

imately a 6 by 8.5 in. area. The environments differed in both geographic scale and mentioned objects. The route texts ad-

is made to the previous sentence, whereas differences on the inference questions as a for hierarchical organizations, a new de-

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## Spatial Mental Models Derived from Survey and Route Descriptions

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In four experiments, subjects read route or survey descriptions of naturalistic environments and then answered verbatim or inference questions from both perspectives and drew maps of the environments. In all studies, subjects were faster and more accurate to verbatim than to inference questions, suggesting that verbatim questions are verified against a representation of the text of the descriptions. Subjects were as fast and accurate to inference questions from the read perspective as from the new perspective, suggesting that inference questions are verified against a representation of the situation described by the text. Map drawings were very accurate for both description types. A separate group of subjects studied maps instead of descriptions, and their performance was comparable to that of description subjects on all tasks. Readers apparently form the same spatial mental models capturing the spatial relations between landmarks from both survey and route descriptions, and from maps. © 1992 Academic Press, Inc.

An informal survey of tourist guide books reveals two styles of description, differing in the perspective taken on the environment. In one, the writer takes the reader on a mental tour or *route*: "As you sail up the Seine from the Place de la Concorde, you first come to the Musee D'Orsay on your right, and then the Louvre on your left. Straight ahead of you, you can see the Ile de la Cite, and the spires of Notre Dame. . . ." Another style of description takes a bird's eye or *survey* perspective: "The Washington Mall is bounded by the Capitol at the east and the Lincoln Memorial at the west. Museums line the southern and northern borders of the middle of the Mall. Along the southern part of the Mall, the most eastern museum is the Air

and Space Museum. Just west of it, across the street, is the Hirschorn Museum, and. . . ." The first type of description gives the reader a set of procedures for way-finding in the environment. The second type provides an overview of the spatial layout. Do these two styles of description have different cognitive consequences? In other words, do they induce different mental representations?

Recent research in memory for discourse has demonstrated the existence of multiple representations of discourse: representations of the phonetic or graphemic properties of actual words (e.g., Glanzer, Dorfman, & Kaplan, 1981), of the propositional content or gist of a discourse (e.g., Johnson-Laird, 1983), and of the situation described by the discourse (e.g., Barclay, 1973; Bransford, Barclay, & Franks, 1972; Johnson-Laird, 1983; van Dijk & Kintsch, 1983). Some of these studies have shown that situational representations reflect the

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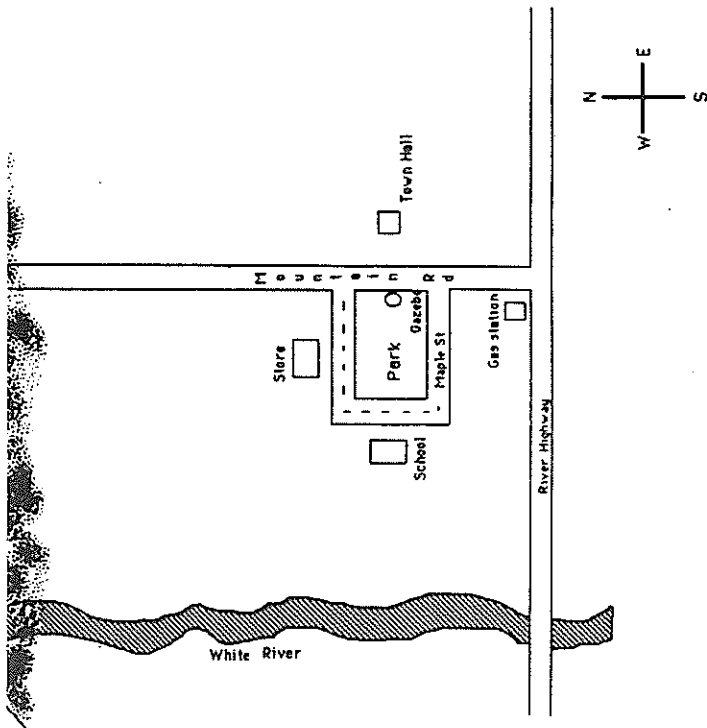


FIG. 2. Map of town.

length was 593 syllables with a range between 483 and 755. A pairwise comparison of text lengths indicated no significant length difference based on perspective.

Fourth, information about a new location followed reference to a previously mentioned location. Research has shown that processing time is faster when sentences are arranged in this given/new order (Haviland & Clark, 1974; Yekovich, Walker, & Blackman, 1979).

*Test statements.* For each pair of descriptions, a set of 28 statements tested knowledge learned from the descriptions. The statements consisted of verbatim sentences from the texts or sentences drawing on information imparted by the texts, but

not directly stated. Each set consisted of the following six types of test statements:

*Four verbatim nontopical statements*—nontopical statements found verbatim in both texts in a pair, for example, "Jefferson is the main center for hiking and cycling." or "The Cafeteria is privately run by a family that leases the space on a permanent basis from the Convention Center."

*Four paraphrased nontopical statements*—paraphrases of nontopical statements found in both texts in a pair, for example, "The chimp show includes chimps playing the piano and riding unicycles." or "Boating, water-skiing, and swimming are some of the water sports that are enjoyed on Pigeon Lake."

Further support for that expectation comes from research investigating learning actual environments from different perspectives. Thorndyke and Hayes-Roth (1982) found locations for survey descriptions. Perrig and Kintsch's route descriptions were organized serially, where the order of mention of landmarks was determined by a path

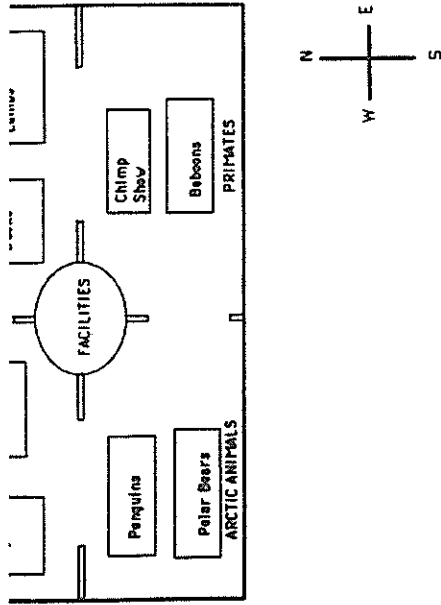


FIG. 3. Map of zoo.

*Four verbatim survey statements*—of the Cafeteria, on the west wall, are the locative statements found verbatim in the survey text, for example, "The gas station lies at the northwest corner of River Highway and Mountain Rd." or "Directly south

*Six survey inference statements*—locative statements relating an item in the environment to another item in the environ-

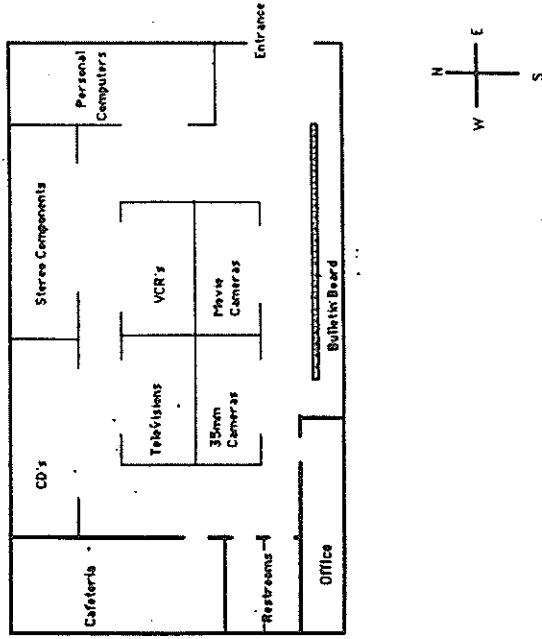


FIG. 4. Map of convention center.

Chi, 1981), a hierarchical organization is more natural for a survey description, while a linear organization is natural to route descriptions. The cognitive consequences of

Dijk & Kintsch, 1983). However, this measure cannot be applied equally to dis- courses with different organizations. For route or linear organizations, co-reference

TABLE 1

## SURVEY DESCRIPTION OF TOWN. EXPERIMENTS 2-4

One of the largest town fairs and pumpkin festivals in the United States is held each year in the town of Etna. Etna is a typical small New England town. The layout of the town has not changed much since it was founded in the 1700's. Etna and its surrounding areas are bordered by four major landmarks: the White Mountains, the White River, the River Highway, and Mountain Rd. The northern border is made up of the White Mountain Range. Running north-south along the western border of this region is the White River. The southern border is made up of the River Highway. Along the eastern border, connecting the River Highway to the mountains, is Mountain Rd. Most of Etna lies west of Mountain Rd. just north of its intersection with the River Highway. Etna is built around four streets that surround the Town Park. On the eastern edge of the park, there is a white gazebo. The gazebo is used to house the town band during afternoon concerts. Along the eastern edge of the Town Park runs Mountain Rd. The other three streets in Etna are each only a block long. Along the southern border of the park runs Maple St. Maple St. is lined with large maple trees. These maples, when they come alive with color in the fall are an attraction for many tourists. Across the street from the park, on separate sides, lie three of the town's main buildings—the Town Hall, the Store, and the School. Across the street from the east side of the park is the Town Hall. The Town Hall is the oldest structure in the town and one of the buildings around which the town was built. Across the street from the north side of the park is the Store. People often gather at the latest town news. Across the street from the west side of the park is the School. The little red, one-roomed schoolhouse is the original school built when the town was founded. At the northwest corner of River Highway and Mountain Rd. is the Gas Station. One of the mechanics from the Gas Station sits in front of the station office and waves to all the cars that drive past.

ment in a way not previously specified in the survey text, for example, "The restrooms are directly south of the Office." or "Horseshoe Dr. runs along the northern shore of Pigeon Lake." These statements maintained the third person and canonical terminology characteristic of the survey text. Three of the statements were true and the other three were false.

*Your verbatim route statements—*

TABLE 2

## ROUTE DESCRIPTION OF TOWN. EXPERIMENTS 2-4

One of the largest town fairs and pumpkin festivals in the United States is held each year in the town of Etna. Etna is a typical small New England town. The layout of the town has not changed much since it was founded in the 1700's. To reach Etna, drive east along the River Highway to where the highway crosses the White River. Continuing on the River Highway, for another half mile past the river you come to, on your left, Mountain Rd. You have reached the town of Etna. As you turn left onto Mountain Rd. from the River Highway, you see, on your immediate left, the Gas Station. One of the mechanics from the Gas Station sits in front of the station office and waves to all the cars that drive past. Straight ahead, you can see the road disappearing into the distant White Mountains. You drive on Mountain Rd. a block past the Gas Station, and come to, on your left, Maple St. Turning left onto Maple St., you see that the street is lined with large maple trees. These maples, when they come alive with color in the fall, are an attraction for many tourists. After turning left onto Maple St. from Mountain Rd., you see, on your right, the Town Park—a central feature of Etna. You travel a block on Maple St. and are forced to make a right turn. On your left, about a half a block after you turn off of Maple St., is the School. The little red, one-roomed schoolhouse is the original school built when the town was founded. Continuing along this street for another half a block, you are again forced to make a right turn. You turn and drive a half a block where you see, on your left, the Store. People often gather at the Store to find out the latest town news. This road continues for another half a block where it dead-ends into Mountain Rd. After you make a right turn onto Mountain Rd., you drive about a half a block to where you see, on your left, the Town Hall. The Town Hall is the oldest structure in the town and one of the buildings around which the town was built. From your position with the Town Hall on your left, you see, on your right, a white gazebo near the edge of the park. The gazebo is used to house the town band during afternoon concerts. You return to where Mountain Rd. dead-ends into the River Highway. You turn left from Mountain Rd. and leave the town of Etna by taking the River Highway.

locative statements found verbatim in the route text, for example, "From your position with Lincoln on your right, you see, on your left, the fishing pier and boat launch for Pigeon Lake." or "As soon as you enter

TABLE 3

## SURVEY DESCRIPTION OF CONVENTION CENTER. EXPERIMENTS 2-4

Several companies that manufacture electronics have decided to get together for a convention to show their wares. A large convention center was chosen because its large rectangular floor plan can be easily changed to accommodate the needs of various conventions. Temporary wall dividers are used to separate the displays and to form a single entrance to each display. The displays have been grouped according to three categories—Visual Equipment, Personal Computers, and Audio Equipment. You go to the east side of the building near the southeast corner where you find the entrance. As you walk into the building, you see, on your left, a Bulletin Board. The Bulletin Board is used in every convention for the business cards of the participating companies. Continuing straight ahead from the entrance, where the Bulletin Board is on your left, you reach, on your right, the Movie Cameras. The Movie Cameras are set up to film people as they walk by the display. Walking past the Movie Cameras on your right, you see, again stretching into the corner of the building, is the Office. From the Office, you are forced to turn right and you see, to your immediate left, the Restrooms. You continue forward from the Restrooms until you see, on your left stretching into the corner of the building, the Cafeteria. The Cafeteria is privately run by a family that leases the space on a permanent basis from the Convention Center. From the Cafeteria, you walk forward, until you are forced to turn right and you see, to your immediate left, the CD Players. On your right are the Televisions. Like many television displays, the sets are lined up along the walls, all tuned to the same station. You walk past the Televisions, on your right, and continue forward until you see, again on your right, the VCR's. On your left are the Stereo Components. This display includes such items as receivers, turntables, speakers, and tape decks. From the Stereo Components you walk forward until you are forced to turn right and you see, to your immediate left, the Personal Computers. There are software samples available for potential customers to test the various computers. From the Personal Computers, you walk until you reach, on your left, the corridor leading to the entrance of the building.

TABLE 4

## ROUTE DESCRIPTION OF CONVENTION CENTER. EXPERIMENTS 2-4

Several companies that manufacture electronics have decided to get together for a convention to show their wares. A large convention center was chosen because its large, rectangular floor plan can be easily changed to accommodate the needs of various conventions. Temporary wall dividers are used to separate the displays and to form a single entrance to each display. The displays have been grouped according to three categories—Visual Equipment, Personal Computers, and Audio Equipment. You go to the east side of the building near the southeast corner where you find the entrance. As you walk into the building, you see, on your left, a Bulletin Board. The Bulletin Board is used in every convention for the business cards of the participating companies. Continuing straight ahead from the entrance, where the Bulletin Board is on your left, you reach, on your right, the Movie Cameras. The Movie Cameras are set up to film people as they walk by the display. Walking past the Movie Cameras on your right, you see, again stretching into the corner of the building, is the Office. From the Office, you are forced to turn right and you see, to your immediate left, the Restrooms. You continue forward from the Restrooms until you see, on your left stretching into the corner of the building, the Cafeteria. The Cafeteria is privately run by a family that leases the space on a permanent basis from the Convention Center. From the Cafeteria, you walk forward, until you are forced to turn right and you see, to your immediate left, the CD Players. On your right are the Televisions. Like many television displays, the sets are lined up along the walls, all tuned to the same station. You walk past the Televisions, on your right, and continue forward until you see, again on your right, the VCR's. On your left are the Stereo Components. This display includes such items as receivers, turntables, speakers, and tape decks. From the Stereo Components you walk forward until you are forced to turn right and you see, to your immediate left, the Personal Computers. There are software samples available for potential customers to test the various computers. From the Personal Computers, you walk until you reach, on your left, the corridor leading to the entrance of the building.

the Zoo, you see, on your right, the ticket booth."

*Six route inference statements—locative statements relating an item in the environment to the subject's current suggested po-*

sition within the environment in a way not previously specified in the route text, for example, "Driving from the Town Hall to the gas station, you pass Maple St. on your right." or "Walking from the Stereo Components to the CD's, you pass, on your right, the 35mm Cameras." These statements maintained the egocentric terminology and second person characteristic of the route text. Three of the statements were true and the other three were false.

In all, there were 22 true and six false statements for each set.

#### Design and Procedure

First subjects answered the questionnaire. Responses to the three self-report questions were noted on a 1 to 7 scale. Then subjects turned to an IBM PC AT controlled by the Micro Experimental Lab (MEL) software package (Schneider, 1988). Instructions described the remaining procedure. In addition to describing all of the experimental tasks, the instructions provided a bit of additional advice. The instructions told subjects to study a text until they felt they could answer any sort of question about the environment described or until they felt they could describe it to someone else. Additionally, they were told to pay attention to all information in the description. Taking notes or drawing diagrams while studying was not allowed. After an opportunity for clarification of instructions, subjects were reminded that they could study at their own pace, but that they could read each text no more than four times and needed to complete the experiment within an hour.

Subjects read four texts: one survey and one route description for the larger scale areas and one of each for the smaller scale areas. The order of presentation and the assignment of description type to environments were randomized across subjects. The texts appeared on a screen approximately 23 lines at a time. For complete presentation, three of the text pairs required

two screens and one pair required three. Subjects scrolled through a text using a designated key. Subjects were allowed, but not required, to read each text four times. The overall reading time for each text was recorded.

After reading a description, subjects verified the corresponding set of 28 test statements by pressing designated keys for *true* or *false*. The statement presentation order was randomized across subjects. Both reaction time and accuracy for each statement were recorded. Finally, for each text, subjects drew a map of the described area from memory. The instructions for this task simply told subjects to draw and label, on a blank sheet of paper, a map of the environment described. For 12 of the subjects, the order that landmarks were drawn was recorded.

## Results

### Study Time

Study time necessarily combines reading time and time to integrate knowledge into memory. Because the descriptions varied in length, both total study time and study time broken down by syllable were used for analyses. The analyses consisted of repeated measure designs using within-subjects factors of description type and order of presentation.

There were significant main effects for both within-subjects factors. Subjects studied route texts longer (497 s, 0.82 s/syllable), on average, than they studied survey texts (365 s, 0.65 s/syllable),  $F(1,29) = 28.12, p < 0.0001$  for study time ( $F(1,29) = 21.47, p < 0.0001$  for study time/syllable). The other within-subjects factor, order of presentation, compared the first and second presentation of a particular perspective—route or survey. Subjects studied the first presentation of a description type longer (453 s, 0.77 s/syllable) than the second presentation (409 s, 0.70 s/syllable),  $F(1,29) = 5.15, p < 0.05$  ( $F(1,29) = 4.49, p < 0.05$ ).

### Test Statements

We collected both accuracy and reaction time (RT) data for the test statements. To control for different test statement lengths, RT per syllable was calculated. RT and RT/syllable analyses gave the same results for all experiments, so in the interest of brevity the total RT results will not be reported here. Repeated measure analyses using within-subjects factors of test statement type and description type were performed using the two dependent measures.

Subjects were faster to respond to true inferences (0.45 s/syllable) than to false inferences (0.5 s/syllable)  $t(29) = 3.58, p < 0.001$ . This is a common finding in reaction time work and held for route and survey analyses were performed using correct RTs inferences individually. The remaining RT analyses were performed using correct RTs to true statements only, but the same pattern of results emerges if correct RTs to false statements are also included. There was no tendency to err more on false than true statements, even though there were more true than false statements.

Both dependent measures showed signif-

icant main effects of statement type: for proportion of errors  $F(5,145) = 10.91, p < 0.0001$  and for RT/syllable  $F(5,145) = 137.57, p < 0.0001$ . Subjects performed better on nonlocative than on locative statements. Neither dependent measure showed a main effect of description type. Performance on route texts was equivalent to that on survey texts. Finally, both dependent measures showed significant interactions between statement type and description type: for proportion of errors  $F(5,145) = 10.88, p < 0.0001$  and for RT/syllable  $F(5,145) = 13.65, p < 0.0001$ . Errors for each text condition and sentence type are displayed in Fig. 5 and reaction times by syllable in Fig. 6.

Simple effects analyses elucidate the interaction between statement type and description type. First, let us eliminate cases where no differences were found. As was expected, since the nonlocative statements were virtually identical within a pair of texts, no significant differences based on the description studied were found for either type of nonlocative statement. Surprisingly, there were no differences due to text

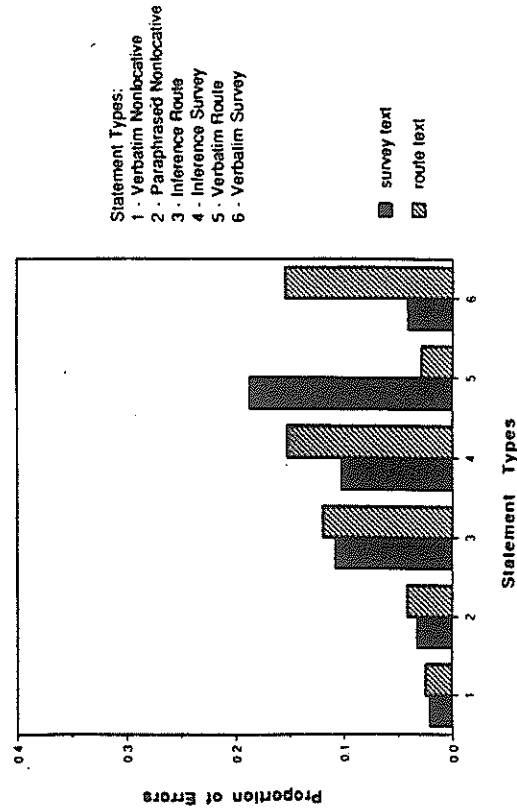


FIG. 5. Proportion of errors for both description types and all test statement types in Experiment 1.

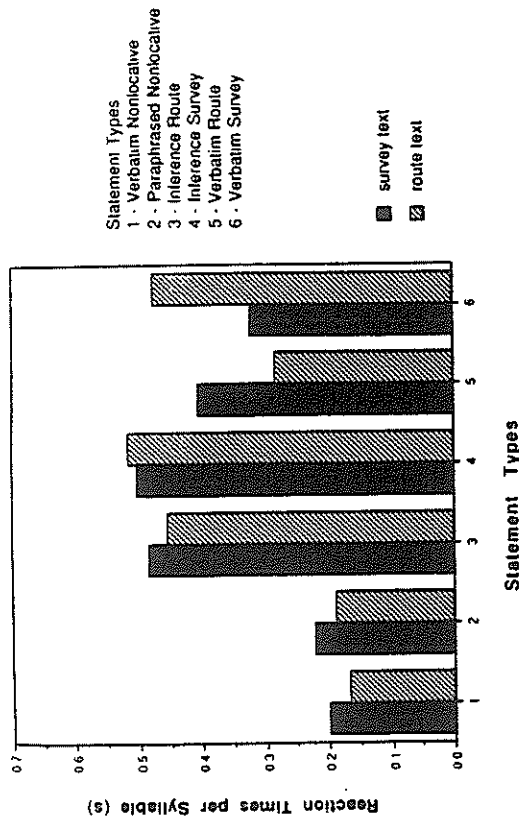


FIG. 6. Reaction times per syllable for both description types and true test statement types in Experiment 1.

perspective on either type of locative inference statement. Survey and route text readers performed equally well on both survey and route inferences.

The verbatim locative statements account for the significant interaction between statement type and description type. Subjects who studied the route text performed significantly better on the verbatim route statements than did subjects who studied the survey text: for proportion of errors  $F(1,29) = 21.19, p < 0.0001$  and for RT/syllable  $F(1,29) = 28.54, p < 0.0001$ . Likewise, survey subjects performed better on verbatim survey statements: for proportion of errors  $F(1,29) = 15.09, p < 0.001$  and for RT/syllable  $F(1,29) = 46.57, p < 0.0001$ .

Analyses of statement types within each description type using Tukey's contrasts corroborate the simple effects results for reaction time. There were no differences in performance on verbatim and paraphrased locative statements. For the locative nonlocative statements, subjects responded faster to route text statements than to any form of in-

drawing errors on the first map of a given perspective (1.28 errors) than they did on the second map of that same perspective (0.72 errors),  $F(1,29) = 4.31, p < 0.05$ .

While running this experiment, the experimenter noticed a correlation between the order subjects drew the items in their maps and the order the items were mentioned in the description studied. This correspondence was verified by recording the drawing order for 12 of the subjects and is examined more rigorously in Experiments 2 and 3.

#### Individual Differences

Only one of the individual difference items yielded significant results. The reported frequency of map use when navigating was positively correlated with both RT measures: RT/syllable,  $r = 0.41, p = 0.03$ . Although the individual difference questionnaire was also administered in Experiments 2 and 3, the overall results yielded no significant effects. Therefore, we will not address the issue of individual differences in these experiments. This questionnaire was not used in Experiment 4.

#### Discussion

##### Study Time

Readers took more time to study the route descriptions. Several differences between the two description types could account for this: moving vs. fixed spatial referent, deictic vs. extrinsic terminology, and linear vs. hierarchical organization. By spatial referent we mean a known location to which the position of new locations is related. For route descriptions, this was an observer moving in the environment, whereas, for survey texts, this was a previously located landmark. Readers of route texts, therefore, had to keep track of the current location and orientation of the observer as well as the fixed locations of the landmarks; in contrast, readers of survey texts needed to keep track of only the fixed landmark locations. Route descriptions

used intrinsic spatial terms, such as *left* and *front*, which change with the changing orientation of the observer. Survey description used extrinsic terms such as *north* and *west*, which are fixed directions in space.

Thus both the moving spatial referent and the egocentric terminology of the route texts may have contributed to an increase in study time for route texts. In addition, the hierarchical organization of the survey texts may have facilitated study time for them. Researchers have argued that the overview given in hierarchically organized texts aids storage and retrieval from memory. Although not always the case, some research has found advantages for hierarchical organizations over serial ones (Dixon, 1987; Smith & Goodman, 1984).

#### Memory

Although maps were drawn more accurately after reading survey texts than after route texts, in both cases, error rates were very low. Similarly, error rates were very low on the true-false statements. Overall, there were fewer errors and faster response times for nonlocative statements than for locative statements. For the nonlocative statements, performance was equal for verbatim and paraphrased statements. For the locative statements, performance was both faster and more accurate for verbatim than for inference statements for both route and survey descriptions. Because responses to verbatim statements were faster than those to both same and different perspective inference statements, it appears that verbatim statements were verified against a representation of the language of the text. Similarly, nonlocative statements could also be verified against a representation of the text, explaining the better performance on these statements compared to locative statements. The locative inference statements, for which there was no advantage to same versus different perspective, appear to be verified against a representation of the situation described by the text. Thus, this study, like previous ones (e.g., Johnson-

Laird, 1983; Perrig & Kintsch, 1985), suggests that readers form multiple representations of text. That the representation of the language of the text is closer to gist than to exact wording is suggested both by previous findings (e.g., Sachs, 1967; Weaver & Kintsch, 1987) and here by the lack of differences between verbatim and paraphrased nonlocative statements. This question will be explored more directly in the next experiment.

The success subjects had in both verifying statements of spatial relations and drawing maps indicates that they formed spatial mental models of the environments portrayed by both route and survey descriptions. Subjects could accurately infer spatial relations they had not specifically studied. What is surprising is finding no effect of text perspective in responses to inference statements. Both route and survey inference statements had equal response accuracy and response time regardless of the perspective of the text studied. In other words, subjects who read route texts performed equally well on both route and survey inference statements, and subjects who read survey texts performed equally well on both survey and route inference statements. Not only were there no differences between same and different perspective inferences for either errors or reaction times, but the actual number of errors and reaction times were very close. The absence of differences is not easily attributed to weak dependent measures as these measures yielded differences between verbatim and inference statements. Because this finding is surprising, because it is a null effect, and because it contradicts previous findings, it will be replicated in the next three experiments.

#### EXPERIMENT 2: VERBATIM VERSUS PARAPHRASED QUESTIONS

In the first experiment, subjects performed better when they could rely directly on memory than when they had to draw inferences from memory. What aspects of previous experience with text produce this

advantage of memory? Previous research on memory for discourse has found representation of both the surface form of a sentence and the gist of a sentence. The strength of these two representations has been hypothesized to be associated to differences between short-term and long-term memory; short-term maintains verbatim content and long-term maintains meaning. Sachs (1967) found that with longer retention intervals, subjects confused close paraphrases with original sentences. Paraphrases resulting in a change of meaning, however, were correctly rejected. More recent experiments have demonstrated longer term memory for exact wording (Bates, Masling, & Kintsch, 1978; Hjelmquist, 1984; Keenan, MacWhinney, & Mayhew, 1977; Kintsch, Welsch, Schmalhofer, & Zimny, 1990). Experiment 2 was designed to examine the extent to which subjects maintain a surface trace in addition to a representation of gist by also testing with paraphrases of locative statements. If subjects maintain a representation of the exact surface form of the text, they should be faster and/or more accurate to verbatim than paraphrased statements. If, however, subjects only maintain memory of the gist of the text, performance on verbatim and paraphrased statements should be equal. This experiment also served as a replication of the first experiment.

Another goal of this experiment was to follow up on the serendipitous finding of the first experiment, that readers appeared to draw landmarks in maps in the order they had been mentioned in the descriptions. To make the comparisons clearer, some of the descriptions were rewritten slightly so that route and survey descriptions of the same environments had quite different orders of mentioning landmarks. To make sure that scoring of orders was objective, two naive experimenters collected the data.

#### Method

##### Subjects

Nineteen undergraduates, 11 female and eight male, from Stanford University par-

ticipated individually in partial fulfillment of a course requirement for introductory psychology. The data from two subjects, both male, were eliminated due to problems logging data.

#### Materials

Materials were taken from Experiment 1. Some modifications were made to the texts. So that we can examine more closely the correlation between drawing order and text presentation order, we changed the order of presentation in some of the texts so that the route and survey descriptions for each environment presented the items in quite different orders. For the test statements, two types of paraphrased locative statements were added to the set, increasing the number of test statements to 36.

*Four paraphrased survey statements*—paraphrases of locative statements found in the survey text. Paraphrasing mainly involved the rearrangement of phrases. For example, "There is a Swimming Beach on the eastern shore of the lake" was paraphrased from "On the east shore of the lake there is a Swimming Beach."

*Four paraphrased route statements*—paraphrases of locative statements found in the route text. For example, "You see the Fishing Pier and Boat Launch for Pigeon Lake, on your left, from your position with Lincoln on your right" was paraphrased from "From your position with Lincoln on your right, you see, on your left, the Fishing Pier and Boat Launch for Pigeon Lake."

Paraphrasing mainly consisted of a reordering of the original phrases. Other changes were not possible, in this case, as there are no synonyms for either the place names or the spatial direction terms.

#### Procedure

Subjects followed the same basic procedure outlined in Experiment 1. The additional test statements increased the time necessary to complete the experiment. To compensate, subjects drew only two of the

four possible maps, a map of the first text studied, and a map of the latter of the two texts taking the other perspective. Two experimenters recorded the order that subjects drew items on their maps. These experimenters were unaware of both the drawing order hypothesis and the text that a subject had actually studied.

## Results

### Study Time

Analyses of variance were performed on total study time and study time per syllable with perspective of description and order of presentation as factors. As before, subjects took longer to study route texts and the first presentation of a description type. Study time averages were 441 s (0.70 s/syllable) for route texts and 367 s (0.62 s/syllable) for survey texts,  $F(1,16) = 5.41, p < 0.05$  ( $F(1,16) = 3.62, p < 0.1$ ). For first presentation, the study time average was 450 s (0.73 s/syllable) and for second presentation, it was 358 s (0.59 s/syllable),  $F(1,16) = 5.91, p < 0.05$  ( $F(1,16) = 4.06, p < 0.1$ ).

### Test Statements

Analyses of variance were performed on errors and reaction time per syllable for correct responses using description types and test statements as within-subjects factors. As before, reaction times to true statements were faster (0.41 s/syllable) than reaction times to false statements (0.47 s/syllable), but there was no tendency to err more on false than on true statements. Subsequent reaction time analyses were for true statements only, but the same effects emerge if false statements are included. Both dependent measures yielded significant main effects of statement type: for proportion of errors  $F(7,112) = 15.80, p < 0.0001$  and for RT/syllable  $F(7,112) = 53.43, p < 0.0001$ . Again subjects performed better on nonlocative statements than on locative statements. No significant main effects for description type were found. There were significant interactions between statement types and descriptions: