teaching such strategies would be beneficial to students.

However, our analyses of the relationship between abilities and strategies suggest that abilities may underly strategy differences. This raises the question of whether low-ability subjects can be taught to use these strategies. Thorndyke and Stasz (1980) found that subjects

with low visual-memory ability showed little improvement in learning after being trained to use effective study procedures, while medium- and high-ability subjects benefited from this training. Two of the instructed procedures, spatial partitioning and conceptual partitioning, play an important role in the effective strategies identified in the current study. If subjects with low visual ability cannot successfully implement these procedures, it seems unlikely that they would be successful in using strategies that require these procedures. Thus, it appears that subsequent research on the trainability of general learning strategies must consider individual differences in learner abilities.

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