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Properties of cognitive maps constructed from texts

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Subjects in three experiments read texts describing the locations of landmarks in a fictitious town. Later they drew sketch maps and verified sentences describing the relative locations of the landmarks. We predicted that subjects would develop mental models of the town that were organized around important landmarks ("anchors"), as are cognitive maps constructed through real-world navigation. More specifically, we expected that landmarks used in the text as reference points for describing the locations of some other landmarks would emerge as anchors in the subjects' cognitive maps and would consequently be recalled more accurately. Results showed that subjects represented such reference-point landmarks more accurately than they did the locations of other landmarks. This effect was independent of: (1) the perspective from which the text was written (route or survey); (2) whether or not a map was present at learning; (3) the order of information in the text (linear or anchors-first), and (4) the amount of information available to the subjects while drawing sketch maps (the full text, the landmark names only, or no information).

People acquire information about spatial environments in different ways, for example, by navigating in the environments, by studying maps, and by reading about or viewing the environments, as when reading a tourist guidebook or watching a video documentary. Cognitive psychologists and human geographers have been interested in studying the nature of the representations that people construct from these different experiences. One line of research has shown that people construct "mental models" from text, which are representations of the objects or situations described in a text (Byrne & Johnson-Laird, 1989; Johnson-Laird, 1983; Mani & Johnson-Laird, 1982) and not just "text-based" representations of the propositional content of the text (van Dijk & Kintsch, 1983). In addition to representing the relations between landmarks that were explicitly described in the text, mental models of spatial environments allow inferences about all possible relations between landmarks (Kulhavy, Schwartz, & Shaha, 1983; Perrig & Kintsch, 1985; Taylor & Tversky, 1992a, 1992b).

Another line of research has investigated the representations that people construct when traveling through a real or simulated environment (e.g., Gale, Golledge, Pellegrino, & Doherty, 1990; Golledge, 1987; Lynch, 1960; Thorndyke & Hayes-Roth, 1982). These representations include the names, locations, and functional characteristics of landmarks. When sufficiently developed, they can be used to infer routes and distances that were not directly experienced during initial encoding (e.g., Golledge, 1987). In this research literature, the term "cognitive map" has been used to refer to people's internal representations of spatial environments.

Both the text-processing literature and the cognitive-mapping literature suggest that people construct spatial representations that contain information about all possible relationships between landmarks, not just about those that were explicitly encountered during learning. This is not surprising, because if people construct mental models from text, these models should resemble cognitive maps constructed by traveling in the environment. One quality of cognitive maps constructed by traveling is that they are organized according to reference points known as "anchors" (Couclelis, Golledge, Gale, & Tobler, 1987; Sadalla, Burroughs, & Staplin, 1980). In this research, we hypothesized that mental models constructed from text are also organized around anchors.

Hierarchical Organization of Cognitive Maps

In a cognitive map constructed by traveling in an environment, an anchor is a personal, familiar landmark that serves as a reference point for a region of space. That is, a person represents the locations of a number of landmarks in a region in relation to a single anchor (Couclelis et al., 1987). For instance, the Psychology building (our usual workplace) serves as the anchor for representing the locations of a number of other buildings around it in the authors' cognitive maps of the UCSB campus.

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In this way, people's representations of a natural environment can be considered hierarchical, with the locations of anchors represented at a higher level of the hierarchical representation and other landmarks represented at a lower level, as deviations from the locations of their anchors. We will refer to these lower level landmarks as "details." When people learn about a new environment by traveling in the real world, they learn the anchors first and recall these landmarks more often and more accurately than they do the details (Gale et al., 1990). This indicates that anchors are important, salient landmarks in people's cognitive maps.

When reading a text that describes a novel environment, a reader has no prior knowledge of the described environment that might render some landmarks more personal or familiar. However, such texts typically begin by describing the locations of some landmarks and then describe other landmarks in relation to these, so that the former landmarks serve as reference points for describing the locations of the latter. We define anchors in a text as landmarks in the described environment that are used in the text as reference points for the description of other landmarks. If anchors in a text also serve as anchors in the cognitive map that a reader constructs from this text, then they should be learned first and be recalled more often and more accurately than other landmarks.

Factors Influencing Cognitive Map Construction

In this article, we consider several different factors that might influence the cognitive maps that people construct from text. These include the perspective from which an environment is described in the text, the presence of a map during learning, and the order of information in the text.

Text perspective. We compared texts written from two different perspectives, a *route* perspective and a *survey* perspective. A route description is written from the perspective of a person traveling through an environment. This type of text is like a set of instructions for how to navigate through an environment (e.g., "turn left on Main Street") in which landmarks are described from an egocentric perspective (e.g., "on your right you will see the rustic town hall"). Thus the frame of reference is intrinsic and moves with the orientation and position of the traveler. In a survey representation, the frame of reference is extrinsic and fixed, as in a printed map, and can be thought of as a representation of the environment from a bird's-eye perspective. In our survey texts, landmarks were described in terms of the cardinal directions (north, south, etc.) as displacements from other landmarks in the environment (e.g., "the rustic town hall is on the north side of Main Street").

Perrig and Kintsch (1985) found an advantage for a route over a survey perspective in comprehension of descriptive text. There are several possible reasons for this result. First, reading is naturally a sequential process, so it might be easier to read a route description, which is also sequential, than to read a survey description, which is not sequential in nature (Taylor & Tversky, 1992b). Second, we naturally learn about new environments by navigation, so a route text describes a situation that is more similar to a real-world experience than is the one that a survey text describes. Third, Taylor and Tversky argued that the survey texts used by Perrig and Kintsch were less determinate and less coherent than the route texts. Therefore, it is important to take account of other text characteristics when interpreting differences in the comprehension of route and survey texts.

Order of information. Order of information is an important text characteristic that can affect the mental models that are constructed from the text (Denis & Cocude, 1992; Denis & Denhiere, 1990; Foos, 1980; Taylor & Tversky, 1992b). For example, if the anchors are mentioned at the beginning of a text, they might be more likely to serve as anchors in the cognitive maps that readers construct from these texts. We investigated this possibility in Experiment 2.

Presence of a map. A growing body of research suggests that constructing a mental model is facilitated when the text is accompanied by a diagram (Glenberg & Langston, 1992; Hegarty, Carpenter, & Just, 1990; Hegarty & Just, in press; Levie & Lentz, 1982; Mandl & Levin, 1989; Mayer, 1989; Mayer & Gallini, 1990). There are several reasons to expect similar facilitation when a text about an environment is accompanied by a map. First, a map displays all the spatial relations between landmarks in an environment. In contrast, a text describes only some of these relations explicitly, so that the others must be inferred. If subjects read a text accompanied by a map, they can inspect the map to encode the spatial relations between objects directly, eliminating the need to make spatial inferences. Second, a text does not usually give exact metric information about the location of landmarks and is thus indeterminate, although, interestingly, readers seem to use default values to infer locations of objects when exact distance information is not given (Mani & Johnson-Laird, 1982). A map is determinate in that each landmark is depicted in a specific location. When reading an indeterminate text, readers can inspect the map to view an exact location rather than use default values to disambiguate the locations of objects in their developing cognitive maps.

EXPERIMENT 1

In Experiment 1, subjects read texts describing a town (adapted from Perrig & Kintsch, 1985) and, in some conditions, also viewed a map of the town. We assessed subjects' cognitive maps from sketch maps that they drew of the town and from their ability to verify statements about the locations of landmarks in the town. In the texts, 3 of the landmarks (the river, the highway, and Main Street) served as reference points for describing the locations of several other landmarks (at least 4 landmarks each). In contrast, no more than 2 landmarks were related to the other landmarks in the town. Therefore, we classified the river, the highway, and Main Street as anchors and the other landmarks as details.

The locations of anchors are learned more easily than the locations of details when people develop cognitive maps from realistic environments (Gale et al., 1990). Therefore, we expected that anchors in text would also be learned more easily than details. Specifically, we predicted that subjects would include the river, the highway, and Main Street more often than they would other landmarks, and that they would place them more accurately on their sketch maps.

Experiment 1 also tested whether the presence of a map at learning affected the cognitive maps that people construct from text. We predicted that people who studied both a text and a map would develop more complete and accurate cognitive maps than would those who studied a text alone. This is because subjects in the text-plus-map condition receive two sources of information about the town, and because the map depicts all the spatial relationships between the landmarks so that the reader does not have to infer those relationships that are not explicitly described in the text.

The presence of a map might also influence which particular landmarks are identified as anchors. For example, a large landmark, such as a park, might be highly salient in a map, making it likely to be identified as an anchor. However, if the text never describes other landmarks in relation to the park, we would not expect the park to become an anchor if only the text was read. In Experiment 1, we assessed whether the addition of a map to the text affected subjects' identification of anchors.

In Experiment 1, we also compared the comprehension of texts written from a route text and those written from a survey text. In this comparison, our main goal was to determine whether text perspective affected the identification of anchors in text. Our theory suggests that a landmark becomes an anchor by virtue of its role as a reference point for describing the locations of other landmarks. Since the same landmarks served as reference points in the route and survey texts, we did not expect text perspective to affect the identification of landmarks. In this experiment, the order of information presented in the route and survey texts was the same; that is, the order in which a person would encounter landmarks on a route through the town. Because this order is more suited to a route than to a survey description (Taylor & Tversky, 1992b), we expected that subjects would construct more complete and more accurate cognitive maps from the route text than from the survey text.

Finally, we predicted that the differences between learning from the route and survey texts would be reduced when a map was present during learning, because a map compensates for some of the difficulties encountered with the survey text, that is, its nonoptimal order of information.

Method

Subjects and Design

Forty-eight undergraduate students (24 males, 24 females) at the University of California, Santa Barbara participated in this experiment for partial credit in an introductory psychology course. The experiment had a 2×2 between-subjects design in which the two factors were map presence (map-plus-text or text only) and text perspective (route or survey). The subjects were assigned randomly to one of four groups, with the constraint that there be equal numbers of males and females in each group (to control for possible gender effects).

Materials

Texts. The texts were one page long and described the spatial configuration of landmarks in a fictitious town from either a route or a survey perspective (see Appendix A). Both versions described the locations of 14 landmarks, including roads, buildings, and natural landmarks such as parks and hills, and the order of information given was the same in the two versions. The landmark locations described included 8 related to the highway, 4 related to the river, and 4 related to Main Street. No more than 2 landmarks were related to any of the other landmarks in the town. The 3 anchors—the river, the highway, and Main Street—were mentioned 4, 8, and 5 times in the text, respectively. The other 11 detail landmarks were mentioned either 1 or 2 times. Each landmark was mentioned the same number of times in the route and the survey texts. The texts did not state the precise distances between the landmarks and, in this sense, were indeterminate.

As a measure of coherence, we divided the texts into sectors containing a single clause and measured the proportion of instances in which two consecutive units had a common referent, that is, contained an expression (noun or pronoun) referring to the same object, which was either a landmark or the person to whom the text was directed (in the case of the route text). The route text contained more sectors (29) than the survey text (23). This was partly due to the inclusion of additional clauses containing navigation directions (e.g., "Turn left on Main Street") and partly due to the fact that, in some cases, information that was given in a separate clause in the route text (e.g., "before you cross the river") was given in a propositional phrase in the survey text (e.g., "south of the river"). Thus, some clauses in the survey text were more complex. The coherence measures for the route and survey texts were .57 and .59, respectively. The route text was somewhat longer (385 words) than the survey text (360 words).

Map. The map was hand drawn on a sheet of 8½″×11″ paper with typed labels indicating landmark names (see Figure 1). The map depicted the 14 landmarks described in the text, plus 7 additional landmarks that were included to explore a hypothesis about text direction of map processing, which is not the focus of this article (see Ferguson, 1993). The layout of the streets was in the form of a grid, with the highway running north–south. The map was not to scale, for example, the size of the hills was small compared with the size of buildings.

Verification statements. The verification statements consisted of 36 statements describing information from the text. There were 30 *spatial* statements (15 true, 15 false), which described spatial relations between 2 landmarks in the town,[1] and 6 *nonspatial* statements (3 true, 3 false), which described nonspatial information presented in the text, for example, "the old General Store is the social center of town for the youth." Six of the spatial statements described landmarks that were included in the map but not in the text.

Procedure

The subjects were tested individually. Each subject was seated at a desk in an open cubicle and was given all materials in the form of a booklet. The first page of the booklet gave instructions to study the text (or the text and map) for as long as needed to "learn the information well enough to be able to describe the area to someone else." In the map conditions, the page with the map was not stapled into the booklet, so that subjects could place it beside the text while reading.

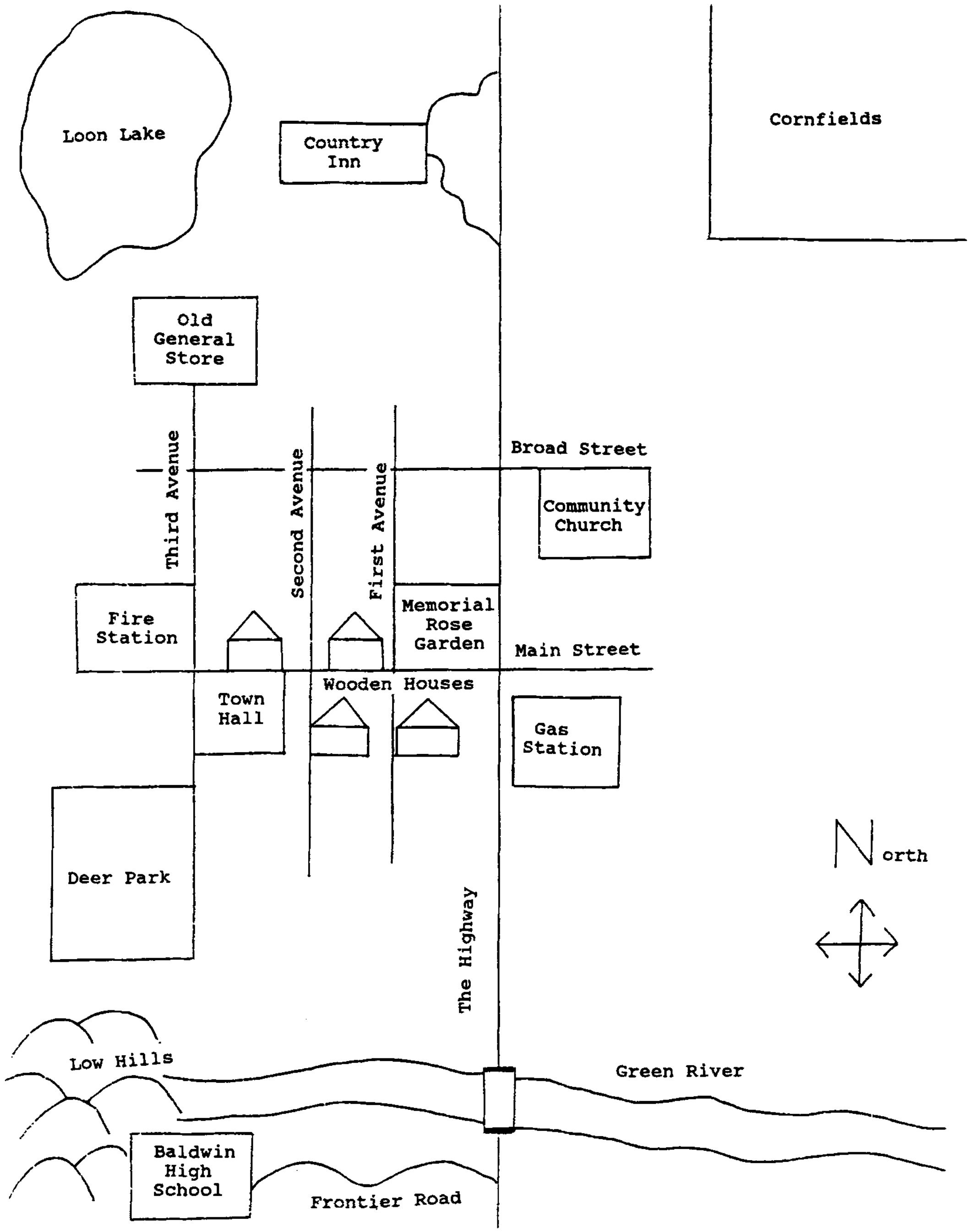

Figure 1. The map studied by subjects in the text-plus-map conditions of Experiment 1.

For half of the subjects, the second set of instructions in the booklet was to draw a map of the town and to include as much information as possible from the materials they had studied. A blank sheet of paper was provided. The third task for these subjects was to circle "true" or "false" for each of 36 statements, which were presented on two pages. The other half of the subjects verified the statements as their second task and then drew a sketch map. The order of tasks had no significant effects on any of the measures.

Results and Discussion

Scoring of Sketch Maps

We examined which landmarks subjects placed on their sketch maps to determine whether the landmarks that we had defined as anchors were included more often and were placed more accurately on the sketch maps. Two independent raters scored each sketch map for completeness and accuracy. Each landmark was scored as being either included or omitted and as being either accurate or inaccurate.

A landmark was scored as being included if (1) the name of the landmark was included somewhere on the map (slight variations, such as "street" instead of "avenue" were allowed), or (2) there was an unlabeled symbol drawn somewhere on the map that could be interpreted unambiguously as that landmark (e.g., little ears of corn for the cornfield).

A landmark was scored as being accurate if its location was consistent with the text description. For example, the gas station was scored as correct if it was north of the river, but south of Main Street, and on the east side of the highway. If either the river or Main Street was omitted, the gas station was scored with respect to the landmarks that were present.[2] Thus, although the texts did not state an exact location for each landmark, this indeterminacy was taken into account in the scoring. Landmarks that were not mentioned in the text were not scored. Interrater reliability was 96%. All ambiguities were resolved by consensus of the two raters. The correlation of accuracy (summed for all landmarks) with inclusion was .86 ($p < .001$).

Inclusion of Landmarks on Sketch Maps

We examined the effects of hierarchy level (anchor or detail), map presence (map-plus-text or text only), and text perspective (route or survey) on overall inclusion of landmarks on sketch maps in a 2×2×2 analysis of variance with repeated measures on the first factor. The means and standard errors for these conditions are presented in Figure 2.

As we predicted, anchors were included more often than details on the subjects' sketch maps [$F(1,44) = 49.82, p < .0001$]. Furthermore, as Figure 3 shows, the

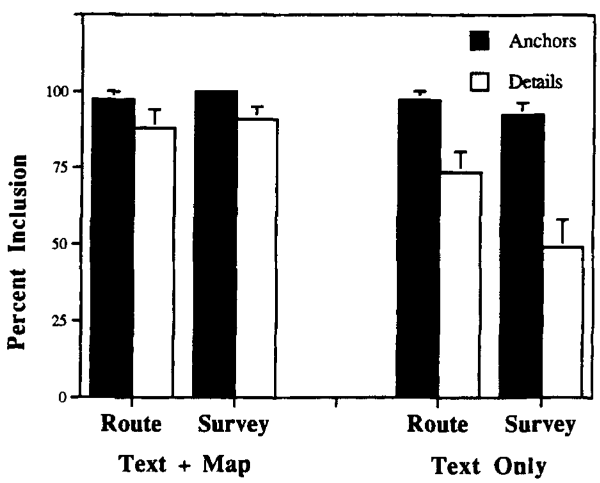

Figure 2. Means and standard errors for inclusion of landmarks on subjects' sketch maps in Experiment 1. Included landmarks comprised both correct and misplaced landmarks. For this and other graphs, standard errors less than 2% are not shown.

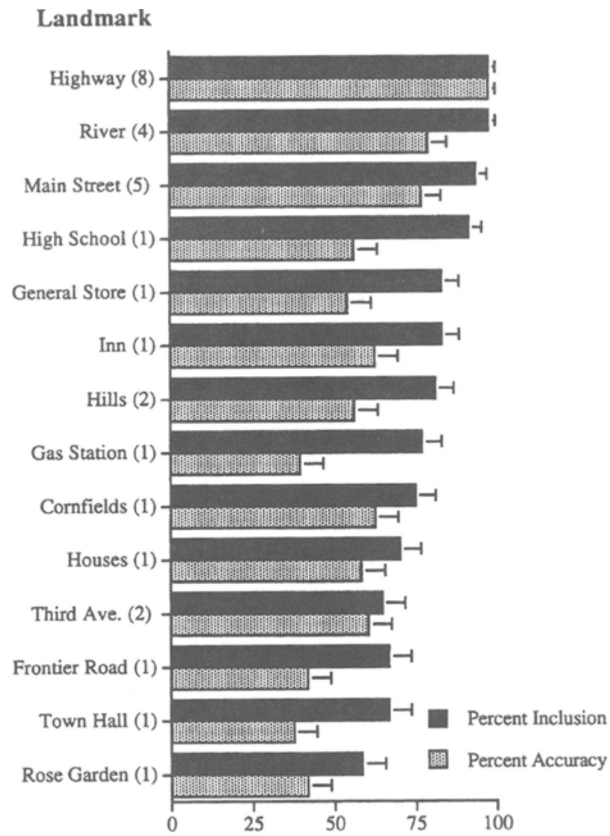

Figure 3. Means and standard errors for overall inclusion and accuracy of the individual landmarks described in the texts in Experiment 1. The numbers in parentheses indicate the number of times the landmarks were explicitly mentioned in the text.

landmarks that we classified as anchors—the river, the highway, and Main Street—were the 3 most frequently included landmarks overall. Subjects who had a map present at learning included more landmarks than did subjects who learned from text alone [$F(1,44) = 12.78, p < .001$]. The main effect of text perspective did not reach statistical significance [$F(1,44) = 1.74$].

As Figure 2 shows, hierarchy level interacted with map presence [$F(1,44) = 16.13, p < .001$], such that the text-plus-map group included more details than did the text-only group [$F(\text{simple})(1,44) = 15.96, p < .001$], but there was no difference between the text-plus-map and the text-only groups in the inclusion of anchors [$F(\text{simple})(1,44) = 1.69$]. Thus, anchors tended to be included by all subjects and the presence of a map improved mainly the inclusion of details.

There was a marginally significant interaction between the factors of text perspective and map presence [$F(1,44) = 3.9, p = .05$]. Analysis of simple effects revealed that among the text-plus-map groups, there was no significant difference between subjects who read route and survey texts [$F(\text{simple}) < 1$], whereas among the text-only groups, subjects who read a route text included more landmarks than did those who read a survey text [F(simple)(1,44) = 5.64, $p < .05$]. These results suggest that presence of a map can compensate for problems with comprehension of survey texts.

Neither the interaction between hierarchy level and text perspective [$F(1,44) = 2.55$], nor the three-way interaction [$F(1,44) = 2.69$] was statistically significant.

Accuracy of Landmark Placement on Sketch Maps

All groups placed anchors more accurately on their sketch maps than they placed details [see Figure 4; $F(1,44) = 73.29$, $p < .0001$]. Subjects who learned from a text and a map were more accurate in landmark placement than were those who learned from a text alone [$F(1,44) = 61.90$, $p < .0001$]. Thus, hierarchy level and map presence affected how well subjects placed landmarks on their sketch maps and not just whether or not they included these landmarks. The main effect of text perspective was not statistically significant [$F(1,44) = 1.20$].

Hierarchy level interacted with map presence [$F(1,44) = 9.02$, $p < .01$], such that there was a greater difference between the text-only and the text-plus-map conditions in the accuracy of details [F(simple)(1,44) = 46.48, $p < .0001$] than in the accuracy of anchors [F(simple)(1,44) = 30.41, $p < .01$].

As with the measure of inclusion, there was an interaction between text perspective and map presence [$F(1,44) = 4.35$, $p < .05$]. For subjects who did not have a map, there was an advantage of a route description over a survey description [F(simple)(1,44) = 5.26, $p < .05$], but for subjects who had a map at learning, there was no such advantage ($F < 1$). This provides further evidence that subjects can use a map to compensate for their difficulties in comprehending the survey text. The interaction of hierarchy level with text perspective was not statistically significant ($F < 1$), and there was no three-way interaction ($F < 1$).

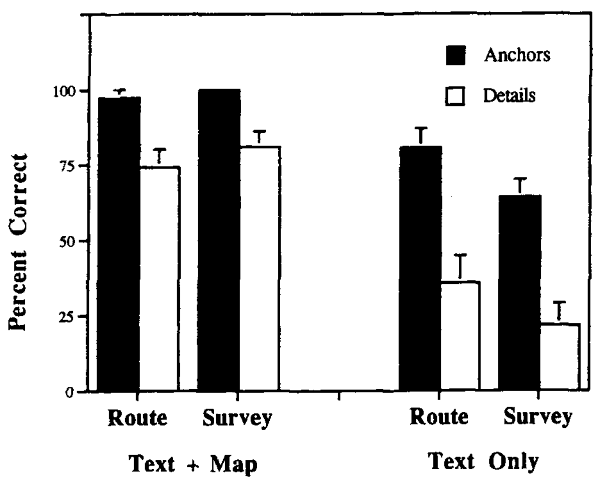

Figure 4. Means and standard errors for accuracy of landmarks on subjects' sketch maps.

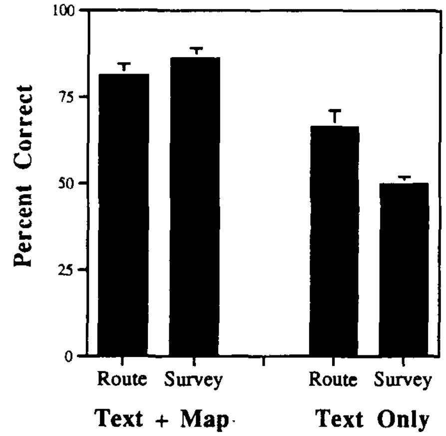

Figure 5. Means and standard errors for the sentence verification task of Experiment 1.

Statement Verification Accuracy

The 24 statements that described spatial information from the text provided another measure of the accuracy of subjects' cognitive maps (see Note 1). This measure, expressed as percentage of statements verified correctly, is shown in Figure 5. This measure had a correlation of .77 ($p < .001$) with inclusion of landmarks on sketch maps and one of .88 ($p < .001$) with accuracy of sketch maps.

The presence of a map during learning increased subjects' ability to verify the statements [$F(1,44) = 56.30$, $p < .001$]. Statements were verified more accurately by subjects who had read the route text than by subjects who had read the survey text [$F(1,44) = 4.40$, $p < .05$]. There was an interaction between map presence and text perspective [$F(1,44) = 9.70$, $p < .01$], such that subjects who had learned from a route perspective were superior to those who had learned from a survey perspective when they had learned from a text alone [F(simple)(1,44) = 11.95, $p < .01$] but not when they had learned from a text and a map [F(simple) < 1]. This showed the same pattern of results as did the sketch-map inclusion and accuracy data.

Conclusion

We defined anchors in text as landmarks that are used as reference points for describing the locations of other landmarks in a descriptive text. The inclusion and accuracy data can be taken as initial evidence that anchors are represented more completely and more accurately in people's cognitive maps than are other landmarks. This was true for all experimental groups, suggesting that anchors are well recalled whether the text is described from a survey or a route perspective and whether or not it is accompanied by a map. However, it should be noted that in addition to serving as reference points for individual landmarks, there were other signals of the particular importance of the specific landmarks that served as anchors in the texts used in Experiment 1. For example, the text stated that Baldwin was located where

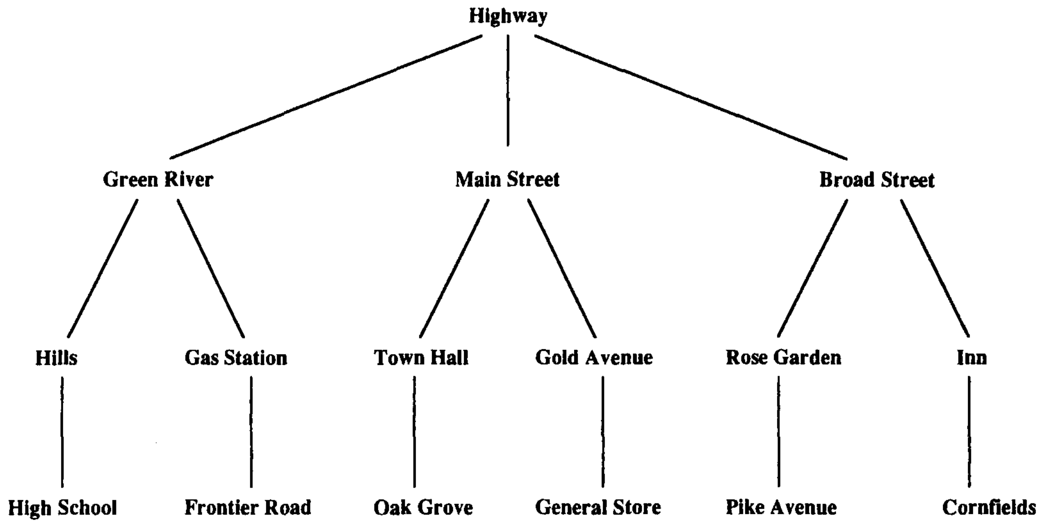

Figure 6. The hierarchical structure of the texts used in Experiments 2 and 3.

the river and the highway met, and that the center of town was to the west of the intersection between the highway and Main Street. Experiments 2 and 3 tested the effects of anchors under more controlled conditions.

Both the sketch-map data and the statement-verification data supported our prediction that subjects construct more complete cognitive maps when a map is present at learning. This replicated research on text and diagrams in other domains (Glenberg & Langston, 1992; Hegarty et al., 1990; Levie & Lentz, 1982; Mandl & Levin, 1989; Mayer, 1989). The data also supported our prediction that subjects construct more complete cognitive maps from route than from survey texts when the order of information is as one would encounter landmarks on a route through the town (Perrig & Kintsch, 1985) and when a map is not present.

EXPERIMENT 2

In Experiment 2, we tested comprehension of descriptive texts that allowed more controlled tests of our hypotheses than were possible in Experiment 1.

Hierarchy of Landmarks in the Text

In Experiment 2, the town described in the texts was different from the one described in Experiment 1; this town was designed so that it had three distinct regions, each of which contained 1 anchor and 4 details. The description of the town was hierarchical in the following sense. As shown in Figure 6, at the top level of the hierarchical description, the locations of the 3 anchors were described with respect to a highway which ran north–south. At the middle level, the locations of 2 details in each region were described with respect to the main anchor of their region. We will refer to these as *primary details*. At the bottom level, the locations of the other 2 landmarks in each region (the *secondary details*) were described with respect to the primary details. It should be noted that primary details might just as well have been called secondary anchors, since they have characteristics of both anchors and details, that is, they serve as reference points for the secondary details, while they themselves are described in relation to the anchors.

This description allowed us to reduce the difference in the number of times that anchors and other landmarks were mentioned in the text. Furthermore, there were no other sentences signaling the importance of anchors in the text (apart from those describing their position in the hierarchical description). We predicted that the anchors would be included more often on subjects' sketch maps and would be placed more accurately on subjects' sketch maps than would the primary details, because they served as reference points for these landmarks. For the same reason, we expected primary details to be represented more accurately than secondary details.

Text Perspective and Order of Information

It is likely that the advantage of the route description over the survey description observed in Experiment 1 was due to a nonoptimal order of information in the survey condition. Taylor and Tversky (1992b) argued that a text organization in which the major regions of an environment are described at the beginning was a more natural organization for a survey text, and they found no difference between comprehension of route and survey texts when the survey texts were organized in this way.

In Experiment 2, we compared the comprehension of texts with two different orders of information. One order, which we will refer to as the *linear* order, described the landmarks in the order in which they would be encountered along a route through the town. The other order, the *anchors-first* text, began with a paragraph describing the anchors in relation to each other and then went on to describe the locations of the details. Thus, the anchors-first text was somewhat similar to the reorganization of the survey text tested by Taylor and Tversky (1992b), in the sense that the anchors defined regions of space (Couclelis et al., 1987) and that therefore information about the major regions was presented first. However, it was not completely comparable since Taylor and Tversky reorganized all the information in the texts, whereas, apart from describing the anchors first, we did not change the order of description of the other landmarks.

If the anchors-first order is more suited to a survey description, then subjects who read a survey/anchors-first text should construct more accurate cognitive maps than subjects who read a survey/linear text. Similarly, if the linear order is more suited to a route description, then subjects who read a route/linear text should construct more accurate cognitive maps than subjects who read a route/anchors-first text. This comparison was not made by Taylor and Tversky (1992b), since they included only the two conditions that were similar to our route/linear and survey/anchors-first conditions.

Verification Statements

The verification statements in Experiment 2 were also modified to reflect the more distinct hierarchy in the text description. The statements could be classified as relating the locations of 2 anchors, the locations of an anchor and a detail, or the locations of 2 detail landmarks. We predicted that subjects would be more accurate in verifying relations at a higher level of the hierarchy.

The verification statements also allowed us to test whether subjects were constructing mental models from the text, as opposed to just text-based representations. The statements either described a spatial relationship that was explicitly described in the text or one that could be inferred from the text. If subjects are constructing only a text-based representation, inference statements should be more difficult to verify than explicit statements, but if they are constructing a mental model, there should be no difference between inference and explicit statements.

Furthermore, the statements described relations between landmarks that were either in the same region of the town or in two different regions. Previous research had shown that when readers construct representations of linear orderings from text, spatial relations between more distant items are easier to verify than the locations of more proximal items (Potts, 1972). In the town described in Experiment 2, the distances between landmarks in the same region were always shorter than the distances between landmarks in different regions (in terms of number of links in the hierarchical structure of relations described in the text). Therefore, we predicted that subjects would be more accurate in verifying statements relating details in different regions than they would be in verifying details in the same region.

Method

Subjects and Design

Forty undergraduates (20 males, 20 females) from the University of California, Santa Barbara participated in this experiment for partial credit in an introductory psychology course. The experiment had a 2×2 between-subjects design, in which the independent variables were text perspective (route or survey) and text organization (linear or anchors-first). Ten subjects were assigned randomly to each of the four groups, with equal numbers of males and females in each group.

Materials

Texts. Four versions of a one-page text described the spatial configuration of 16 landmarks in a fictitious town (see Appendix B). The landmarks consisted of a central highway, 3 anchors that each intersected the highway, and 12 detail landmarks. There were 4 details in the region of each anchor. The spatial relations between the anchor of the region and each of the 2 primary details were explicitly described in the text. The locations of the 2 secondary details in each region were explicitly described in relation to the primary details (see Figure 6). Except for the highway, each of the landmarks was mentioned between 2 and 4 times in the text. The highway was mentioned 6 times and was excluded from the analyses. Again, no distances were mentioned.

Two of the four text versions described the landmark locations from a *route* perspective; the other two described the locations from a *survey* perspective. Within each perspective condition, one text described the landmark locations in a *linear* order and the other described the locations in an *anchors-first* order, as described above. In the linear texts, there were three paragraphs, each describing one region of the town. In the anchors-first texts, there were four paragraphs, the first describing the anchors in relation to each other and the other three describing the remaining landmarks in each region in the same order as did the linear versions (see Appendix B). The order of information was the same for the route and survey versions of each text organization.

To ensure coherence, the sentences in all four texts described the locations of landmarks in given–new order (Britton & Gulgoz, 1991; Haviland & Clark, 1974); that is, information about a new landmark followed a reference to a previously mentioned landmark. As in Experiment 1, we computed the number of words, the number of clause sectors, and the coherence of the four texts. The route/linear text had 385 words, 38 clauses, and a coherence of .65; the route/anchors-first text had 360 words, 35 clauses, and a coherence of .65; the survey/linear text had 342 words, 31 clauses, and a coherence of .67; and the survey/anchors-first text had 338 words, 31 clauses, and a coherence of .63.

Verification statements. There were 60 statements, all of which used survey wording and followed the format "The (*landmark*) is (*direction*) of the (*landmark*)." For false statements, the stated direction was the opposite of the correct direction, that is, "south" was substituted for "north," "east" for "west," and vice versa. Each statement compared 2 landmarks: 2 anchors, an anchor and a detail, or 2 details. Twenty-four statements described the spatial relationship between 2 landmarks within the same region (*within-region* comparisons) and 36 landmarks described the spatial relationship between landmarks in two different regions (*between-region* comparisons). Fifteen statements described 2 landmarks whose spatial relationship was explicitly described in the text (*explicit* statements) and 45 statements described 2 landmarks whose relationship was not explicitly described in the text (*inference* statements).[3]

The statements were presented on a MacIntosh IIci computer using Mindlab software (Meike, Barucha, Baird, & Stoekig, 1988). Mindlab is a programming shell that presents stimuli and collects reaction time.

Procedure

The subjects were seated at individual computer workstations and tested in groups of 2 to 7. They were given 5 min to study the text, which was presented on paper in a plastic cover. The instructions were the same as in Experiment 1. The subjects were not informed of the nature of the subsequent tasks. The texts were collected and each subject received a pencil and a blank sheet of paper. Instructions to draw a map of the town were the same as in Experiment 1.

Then the subjects read instructions, presented on the computer screen, which described the statement-verification task. The statements were presented one at a time in the center of the screen. The "d" and the "k" keys on the keyboard were labeled "F" for "false" and "T" for "true," respectively. The rest of the keys were covered. The subjects were instructed to answer as quickly as possible without sacrificing accuracy.

Results and Discussion

As in Experiment 1, we scored which landmarks the subjects had included on their sketch maps and the placement accuracy of those landmarks. The criteria for inclusion and accuracy of a landmark were the same as in Experiment 1. Figure 7 shows an example of a map that received a perfect score according to these criteria, that is, all anchors and details were included and correctly placed.

Inclusion of Landmarks on Sketch Maps

We examined the effects of hierarchy level (anchor, primary detail, or secondary detail), text perspective (route or survey), and order of information (linear or anchors-first) on inclusion of landmarks on sketch maps in a 3×2×2 analysis of variance, with repeated measures on the first factor. As Figure 8 shows, there was an effect of hierarchy level [$F(2,68) = 25.10, p < .0001$]. Planned comparisons showed that this effect was due to the difference between anchors and details [$F(1,34) = 43.78, p < .0001$]; there was no difference between the two levels of details ($F < 1$).

There was a marginal main effect of text perspective on inclusion of landmarks [$F(1,34) = 3.54, p = .07$] such that subjects who read route texts included more landmarks than did subjects who read survey texts (see Figure 8). This replicates the results for the text-only conditions in Experiment 1. Text perspective also interacted with hierarchy level [$F(1,34) = 3.92, p < .05$)]. Simple effects indicated that the route and survey groups did not differ in their inclusion of anchors [F(simple) < 1]. The route groups included more details than did the survey groups, but this effect reached statistical significance only in the case of secondary details [F(simple)(1,34) = 5.77, $p < .05$, for secondary details; F(simple)(1,34) = 2.18, n.s., for primary details]. These results indicate that the differences in inclusion due to text perspective are for details and not for anchors.

The effect of order of information on inclusion was not statistically significant ($F < 1$), nor was the interaction of order with any of the other factors [for order × perspective, $F < 1$; for order × hierarchy level, $F(2,68) = 1.75$]. Thus, the differences in comprehension between route and survey text are not eliminated when the major regions of the environment are described at the beginning of the text.

Accuracy of Landmark Placement on Sketch Maps

As Figure 9 shows, hierarchy level affected accuracy of landmark placement [$F(2,68) = 37.93, p < .0001$] such that there was a difference between accuracy of anchors and details [$F(1,34) = 61.08, p < .0001$], but no significant difference between the two levels of details ($F < 1$). These effects of hierarchy level are similar to the inclusion data and the results of Experiment 1. They also suggest that although there were three levels of the hierarchy in the text, subjects did not differentiate between the two levels of details. It is possible that this was due to the creation of spatial chunks (cf. Chase & Simon, 1973; Egan & Schwartz, 1979). That is, subjects might have integrated the information about the four details of a given region into a single chunk.

The effect of text perspective on accuracy of landmark placement was not reliable in this experiment [$F(1,34) = 1.89$, n.s.], nor did this factor interact with hierarchy level [$F(2,68) = 1.87$]. The order of information in the text did not significantly affect accuracy ($F < 1$), nor did it interact with hierarchy level ($F < 1$) or text perspective ($F < 1$).

Analysis of Linear Landmarks

Although the primary details served as reference points for the secondary details, they did not emerge as anchors in subjects' cognitive maps. One possible alternative explanation for the effects of hierarchy level observed in Experiment 2 is that all of the landmarks that emerged as anchors were long and linear (streets or a river), whereas the details included nonlinear (e.g., buildings and parks) in addition to linear landmarks. It is possible that linear landmarks are remembered better because they occupy a larger amount of space. To test this possibility, we compared the inclusion of the streets that were anchors (Main and Broad streets) with the inclusion of the streets that were details (Gold and Pike avenues), and found that there was still a reliable effect of hierarchy level [$F(1,34) = 30.57, p < .0001$], such that the anchor streets ($M = 96.0\%$, $SD = 13.66$) were included more often than the detail streets ($M = 71.9\%$, $SD = 31.50$). Similarly, anchor streets ($M = 86.8\%$, $SD = 27.72$) were placed more accurately than detail streets [$M = 57.9\%$, $SD = 37.72$; $F(1,34) = 40.55, p < .0001$].

These analyses also showed significant interactions of hierarchy level with text perspective [$F(1,34) = 5.01$, $p < .05$, for inclusion, $F(1,34) = 5.35, p < .05$, for accuracy]. There was no significant difference in inclusion of anchor streets between the route conditions ($M = 95\%$, $SD = 15.8$) and the survey conditions [$M = 98\%$, $SD = 7.9$; F(simple) < 1]. However, subjects who read a route text included detail streets somewhat more often

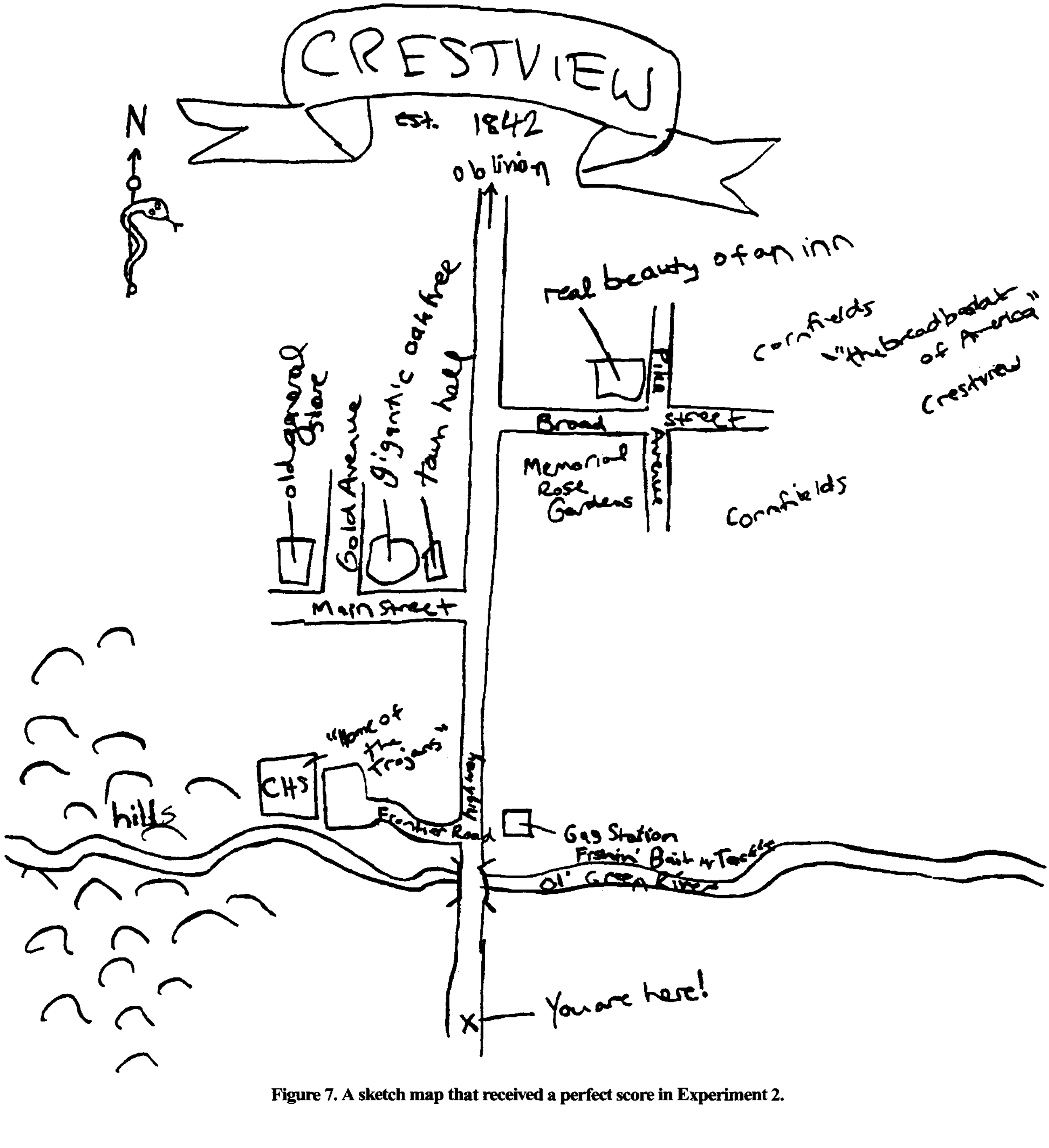

Figure 7. A sketch map that received a perfect score in Experiment 2.

(M = 80%, SD = 32.2) than did subjects who read a survey text [M = 62%, SD = 30.0; F(simple)(1,34) = 3.13, p = .08]. Similarly, there was no significant difference between the route (M = 88%, SD = 8.0) and the survey groups (M = 86%, SD = 10.4) in placement of anchor streets [F(simple) < 1], but the route group was more accurate (M = 68%, SD = 11.9) than the survey group (M = 45%, SD = 10.8) in placing detail streets on their sketch maps.

These results replicate the pattern of the overall analysis and show that subjects do not identify all linear landmarks as anchors. In fact, subjects included detail streets on their sketch maps less often (M = 72%, SD = 31.5) than they did other details [M = 78%, SD = 21.2; $F(1,34) = 5.07, p < .05$]. The accuracy of detail streets (M = 58.00, SD = 37.7) and other details (M = 55.56, SD = 29.9) did not differ significantly.

Statement Verification

Statement-verification data provided an additional test of the hypothesis that landmarks at a higher level of the hierarchical structure in the text are represented

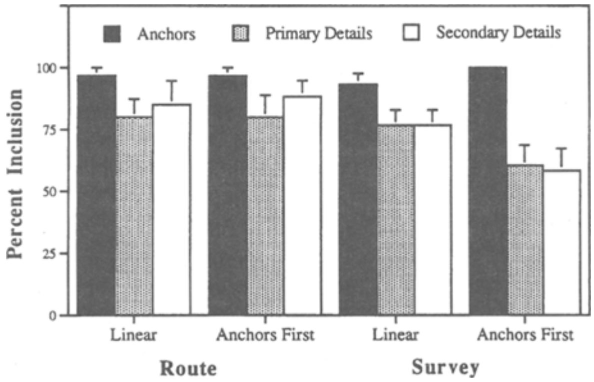

Figure 8. Means and standard errors for inclusion of landmarks on subjects' sketch maps in Experiment 2.

more accurately than lower level landmarks. We assessed the effects of hierarchy level, text perspective, and text organization in a three-way analysis of variance with repeated measures on the first factor. We predicted that anchor–anchor relations would be verified more accurately than anchor–detail relations, which in turn would be verified more accurately than detail–detail relations in all four text conditions. Because all of the anchor–anchor relations were inferred, and because there were different proportions of explicit and inferred statements at different levels of the hierarchy, this analysis was based on inferred statements only. All data were expressed as percentages of the items in that category that were answered correctly.

There was a marginal effect of hierarchy level [$F(2,72) = 2.76, p = .07$], such that anchor–anchor statements were verified most accurately ($M = 81\%$, $SD = 5\%$), followed by anchor–detail statements ($M = 79\%$, $SD = 3\%$) and then by detail–detail statements ($M = 73\%$, $SD = 3\%$). Planned comparisons indicated a significant difference in accuracy between anchor–detail and detail–detail statements [$F(1,36) = 5.35, p < .05$] and a marginal difference between anchor–anchor and detail–detail statements [$F(1,36) = 4.05, p = .05$]. There was no significant difference between anchor–anchor and anchor–detail statements ($F < 1$). Neither text perspective [$F(1,36) = 1.99$] nor organization ($F < 1$) had significant effects in this analysis.

If subjects are constructing only a text-based representation, inference statements should be more difficult to verify than explicit statements, but if subjects are constructing a mental model, there should be no difference between inference and explicit statements. In a 2×2 analysis of variance, we analyzed the effects of type of statement (explicit or inference) and hierarchy level (anchor–detail or detail–detail) on statement-verification accuracy for within-region statements.[4] Neither the effects of inference [$F(1,39) = 1.55$] nor the effects of hierarchy level ($F < 1$) were significant in this analysis. These data argue against the view that subjects are only constructing a text base. In fact, the trend is for inference statements to be verified more accurately ($M = 70\%$, $SD = 7\%$) than explicit statements ($M = 68\%$, $SD = 5\%$).

If subjects are constructing mental models and not just text-based representations, then between-region relationships should be easier to verify than within-region relationships. We therefore compared inferences within regions with inferences between regions and the effects of text perspective and organization on these inferences. In this analysis, there was a marginal main effect of text perspective [$F(1,36) = 3.33, p = .08$], such that subjects who read the route text were more accurate ($M = 79\%$, $SD = 3$) than subjects who read the survey text ($M = 71\%$, $SD = 3$). The main effect of distance of inference (within or across region) was not significant [$F(1,36) = 1.76$], but there was a marginal interaction of distance with text perspective [$F(1,36) = 3.37, p = .07$]. Simple effects indicated that for the route group, between-region relations were verified more accurately ($M = 83\%$, $SD = 3.9$) than within-region relations [$M = 75\%$, $SD = 3.2$; $F(\text{simple})(1,36) = 4.99, p < .05$], whereas for the survey group, the difference between inferences within ($M = 71\%$, $SD = 3.5$) and between regions ($M = 70\%$, $SD = 4.5$) was not reliable ($F < 1$).

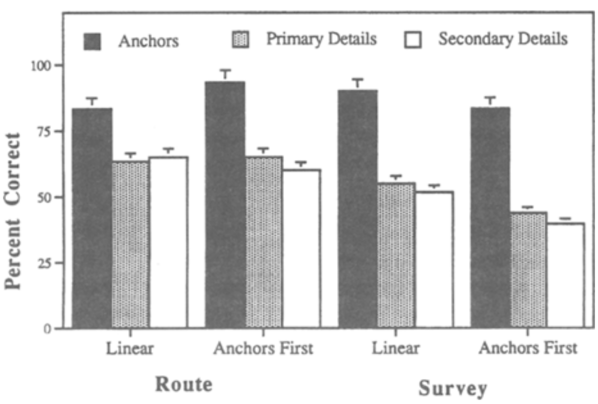

Figure 9. Means and standard errors for accuracy of landmark placement on subjects' sketch maps in Experiment 2.

Types of Errors in Sketch Maps

If anchors function as reference points in subjects' cognitive maps, an anchor error should increase the probability of detail errors in the region of that anchor. More specifically, if an anchor is misplaced, details that do not remain in their original region should be more likely to move to the new region of the anchor than to some other location.

To test these expectations, we classified detail errors on subjects' sketch maps according to the following criteria: (1) If a detail landmark was in the correct region but misplaced within that region, then the detail was scored as *locally misplaced*; (2) if the anchor of a region was moved and a detail from that region was drawn in the correct spatial relationship with respect to that moved anchor, then the detail was scored as *correctly* *moved*; (3) if the anchor of a region was moved and a detail from that region was drawn near the moved anchor but was misplaced with respect to the anchor's new location, then the detail was scored as *incorrectly moved*; (4) if a detail was placed anywhere else on a map, it was scored as *otherwise incorrect*.

In general, there were very few anchor errors [4 omissions (3.5%) and 9 misplacements (7.9%)], so that it was not possible to analyze these data using statistical tests.

When the anchor in a region was correct, more of the details in that region were correct (59%) than they were when the anchor was either misplaced (33%) or omitted (19%). Among those maps in which an anchor was moved, more details moved to the new region of the anchor (25%) than to another location (6%). When anchors moved, 36% of their details were placed in the correct region and 33% of their details were omitted. These data provide preliminary evidence that some detail errors are a consequence of anchor errors.

Conclusions

In summary, both the sketch-map data and the statement-verification data replicated Experiment 1 and indicated that anchors are included more often and represented more accurately in subjects' cognitive maps than are details. However, only one anchor emerged in each region, although more than one landmark served as a reference point in the text.

As in Experiment 1, the text perspective affected subjects' representations such that subjects who read the route text constructed more complete cognitive maps than did subjects who read the survey text. The statement-verification data in this study were consistent with the fact that all groups of subjects constructed mental models as opposed to text-based representations. Consistent with the sketch-map data, the statement-verification data suggest that the route group constructed more accurate mental models than did the survey group.

Order of information failed to show any effects in this experiment. This is interesting given that Taylor and Tversky (1992b) eliminated differences in the comprehension of route and survey texts by reorganizing the survey texts in a manner somewhat similar to our reorganization. There are a number of possible reasons why Taylor and Tversky's results did not generalize to our study. First, they reorganized the whole text, whereas we just changed the position of the anchor information. Second, the texts in our study described a more complex environment than did the texts in their study. It is possible that subjects constructed a representation of the overview of the town when they read the first paragraph of the text but lost this overview from working memory when they read the second paragraph (describing the first region of the town in detail), so that the overview was no longer available when they read the later sections of text. Third, it is possible that the equivalence of the route and survey texts in Taylor and Tversky's research was due to a ceiling effect, and that differences between route and survey texts still occur for longer texts that describe more complex environments. Fourth, in Taylor and Tversky's work, the "anchors" were the external boundaries of the environments, whereas in our experiment, they were landmarks more central to the environment.

EXPERIMENT 3

Experiments 1 and 2 showed that when people learn about a town from a descriptive text alone, they show better memory for anchors than for detail landmarks and better memory for details when the text is written from a route perspective than when it is written from a survey perspective. We assumed that the texts conveyed sufficient information about the locations of components and that the errors that we observed were due to limitations of subjects' comprehension processes (e.g., working-memory limitations) or to decay of subjects' cognitive maps from the time they were constructed to the time that the subjects are asked to draw or verify statements about locations in the town.

However, a possible alternative explanation for the results of Experiments 1 and 2 is that the information conveyed by the texts with regard to the locations of all the landmarks was not sufficient for an accurate sketch map of these landmarks to be drawn. More specifically, our results may have occurred because the texts provided too little information about the detail landmarks, or because the route texts were more comprehensible than the survey texts. Although we equated the number of explicit mentions of landmarks, the order of information, and the coherence of the route and survey texts, there were also some differences between these texts (i.e., the route texts were longer and the survey texts contained more complex clause units).

In Experiment 3, we tested these alternative explanations for our results by including conditions in which subjects were asked to draw a map directly from a route or a survey text. We will refer to these conditions as the *full-text* conditions. If the problems with the survey conditions are due to such factors as clause complexity, then the subjects' maps should be less accurate if they are drawn directly from the survey text than if they are drawn directly from the route text. Similarly, if the difficulty in recalling detail landmarks is due to the fact that there is insufficient information in the text about these landmarks, then subjects should place detail landmarks less accurately than anchor landmarks even when drawing a map directly from the text. We maintain that the results in Experiments 1 and 2 were due to limitations of comprehension and memory processes. Therefore, we expected that when subjects were allowed to refer back to the text while drawing, they would depict the details as often and as accurately as they depicted the anchors. We also expected that subjects in the full-text condition would draw correct maps, regardless of text perspective.

A large proportion of the sketch-map errors in Experiments 1 and 2 were omission errors. A second purpose of Experiment 3 was to clarify whether subjects omitted a landmark from their maps because they did not recall the identity of the landmark or because they did not recall its location. To differentiate between these two possible causes of omission errors, we added a condition in which subjects were given a list of the names of all the landmarks in the town while they drew their sketch maps. We will refer to this as the *checklist* condition. The sketch maps of subjects in the checklist condition should include more landmarks than the sketch maps of subjects in the memory condition. If omission errors are due mainly to failure to recall landmark identity, and if landmark identity cues location, then placement of landmarks on the sketch maps should also be more accurate for subjects in the checklist condition than for subjects in the memory condition. However, if omissions are due to failure to recall landmark location, independent of landmark identity, then subjects in the checklist condition should be no more accurate than subjects in the memory condition.

Method

Subjects and Design

Sixty undergraduates (30 females, 30 males) enrolled in an introductory psychology course participated in the experiment to fulfill a course requirement. The study had a 2×3 between-subjects design. The two independent variables were text perspective (route or survey) and test condition (full text, checklist, or memory). With equal numbers of males and females in each condition, 30 subjects were assigned to read a route perspective text and 30 were assigned to read a survey perspective text under one of the three test conditions.

Materials

The two versions of the texts were identical to the route and survey texts from the linear organization condition of Experiment 2. The checklist was a sheet of paper containing the names of the 16 landmarks described in the text, arranged in a random order in two columns.

Procedure

The subjects, seated several seats apart from one another in a large room, were tested in groups of 5 to 12. As in Experiment 2, all subjects were given 5 min to read the text and were instructed to learn as much as they could about the locations of landmarks in the town.

For the map-drawing task, subjects in the full-text condition were instructed to draw a map of the town and were told, "You may use the text to help you as you draw." Subjects in the checklist condition were instructed to include all of the landmarks in their sketch maps, even if they had to guess some of the locations. The map-drawing task for subjects in the memory condition was identical to that of Experiments 1 and 2. There was no statement-verification task in Experiment 3.

Results and Discussion

Inclusion of Landmarks on Sketch Maps

The sketch maps were scored using the same criteria as in Experiment 2. As Figure 10 shows, anchors were included more often than details [$F(1,54) = 28.76, p < .0001$]. There was also a main effect of test condition [$F(2,54) = 10.75, p < .0001$], such that the memory group included significantly fewer landmarks than did the full-text and checklist groups [$F(1,54) = 21.44, p < .0001$] and the latter groups did not differ in the number of landmarks included ($F < 1$).

We predicted an effect of hierarchy level only in the memory condition, because we expected the other two groups to include all landmarks. Consistent with this prediction, the data showed a hierarchy level × test condition interaction [$F(2,54) = 10.61, p < .0001$], such that subjects in the memory condition included more anchors than details [$F(1,54) = 46.72, p < .0001$] and there was no significant difference between inclusion of anchors and details for either the checklist group ($F < 1$) or the full-text group [$F(1,54) = 2.49$]. As shown in Figure 10, subjects in the checklist and full-text groups included all of the anchors and almost all of the details.

There were no significant effects of text perspective on inclusion in this experiment ($F < 1$), nor did text perspective interact significantly with any of the other factors ($F < 1$ for each interaction).

Accuracy of Landmark Placement

A significant main effect of hierarchy level [$F(1,54) = 85.55, p < .0001$] showed that, on subjects' sketch maps, anchors were placed more accurately than details (see Figure 11). The main effect of test condition was also reliable [$F(2,54) = 18.83, p < .0001$]. As predicted, subjects in the full-text condition were more accurate than subjects in the checklist and memory conditions [$F(1,54) = 35.31, p < .0001$], and the accuracy of the checklist and memory groups did not differ significantly [$F(1,54) = 2.34$]. The fact that a checklist did not improve accuracy of recall suggests that omissions in the memory condition are due to failure to recall landmark location rather than landmark identity.

We predicted an effect of hierarchy level on accuracy of landmark placement for the memory and checklist

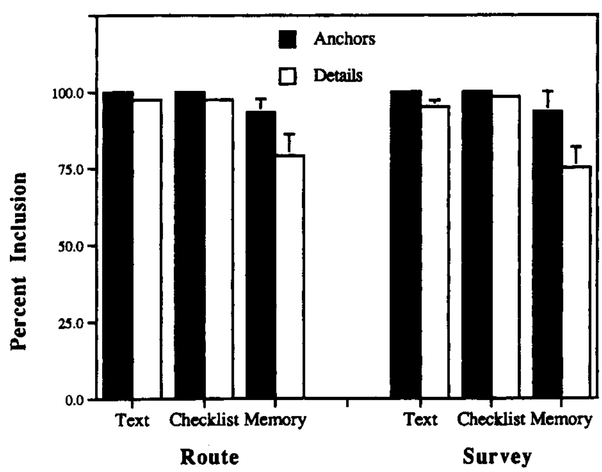

Figure 10. Means and standard errors for inclusion of landmarks on subjects' sketch maps in Experiment 3.

groups, but not for the full-text group. There was an interaction of hierarchy level with test condition [$F(1,54) = 9.55, p < .001$], such that anchors were placed more accurately than details by all three groups, but the difference between anchor and detail accuracy was smaller in the full-text group [F(simple)(1,54) = 5.24, $p < .05$] than in the memory group [F(simple)(1,54) = 71.70, $p < .0001$] and the checklist group [F(simple)(1,54) = 27.71, $p < .0001$]. The difference in accuracy between anchor and detail placements in the full-text group was not predicted, and indicates that the description of anchors in the text might have been clearer than the description of details. The interaction indicates that this alone cannot account for the effects of hierarchy level observed in the memory and checklist conditions.

The main effect of text perspective did not reach statistical significance [$F(1,54) = 2.71$]. As in Experiments 1 and 2, there was a significant interaction of text perspective with hierarchy level [$F(1,54) = 5.05, p < .05$], such that there was no significant difference between the route and survey groups on accuracy of anchor placement ($F < 1$), but those who read the route text placed details significantly more accurately than did those who read the survey text [$F(1,54) = 5.55, p < .05$].

The interaction of text perspective with test condition was not significant [$F(2,54) < 1$]. Most importantly, when subjects were allowed to read the text while drawing their sketch maps, both the route and survey groups were highly accurate (see Figure 11) and there was no significant difference in accuracy between the two groups ($F < 1$). Thus, the route and survey texts were equally comprehensible.

Types of Errors in Sketch Maps

As in Experiment 2, we considered the effect of anchor errors on detail errors by classifying detail errors as (1) locally misplaced, (2) correctly moved to the new region of an anchor, (3) incorrectly moved to this new region, (4) otherwise incorrect, or (5) omitted. This classification was not possible for the full-text group, since there were no anchor misplacements or omissions for this group.

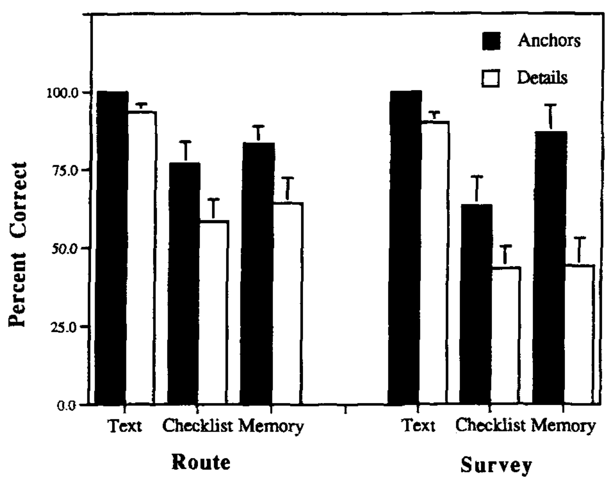

Figure 11. Means and standard errors for accuracy of landmark placement on subjects' sketch maps in Experiment 3.

For the memory group, the results were similar to those of Experiment 2. There were few anchor errors (15%); four were omissions (6.6%) and five were misplacements (8.3%). More of the details were correct (60%) when the anchor in that region was correct than when the anchor was either misplaced (10%) or omitted (6%). When an anchor moved, more of its details moved to the new region of the anchor (35%) than to another location (15%), while 20% were placed in the correct region and 30% were omitted.

For the checklist condition, there were no anchor omissions, since subjects were instructed to include all landmarks on their maps. Thirty percent of the anchors were misplaced. Again, in this condition, more of the details were correct (64%) when the anchor in that region was correct than when the anchor was misplaced (17%). When subjects in this condition misplaced an anchor, more of the associated details moved to the new region of the anchor (39%) than to some other region (19%), while 28% were placed in the correct region and 4% were omitted. These data support the interpretation that the anchor operated as a reference point for representing the locations of the details, so anchor errors caused detail errors.

GENERAL DISCUSSION

The research presented in this article suggests that when people read a text describing a spatial environment, they represent some landmarks in the environment more completely and more accurately than others. These landmarks are anchors, that is, landmarks that are used in the text as reference points for describing the locations of other landmarks. In our experiments, anchors were represented more accurately than details regardless of whether the text was accompanied by a map, was written from a route or a survey perspective, or the information was presented in a linear or an anchors-first order. This was also true regardless of whether subjects drew sketch maps from memory, from a list of the landmarks in the town, or from the entire text.

Characteristics of Anchors and Details

To interpret this robust effect, we must consider the different characteristics of the landmarks that emerged as anchors in subjects' cognitive maps. In doing this, it is important to distinguish between characteristics of an environment, characteristics of a text describing that environment, and characteristics of a person's cognitive map of the environment.

We defined an anchor as a landmark that is used in the text as a reference point for defining the location of other landmarks. However, in addition to this defining characteristic, there were several other characteristics of the landmarks that emerged as anchors in subjects' representations. First, the anchor was typically the first landmark mentioned in a paragraph, so the memorability of an anchor might be partly due to a primacy effect. Second, the names of the anchors, for example, "Main" and "Broad" streets, might have signaled that they were important. Third, anchors were explicitly related to more landmarks than were details, so anchors were necessarily mentioned more often in the text. However, note that, in Experiments 2 and 3, the difference between the number of mentions of anchors and of details was smaller than in Experiment 1, but this did not affect the strength of the effects appreciably. Furthermore, if number of mentions was the only factor contributing to the memorability of a landmark, we would not have found the observed differences between the route and survey conditions, since number of mentions of each landmark was equated for the route and survey versions of each text.

Future experiments should assess the contributions of each of these factors to the memorability of anchors. One might control for the number of mentions of anchors and details by including some nonspatial information about the detail landmarks. One might vary the position of this additional information so that the anchor is not always the first landmark mentioned in the paragraph. Finally, one could use more neutral names for anchors, that is, names that do not signal importance.

There are also characteristics of the described environment itself that might contribute to people's superior memory for anchors. Studies of how a person learns a new environment through navigation have identified several characteristics of landmarks that serve as anchors in people's representations. For example, anchors tend to be large, have important functions in the environment (e.g., intersections of major streets), and be familiar (Couclelis et al., 1987; Gale et al., 1990). In the present study, the landmarks that emerged as anchors were all linear landmarks (streets or a river) and extended over a greater distance in the environment than landmarks (such as buildings) whose location could be described by a single point. However, Experiment 2 revealed that a street does not necessarily become an anchor, inasmuch as streets that were defined as anchors were recalled better than streets that were defined as details and detail streets were recalled no better than other details. Future research should investigate whether smaller, less salient landmarks can develop the same anchor status when the text describes them as reference points for the location of other landmarks.

The number of landmarks that people identify as anchors might also be determined by the nature of people's representations of spatial relations. In our experiments, the texts were written such that there was a single main anchor in each region, so the number of anchors was equal to the number of regions. Although the primary details in Experiment 2 served as reference points for describing the locations of the secondary details, these landmarks were not recalled more often or more accurately than the secondary details, suggesting that they did not emerge as anchors in subjects' representations. One interpretation of these results is that being a reference point is not a sufficient condition for becoming an anchor, and some of the characteristics described above (such as being mentioned first or more often) might also be necessary conditions for a reference point to function as an anchor point in subjects' cognitive maps.

Another interpretation of these data is that regionalization in people's cognitive maps is a reflection of working-memory limitations. We suggest that if a region includes a small number of landmarks (say 5 or fewer), people will represent the details in that region as a single chunk (cf. Chase & Simon, 1973; Egan & Schwartz, 1979), but that if a region is more complex, people will create subregions so that another hierarchy level emerges in their representations. According to the anchorpoint hypothesis, all regions have an anchor, so that the creation of subregions should be accompanied by the identification of new anchors. This idea could be tested in future research by varying the number of landmarks mentioned in a text describing a spatial environment. For example, if a text had a hierarchical structure that was similar to those in Experiments 2 and 3, but there were 3 secondary details described in relation to each primary detail, we might expect primary details to have more of the characteristics of anchors (i.e., be recalled more often and more accurately).

This research shows that anchors are included more often and more accurately than details in subjects' cognitive maps and that statements about these anchors are verified more accurately than statements about details. If anchors are truly serving as reference points, then anchor errors should cause detail errors, that is, if an anchor is moved, its associated details should be moved in the same direction. The data in Experiments 2 and 3 showed some agreement with this expectation, but this finding is best interpreted as preliminary, because there were so few anchor errors in these experiments. We could test this hypothesis further in future studies in which subjects are asked to read about even more complex environments so that they will make more anchor errors.

Other methodologies might be used to show that anchors function as reference points in cognitive maps constructed from text. One common method for discovering the hierarchy implicit in a cognitive representation is to examine the order in which people include landmarks when drawing a sketch of their cognitive map (Gale et al., 1990) or describing their cognitive map verbally (Hirtle & Jonides, 1985; Taylor & Tversky, 1992a). If anchors are functioning as reference points, they should be drawn (or mentioned) before other landmarks in their region so that other landmarks can be represented with respect to them. Another possible method is to determine whether anchors prime their associated details. Previous research has shown that landmarks in the same region of a cognitive map prime each other (McNamara, 1986; McNamara, Hardy, & Hirtle, 1989) and that anchors prime details more than details prime anchors (Shute, 1984).

Comprehension of Descriptive Text

Our research contributes to general theories of text processing by suggesting a common strategy used in reading narratives and descriptive texts. Research on comprehension of narrative text shows that readers are sensitive to the hierarchical relations among the events in a story, so that more important events are better recalled (e.g., Mandler & Johnson, 1977; Rumelhart, 1975; Thorndyke, 1977). Our research shows that readers also have better memory for landmarks described at higher levels in a hierarchy of spatial relations in a descriptive text. Although, in our research, the term "hierarchy" is used in a sense that is different from that used in story-comprehension research, this commonality points to a general comprehension strategy, suggesting that readers are sensitive to the most important information in a text, whether this describes events in a narrative or landmarks in a spatial environment.

The sentence-verification data supported the results of previous research (e.g., Bransford, Barclay, & Franks, 1972; Johnson-Laird, 1983; van Dijk & Kintsch, 1983), suggesting that subjects construct mental models from text and not just text-based representations. Inference statements were no more difficult to verify than explicit statements for subjects who read both the route and the survey texts, and statements relating landmarks in different regions were easier to verify than inferences relating landmarks in the same region, at least for subjects who read the route text.

Experiment 3 revealed that knowledge about identity and information about location of landmarks are separable. The fact that subjects sometimes misplace landmarks on their sketch maps indicates that they can recall the identity of a landmark in an environment without recalling its location. In Experiment 3, providing subjects with a list of landmark names did not improve their accuracy in placing these landmarks. Therefore, landmark identity does not cue landmark location. A future study might determine whether a landmark's location can cue its identity by using a map with pointers to particular locations and asking subjects to name the landmarks at those locations.

Effects of Text Perspective

In all three experiments, subjects who read a route text tended to construct more accurate representations than did subjects who read a survey text, although the size of the effects differed across experiments. Thus our results are consistent with those of Perrig and Kintsch (1985). However, it would be wrong to conclude that route texts necessarily lead to more accurate representations than do survey texts. Taylor and Tversky (1992b) found that when they reorganized survey texts, such as those used by Perrig and Kintsch, the differences in comprehension due to text perspective were eliminated.

It is interesting to note that we found differences in comprehension of route and survey texts, even though our texts were equated for coherence and we took account of any differences in determinacy in our scoring scheme. Furthermore, we found differences in memory of our route and survey texts, even though both included sufficient information to draw a highly accurate map of the environment (i.e., as accurate as the maps drawn by the full text groups in Experiment 3). Finally, in Experiment 2, we found no effects of a limited reorganization of the texts such that information about anchors was presented first, thus providing an overview of the described environment. A comparison of the different studies that compare comprehension of route and survey texts suggests that it might not be possible to write route and survey texts that lead to equally accurate mental models while equalizing the order of information in the texts, because the optimal orders of information for route and survey texts are substantially different.

The addition of a map to the texts in Experiment 1 eliminated the differences between the route and survey groups. This is not surprising inasmuch as a map shows the location of each landmark explicitly, whereas a text describes only some locations explicitly, leaving others to be inferred. It appears that the survey versions of our texts required more difficult inferences than did the route versions, and that these differences were eliminated in the text-plus-map conditions, since, with a map available, subjects no longer had to infer the locations of any landmarks.

Despite the fact that there are some differences in the cognitive maps that people construct from route and survey texts, the main conclusions of our studies point to the similarity of the representations formed from the two texts (cf. Taylor & Tversky, 1992b). Although subjects who read route and survey texts differed in overall inclusion and accuracy, they were alike in that both groups represented the anchors defined by the text more accurately than they did the details. Thus, subjects' cognitive maps were hierarchically organized, regardless of whether they were constructed from the more difficult survey texts or from the easier route texts.

In conclusion, when people construct mental models of a town by reading text, these mental models have properties similar to those of cognitive maps constructed by traveling in a real or simulated environment. In particular, our experiments have shown that these mental models are organized around important reference points called anchors. When the environment is described in a text, the anchors in people's mental representations of the environment are those landmarks that serve as reference points for describing the locations of other landmarks in the text.

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NOTES

1. The spatial statements included statements in both route and survey wording, statements that were explicit in the text, and statements that could be inferred from the text. Because these factors were confounded with other factors that affect difficulty (such as whether the landmarks related in the statement were anchors and details), it was not possible to assess the effects of these factors in Experiment 1. Neither was it possible to compare anchor and detail accuracy using this measure, because each question asked about the relationship between two landmarks, either of which could be an anchor or a detail.

2. Occasionally subjects reversed east and west in their representations. If such a subject drew a compass rose on his/her sketch that indicated this reversal, the sketch map was scored with respect to this erroneous reference system.

3. Note that explicit statements were not taken verbatim from the text, but always described a relationship that had been explicitly described in the text. For example, the text might state "Next to the town hall, to the west, is an ancient oak tree grove." An explicit statement verifying this relationship might state, "The town hall is east of the oak grove."

4. Note that this was possible only for within-region statements, as there were no explicit statements that related landmarks in two different regions.

APPENDIX A

Route and Survey Texts Used in Experiment 1

(Route) BALDWIN: A NICE PLACE TO GO

The little town of Baldwin is an old frontier town in the Midwest.

To get there by car, drive straight along the highway to the Green River, which flows out of some low hills to your left.

Before you cross the river, off toward the hills you can see Baldwin High School, which is connected to the highway by the small Frontier Road.

The river marks the boundary of the main part of Baldwin.

After you cross the River, you pass a Gas Station on your right.

Just ahead, where the Highway intersects with Main Street, the center of town is to your left.

On the far corner of Main Street you see the Memorial Rose Garden.

Turn left on Main, and after a few blocks, on the left hand side, you see the Town Hall at the corner of Third Avenue.

Looking to your left down Third Avenue, you can see the old General Store at the end of the street.

It is the social center of town, especially for the youth.

Return on Main Street to the Highway, driving under the majestic elm trees, which line the street and shade the white wooden houses.

In the cool of the evening, people of all ages gather on their porches.

To follow the highway out of town, turn left at the Main Street intersection.

Just outside of Baldwin, you will pass a little Inn set off the road to the left, where guests are welcomed with fresh, hearty, country meals.

On your right-hand side, the land is flat, and you see vast cornfields as you look into the distance.

(Survey) BALDWIN: A NICE PLACE TO BE

The little town of Baldwin is an old frontier town in the Midwest.

It is located where the North-South Highway crosses the Green River, which flows out of some Low Hills west of the Highway.

South of the River, off in the direction of the Hills, is Baldwin High School, which is connected to the Highway by the small Frontier Road.

The River marks the main part of Baldwin.

North of the River there is a Gas Station on the East side.

Where the Highway intersects with Main Street, the center of town is to the West.

At the corner, on the north side of Main is the Memorial Rose Garden.

The Town Hall is a few blocks west of the Highway, on the South side of Main Street at the corner of Third Avenue.

At the northern end of Third Avenue is the General Store.

It is the social center of town, especially for the youth.

On Main Street there are majestic elms that line the street and shade the white wooden houses.

In the cool of the evening, people of all ages gather on their porches.

From the Main Street intersection, the Highway continues northward out of town.

Just outside of Baldwin, there is a little Inn set off the road on the west side of the Highway, where guests are welcomed with fresh, hearty country meals.

On the east side of the Highway, the land is flat, and for quite a distance, there are vast cornfields.

APPENDIX B

Route/Linear and Survey/Linear Texts Used in Experiments 2 and 3 and Route/Anchors-First and Survey/Anchors-First Texts Used in Experiment 2

(Route/Linear) CRESTVIEW

The little town of Crestview is an old mining town. To reach Crestview by car, drive north along the highway. Crestview begins where you cross the Green River. The river flows out of some low hills that lie to your left. Just after you drive across, you can see Crestview High School, which lies on the bank to your left at the base of the hills. The small curvy Frontier Road begins on your left and provides the connection to the high school from the highway. On your right, directly across from the entrance to Frontier Road, you see a gas station. The gas station is on this river bank, and fishing bait and tackle can be purchased there.

Continue ahead along the highway to the center of Crestview, until you intersect Main Street which extends to your left. Turn left on Main Street and in the middle of the block you will see the rustic town hall that stands on the right side of the street. Next to the town hall, just ahead, you pass an ancient oak tree grove, which extends to the end of the block. There Gold Avenue intersects Main Street and extends to the right. On the other side of the intersection, on the right corner of Gold Avenue, you see the old general store. For over 150 years, folks have enjoyed the view out of the front of the general store, across to the oak tree grove.

Turn around and go back to where you turned onto Main Street, then turn left to continue on the highway. Continuing through Crestview, the highway intersects Broad Street, which extends to your right. Turn right on Broad Street, and on the right side, the Memorial Rose Gardens begin. Drive ahead past the rose gardens for one block until they are bordered by Pike Avenue, which is the next intersecting street. To your left, on the near corner of Broad Street, you see a beautiful inn. Beginning on the other side of Pike Avenue you see vast cornfields. These cornfields have grown across from the inn, stretching into the distance ahead and to the left, since the days of the 49ers. Turn around and go back to the intersection of Broad Street and the Highway. Turn right to drive out of Crestview.

(Route/Anchors First) CRESTVIEW

The little town of Crestview is an old mining town. To reach Crestview by car, drive north along the highway. Crestview begins where you cross the Green River. You can continue ahead along the highway until it intersects Main Street, which extends to your left. Further ahead the highway intersects Broad Street, which extends to your right. The highway continues ahead out of Crestview.

When you get into Crestview, the river flows toward you out of some low hills that lie to your left. Just after you drive across, you can see Crestview High School, which lies on the bank to your left at the base of the hills. The small curvy Frontier Road begins on your left and provides the connection to the high school from the highway. On your right, directly across from the entrance to Frontier Road, you see a gas station. The gas station is on this river bank and fishing bait and tackle can be purchased there.

In the center of Crestview, turn left on Main Street, and in the middle of the block you will see the rustic town hall that stands on the right side of the street. Next to the town hall, just ahead, you pass an ancient oak tree grove which extends to the end of the block. There Gold Avenue intersects Main Street and extends to the right. On the other side of the intersection, on the right side of Gold Avenue, you see the old general store. For over 150 years, folks have enjoyed the view out of the front of the general store, across to the oak tree grove.

Continuing through Crestview, turn right on Broad Street and on the right side, the Memorial Rose Gardens begin. Drive ahead past the rose gardens for one block until they are bordered by Pike Avenue, which is the next intersecting street. To your left, on the near corner of Broad Street, you see a beautiful inn. Beginning on the other side of Pike Avenue, you see vast cornfields. These cornfields have grown across from the inn, stretching into the distance ahead and to the left, since the days of the 49ers.

(Survey/Linear) CRESTVIEW

The little town of Crestview is an old mining town. The road to Crestview runs north. Crestview begins where the highway crosses the Green River. The river flows to the east out of some low hills that lie to the west. Just across, to the north, Crestview High School lies on the bank to the west at the base of the hills. On the west side of the highway, the small, curvy Frontier Road provides the connection to the high school. To the east, directly across from the entrance to Frontier Road, is a gas station. The gas station is on the northern river bank and fishing bait and tackle can be purchased there.

In the center of Crestview, the highway intersects Main Street, which extends to the west. To the west on Main Street, in the middle of the block, the rustic town hall stands on the north side of the street. Next to the town hall to the west is an ancient oak tree grove, which extends to the end of the block. There Gold Avenue intersects Main Street and extends to the north. On the northwest corner of Gold Avenue is the old general store. For over 150 years, folks have enjoyed the view toward the east from the general store, across to the oak tree grove.

From the intersection with Main Street, the highway continues north. In the north of Crestview, the highway intersects Broad Street, which extends to the east. East on Broad Street, on the south side, the Memorial Rose Gardens begin. The rose gardens extend one block to the east, until they are bordered by Pike Avenue, which is the next intersecting street. On the north side of Broad street, on the west corner, is a beautiful inn. Beginning on the east side of Pike Avenue are vast cornfields. These cornfields have grown across from the inn, stretching into the distance since the days of the 49ers. The highway continues from its intersection with Broad Street out of Crestview.

(Survey/Anchors First) CRESTVIEW

The little town of Crestview is an old mining town. The road to Crestview runs north. Crestview begins where the highway crosses the Green River. The highway continues north and intersects Main Street, which extends to the west. The highway continues further north and intersects Broad Street, which extends to the east. The highway then continues out of Crestview.

In the south of Crestview, the river flows to the east out of some low hills that lie to the west. Just across, to the north, Crestview High School lies on the bank to the west at the base of the hills. On the west side of the highway, the small curvy Frontier Road provides the connection to the high school. To the east, directly across from the entrance to Frontier Road, is a gas station. The gas station is on the northern river bank and fishing bait and tackle can be purchased there.

In the center of Crestview, to the west on Main Street in the middle of the block, the rustic town hall stands on the north side of the street. Next to the town hall to the west, is an ancient oak tree grove, which extends to the end of the block. There Gold Avenue intersects Main Street, and extends to the north. On the northwest corner of Gold Avenue is the old general store. For over 150 years, folks have enjoyed the view toward the east from the general store, across to the oak tree grove.

In the north of Crestview, east on Broad Street, on the south side, the Memorial Rose Gardens begin. The rose gardens extend one block east until they are bordered by Pike Avenue, which is the next intersecting street. On the north side of Broad Street, on the west corner, is a beautiful inn. Beginning on the east side of Pike Avenue are vast cornfields. These cornfields have grown across from the inn, stretching into the distance to the east and north, since the days of the 49ers.

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