Differing Map Construction and Text Organization and Their Effects on Retention

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Abstract:
On the basis of Kulhavy's (R. W. Kulhavy, J. B. Lee, & L. C. Caterino, 1985) conjoint retention model of text learning with organized spatial displays, the authors conducted 2 experiments to analyze the effects of different types of maps and a considerate text (i.e., a text that follows the scanning pattern or the map) or an inconsiderate text. In the 1st study, 158 participants viewed an intact or a segmented map and a considerate or a randomized text. Those participants who viewed the intact map and read the considerate text recalled significantly more information than those who viewed the intact map and read the randomized text. In the 2nd study, 179 participants viewed a flat map, a 1-point perspective map, or a 2-point perspective map, and a considerate text formulated on the basis of the predicted miming pattern of the map. Those participants who viewed the flat map recalled significantly more information than those who viewed the perspective maps.
Key words: dual coding theory, recall, spatial displays

Article:
As instructors, we are all looking for ways to improve and increase learning in our classrooms. In several studies, Kulhavy and his colleagues (e.g., Abel & Kulhavy, 1986; Dean & Kulhavy, 1981; Kulhavy, Stock, Verdi, Rittschof, & Savenye, 1993; Kulhavy, Stock, Woodard, & Haygood 1993; Schwartz & Kulhavy, 1981) tested a model of text learning that uses organized spatial displays, such as maps and diagrams, in order to explain why such displays improve a person's ability to recall related text facts, According to Kulhavy's conjoint retention model (Kulhavy, Lee, & Caterino, 1985), which is derived from Paivio's dual coding model (Paivio, 1986), information can be stored as either verbal or nonverbal memory codes. Verbal information is stored sequentially as propositions in a verbal store, whereas nonverbal information is stores as intact images in a separate and distinct nonverbal memory code. Although the verbal and non- verbal codes are separate (distinct), there are referential links between them that can he used as retrieval cues for information stored in one another. When a person learns an organized spatial display, such as a map, in conjunction with a related text, the map is stored as an intact image in the nonverbal code, whereas the text is stored sequentially as a series of propositions in the verbal code. Therefore, when participants are asked to recall facts from a related text, they can use information from both codes as retrieval cues.

Also in accordance with the model, images created from viewing the maps contain both feature and structural information (Kulhavy, Woodard, Haygood, & Webb, 1993). Feature information includes what Berlin (1983) called the *retinal variables,* including color, size, and shape. Structural information concerns the spatial and metric relations among the features on the map. Kulhavy, Woodard et al. (1993) removed structural inflation For one group of students and observed that they recalled fewer names and facts about the features and that they reconstructed the map less accurately. Therefore, researchers believe that the structural information found within intact visual displays allows those who use them to create intact images.

The images in the model enjoy a privileged status when compared with propositions. Propositions are stored serially (van Dijk & Kintsch, 1983), whereas images are processed and stored as a whole unit (Reynolds, 1968). According to the model, two advantages are inherent in encoding structural information (Kulhavy, Stock, Woodard, & Haygood, 1993). First, there is a cuing advantage because the partial relations among features provide extra information for accessing text events. Second, there is a computational advantage because the intact information contained within the image is simultaneously available, and therefore having that information allows the participant to shift attention across the image from one feature to another without absorbing a great deal of memory resources (Larkin & Simon, 1987; Paivio, 1986).

In the research previously conducted, students' recall has consistently been found to be greater when (a) the organized spatial display is studied first (Kulhavy, Stock, Verdi et al., 1993; Stock, Kulhavy, Webb, Pridemore, & Verdi, 1993), (b) the features are located on the display rather than listed next to it (Schwartz & Kulhavy, 1981), and (c) the borders within and around the map are included (Kulhavy, Woodard et al., L993). However, very little research has been conducted on whether differences in construction such as perspective or multiple or segmented displays affect recall (Johnson, Verdi, Kealy, Stock, & Haygood, 1995). Johnson and her colleagues asserted that in research in the map-text tradition, a "plan view"[1] or flat format that is traditional to cartography has generally been used. They also suggested that advances in computer technology are making it likely that perspective maps will be used in instruction. A search of geography textbooks at a university's library showed that in all but one, perspective maps were used, and the majority contained segmented maps on which the whole region was shown originally but was then broken up by local areas. They observed that students recalled more information when they studied a perspective map rather than a flat map or a plan view map, and the researchers argued that the increase in dimensionality provided a richer encoding base for structural relations among features and reference points. The increase in information increased recall. Segmented maps—that is, maps in which sections of the maps, such as a collection of islands, are broken apart—have not been systematically studied within the Kulhavy (Kulhavy et al., 1985) model.

Although the organization of the text has a rich tradition of research in the reading literature (see Meyer, 1975, or Kintsch & van Dijk, 1978), it has not been systematically examined within the Kulhavy model and is not a major component of the model. One component of text organization that affects the recall of information is the considerateness of the text (Armbruster, 1984; Kantor, 1977; Kantor, Anderson, & Armbruster, 1983). Simply, a *considerate text* is organized in such a way that it allows one to gather information efficiently, and it increases recall and comprehension, *Inconsiderate texts* are associated with lower recall and comprehension. The inconsiderateness of textbooks has also been examined (Kantor, Anderson, & Armbruster, 1983).

In Western civilization, it is recognized that literate individuals organize and read text from top to bottom and from left to right. Therefore, as an individual reads a passage, he or she starts at the top left-hand corner and stops at the bottom right-hand corner. According to Winn (1991) and Brandt (1945), items on a map should also be encoded in a top-to-bottom and left-to-right fashion, Winn also asserted that the order in which we encounter the items on a map might influence how we interpret them. There is, however, evidence from a map reconstruction study that perspective maps are processed in the reverse order (bottom to top; Johnson et al., 1995). In the Johnson et al. study, students reconstructed map features bottom-to-top or top-down on the basis of the scanning pattern of the map. They observed that students who saw the flat (plan) map tended to place features from the top of the map first during the reconstruction task and students who saw the perspective maps tended to place features from the bottom of the map first during the reconstruction task. They also argued that students attended first to the bottom of the map. The experimenters did not study the organization of the text, however, and as others have observed (e.g., Kantor et al., 1983), the organization of the text can affect recall of information.

Given that we process text top-to-bottom and left-to-right and that we view flat maps and diagrams the same way, a considerate or ordered text would be one in which the features from the map are discussed in the text on the basis of the predicted scanning pattern of the map. For example, if someone were viewing a flat, or *ordered-top,* map, the features that are at the top of the map should be discussed first in the text if someone were viewing a perspective, or *ordered-bottom, map,* the features that are at the bottom of the map would be discussed first in the text. Matching the scanning pattern of the map with the features discussed in the text may be more considerate and may afford an increase in the recall of information.

Therefore, because of the paucity of research on segmented and perspective maps and on text organization within the Kulhavy model and in map research literature, our purposes in the present experiments were to examine the effects of map segmentation and perspective and the effects of text organization on recall of information. Our further purpose in this study was to replicate and extend the Johnson et al. (1995) findings with a different perspective map. The following were our predictions for Experiment 1:

1. Participants viewing an intact map will recall significantly more facts and features and will produce more accurate and complete maps than those participants who view the same map as a series of individual maps (segmented) because the multiple maps are not simultaneously available in memory. The poorer accessibility of the multiple maps will be a resource disadvantage; therefore, those who view the intact map will have a computational advantage (Kulhavy, Stock et al., 1993).

2. Participants who view the ordered-top map after viewing the intact map will recall significantly more text facts than participants who read a random text because the order of the text will match the predicted scanning pattern of the map (Johnson et al., 1995; Winn, 1991). Moreover, the ordering of the text should allow the participants to gather text information in a more efficient manner (e.g., Armbruster, 1984). In a random text, the same sentences are included, but the sentences are randomly arranged rather than organized to match the scanning pattern.

EXPERIMENT 1

Method

Research Design and Participants

In this study, we used a 2 x 2 (Text: ordered vs. random x Map: intact vs. segmented) factorial design. Ordered text means that the features on the map are discussed in the text in same order as they would be scanned on the map (top-down and left to right). For example, features Bank, Palace, and Burial Grounds in our experimental materials were at the highest and left-most corner on the intact map, so they were the first features discussed on the ordered text page. Random text means that features on the map are discussed not in the predicted scanning pattern but in a random pattern. The map and text are fully redundant. Each feature on the map is also discussed in the text. Participants were shown an intact map of the five Molucca Islands or a series of five maps, each depicting one of the islands. Next, participants read the text about life in the Molucca Islands. Participants then were asked to recall all the facts they could remember from the text and to reconstruct the map. Recall of related text facts, feature names, and the accuracy of map reconstruction were used as dependent measures in this study. The participants were 158 college students from a psychology department. Who received class credit for participating in the study. On the basis of when the students arrived for the study and a random numbers sheet, we randomly divided the participants into four experimental groups: intact/top-down, n = 39; segmented/top-down, n = 44; intact/random, n = 40; and segmented/random, n = 35.

Materials

For this study, we created two maps of the Molucca Is one containing art intact map of the five islands and the other depicting the islands separately. Both maps contained 15 features (e.g., Bay, Burial Grounds, and Gem Mines), with 3 features on each of the five islands, each labeled by a square and the feature name. None of the individual islands was labeled. The title "Molucca Islands" was printed at the top of the page. The five individual island maps were made from the original. Each of those maps depicted only one of the islands and the 3 features that appeared in the original location on the intact map. All maps were printed in black ink and covered most of a 21.6-cm x 27.9-cm sheet of white paper.

The ordered-top text contained 394 words and was broken into five paragraphs. The five paragraphs provided information about all of the features on the map (e.g., "People go to the Bay to watch the children dive for coins"). We created the random text by using the same sentences as in the ordered text and simply placed the sentences in a random order. Reading statistics indicated that there were not significant differences between the texts in level or ease of readability.

Procedure

Once all the participants were seated and quiet, they were instructed to open Envelope 1 and read the cover page of instructions. The participants were told to study the material carefully and that studying that material would help them learn related information to he presented later. They were then informed that they would have 5 min to study the material found on the following page. The participants studied either the intact map or the segmented map of the Molucca Islands. After answering all procedural questions, they were instructed by the monitor to begin studying. When the allotted time had elapsed, they were instructed to stop studying and return the materials to Envelope 1. Note that all participants studied the map first because, in other studies, participants have consistently been found to recall more information if given the map first than if given the text first (e.g., Kulhavy, Stock, Verdi el al., 1993; Stock et al., 1993).

Next, the participants were instructed to open Envelope 2, take out the material within, and read the cover sheet of instructions. The instructions informed the participants that the material should be studied carefully and that the previous information should help them learn this related information. Again, the participants were instructed that they would have 5 min to study the material found on the following page. Participants studied either the ordered-top text or the random text. After answering all procedural questions, we instructed them to begin their study. When the allotted 5 min of time had elapsed, they were informed to return their materials to Envelope 2 and were then given a 1-min rest period.

Following the rest period, the students were instructed to open Envelope 3 and remove its contents. Envelope 3 contained a cover sheet or instructions followed by two blank pieces of paper. The instructions informed the participants that they had 10 min to write down everything they could remember from the text they had read about the Molucca Islands. After all procedural questions were answered, we instructed the participants to begin their free recall. After 10 min had elapsed, participants were instructed to return the materials to Envelope 3 and to open the final envelope.

Envelope 4 contained a cover sheet of instructions followed by the intact map of the Molucca Islands with the 15 features but with their labels removed. In other words, participants saw only an outline of the Molucca Islands and the words "Molucca Islands" printed in the top right-hand corner of the page. They were informed that they would have 10 min to place an X at the exact location a feature was located on the original map and to write the name of that feature beneath the X. After answering all procedural questions, the monitor instructed the participants to begin the map reconstruction task. When 10 min had elapsed, participants were instructed to return the material to Envelope 4 and then to return all the envelopes to a monitor. Upon completion of the last task, the group was dismissed from the experiment.

Scoring

We scored the free-recall protocols fur correct feature names and text facts recall by using a gist scoring criterion. By the term *gist*, we mean that verbatim answers were not required if the overall meaning was present. For example, the related text for Temple was, "People learn about the history of the island by viewing the mosaics which depict famous moments in the islands' history?' However, the answer, "Where a person learns the history of the island by viewing art pictures," was considered acceptable. Each correctly recalled event was given 1 point. We determined the accuracy of feature location by placing a transparency of the map over each reconstruction; a feature was counted as accurately located if it overlapped at least 50% of the original location on the map. We based the decision that a feature had been correctly placed on whether the student had located that feature within a 1/2 -in. circumference around the original spot and whether the name of the feature was present. Each correct placement was also given 1 point. Four scorers who were unaware of the predictions made for the study did the original scoring. A fifth person regraded a random sample of protocols, eight from each of the four experimental conditions. A 90% agreement was found between the two scorings.

Results

We used a series of planned contrasts to test the predictions. PROC GLM in SAS (SAS Institute, Inc., 1990) was used for the planned contrasts. See Tables 1 and 2 for means, standard deviations, and effect sizes. All statistical tests reported were significant at the $p < .05$ level.

TABLE 1
Means and Standard Deviations for Recall of Information in Study 1

	Map type/text format							
	Intact/random		Intact/ ordered-top		Segmented/ random		Segmented/ ordered-top	
Recall information	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Feature name	11.60	3.70	12.95	2.47	11.11	1.94	11.25	3.35
Text facts	9.10	4.02	10.72	3.18	9.00	3.39	8.35	4.00
Match	8.64	4.25	10.05	3.60	8.00	3.73	7.57	4.23
On map	13.25	2.61	13.85	1.95	12.00	2.93	11.73	3.58

Note. Feature name = correct recall of name of feature on the map (e.g., Bank); text facts = correct recall of text information (e.g., people visit the palace to view the crown jewels); match = correspondence between feature name and text fact; on map = correct placement of feature on the outline of the map.

Participants who viewed the intact map recalled statistically significantly more feature names, $F(1, 157) = 4.07$, *ES* = 0.36, text facts, F(l, 157) = 4.38, *ES* =0.33, and feature—fact matches, $F(1, 157) = 6.01$, ES = 0.40, than participants who viewed the series of five maps. Moreover, participants viewing the intact map accurately recorded statistically significantly more features on the map reconstruction, $F(1, 157) = 13.70$, *ES* = 0.61, than did those participants who viewed the series of five maps. Participants who viewed an intact map and read the ordered-top text recalled statistically significantly more feature names, $F(1,157) = 3.62$, *ES* = 0.43, and text facts, $F(1, 157) = 3.84$; *ES* = 0,46, than did those participants who viewed the same intact map but read the random text. The effect sizes reported are considered moderate to small according to Cohen (1988).

TABLE 2
Effect Sizes for Study 1

	Effect size	
Recall information	Intact vs. segmented	Intact ordered vs. intact random
Features	0.36	0.43
Facts	0.33	0.46
Matches	0.40	.0.36
On map	0.61	0.13

Note. We calculated effect size (*ES*) by using Glass's (1978) equation: $ES = |X_1 - X_2|/s_c$. Therefore, the effect size was based on the difference between the two conditions divided by the "within-group standard deviation" (p. 366).

However, no difference was found for participants viewing a series of maps and reading either an ordered-top or a random text, In each case, the results supported our predictions concerning the images created from intact maps and that participants' text recall would be facilitated by viewing an order of the text that matched the scanning pattern of the map. The observations from this study appear to support the Johnson et al. (1995) argument that the organization of the text affects recall because of the predicted scanning pattern, but the design of this study did not permit us to determine if changing the perspective of the map would affect recall. These results provide initial information about the ordering of the text and the scanning of the map but do not indicate whether those observations would hold with a perspective map.

EXPERIMENT 2

Predictions

The following predictions were based on the arguments presented in the studies of Johnson et al. (1995), Brandt (1945), and Winn (1991) concerning the possible scanning patterns of participants who view perspective or flat maps, In addition, as stated in Prediction 2 of Experiment 1, the order of the text should allow text information to be more efficiently gathered because the scanning pattern of the map and the text are similar.

1. Because of the predicted scanning pattern (Johnson et al. 1995), participants who study the one-point perspective map and the ordered-bottom text will recall more text facts than those who study the one-point perspective map and the ordered-top text.

2. Because of the predicted scanning pattern, participants who study the two-point perspective map and the ordered-bottom text will recall more text facts than participants who study the two-point perspective map and the ordered-top text.

3. Because of the predicted scanning pattern (Johnson et al., 1995), participants who study the flat map and the ordered-top text will recall more text facts than participants who study the flat map and ordered-bottom text.

4. In accordance with previous research observations (Johnson et al. 1995), participants who study a perspective map will recall more text facts than those who study a flat map.

Method

Research Design and Participants

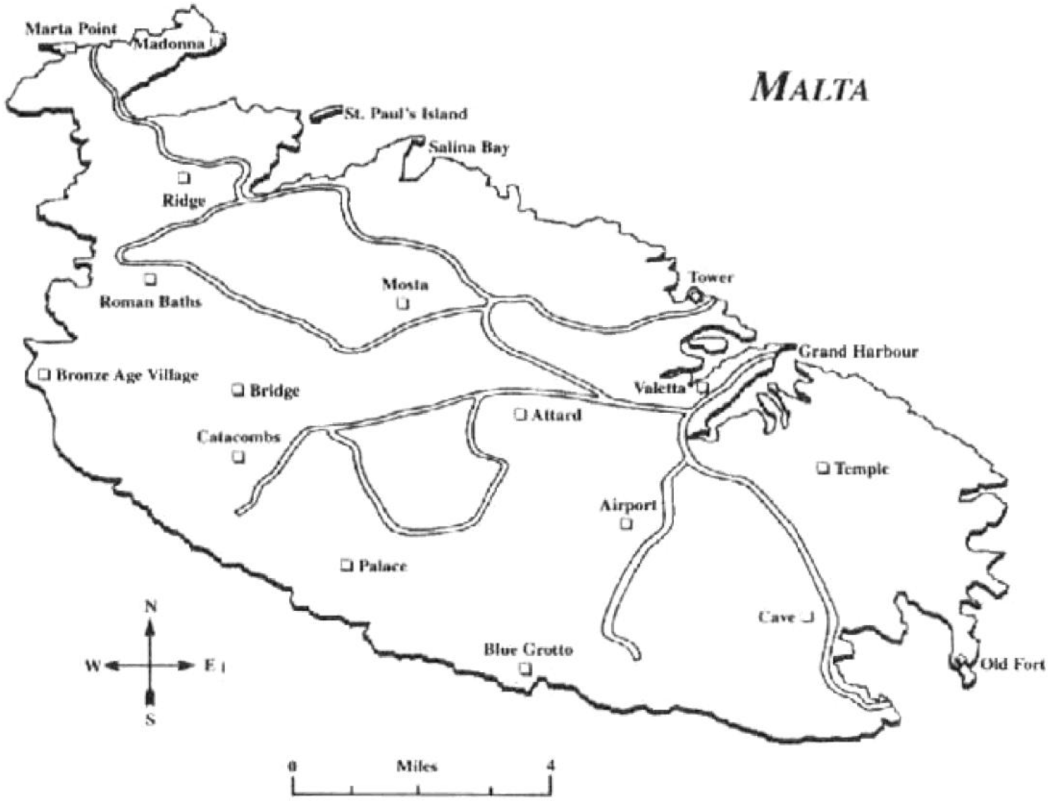
We used in this study a 3 x 2 (Map: flat vs. one-point perspective vs. two-point perspective x Text: ordered-top vs. ordered-bottom) factorial design. The participants were 179 undergraduate volunteers who were randomly assigned to one of six experimental groups: flat map/ordered-top text (n = 30); flat map/ordered-bottom text (n =30; one-point map/ordered-bottom text *(*n = 30): one-point map/ordered-top text (n = 30): two-point map/ ordered-top text (n = 30); and two-point map/ordered-bottom text (n 28).

Materials

Three maps of the island of Malta were created. Each map contained 20 features marked by a small geometric icon and the name label of each feature. All maps also included a compass rose, a scale depicting mileage, and the name of the island. The maps were printed with black ink on white paper (21.6 cm x 27.9 cm). The flat map, which appeared vertically on the page, was two-dimensional, and the icons and borders were void of any indication of depth. The one-point perspective map provided a small indication of depth (see Figure 1). For the observer of that map, depth perception was apparent along the borders of the island and on the geometric icons. The two-point perspective map provided a more pronounced indication of depth. The participant observed what appeared to be a three-dimensional view of the island. The depth perception was greater for the borders and the geometric icons. A cartographer and a commercial artist rendered the perspective maps to faithfully duplicate the nut depiction in all aspects except the vantage point of the viewer.

The ordered-top text contained a 472-word passage separated into four paragraphs. In each paragraph, five of the locations on the map were discussed (e.g., "At Mafia Point people can see the small visible fields which are the only remains of a nineteenth century soil rehabilitation project"); a transition sentence was included so that the text would flow smoothly. We designed the ordered-top text so that the top-left features (e.g., Marta Point) were discussed first and the bottom-right features were discussed last. For the ordered-bottom text, the order of features described was reversed. Bottom-right features, such as Old Fort, were discussed first; and opposite features, such as Marta Point, were discussed last.

FIGURE 1. One-point perspective map of the island of Malta for Study 2.



Procedure

Participants were tested in groups of 25-30; each group contained approximately equal numbers from both experimental conditions. Once all the participants were seated and quiet, they were instructed to open Envelope 1 and to read the cover page of instruction. The participants were told to study the material carefully and that studying this material would help them learn related information to be presented later. They were then informed that they would have 5 min to study the material found on the following page. The participants studied the flat, the one-point perspective map, or the two-point perspective map of the island of Malta. After answering all procedural questions, they were instructed by the monitor to begin studying. When the allotted 5 min had elapsed, they were instructed to stop studying and return the materials to Envelope 1. Note that all participants studied the map first because in other studies participants had consistently been found to recall more information if given the map first than if given the text first (e.g., Kulhavy, Stock, Verdi et al., 1993; Stock et al., 1993).

Next, the participants were instructed to open Envelope 2, take out the material within, and read the cover sheet of instructions. The instructions informed the participants that the material should be studied carefully and that the previous information should help them learn this related information. The participants were instructed that they would have 5 min to study the material found on the following page. Participants studied either the ordered-top or the ordered-bottom text. After answering all procedural questions, they were instructed to begin their study. When the allotted time had elapsed, they were informed that they should return their materials to Envelope 2 and were then given a 1-min rest period.

Following the rest period, the participants were instructed to open Envelope 3 and remove its contents. Envelope 3 contained a cover sheet of instructions followed by two blank pieces of paper. The instructions informed the participants that they had 10 min to write down everything they could remember from the text they had read about the island of Malta. After all procedural questions were answered, the participants were instructed to return the materials to Envelope 3 and open the final envelope. Envelope 4 contained a cover sheet of instructions followed by the map of the island of Malta with the 20 features and their labels removed. In other words, participants saw only an outline of the island of Malta with the word *Malta* printed in the top right-hand corner of the page. They were informed that they would have 10 min to place an X at the exact location a feature was originally located and to write the name of that feature beneath the X. After answering all procedural questions, the monitor instructed the participants to begin the map reconstruction task. When 10 nun had elapsed, the participants were instructed to return the material to Envelope 4 and then to return all the envelopes to a monitor. Upon completion of the last task, the group was dismissed from the experiment.

Scoring

We scored the free-recall protocols for correct feature name and text fact recall by using a gist scoring system, as in Study 1; that is, verbatim answers were not required if the overall meaning was present. For example, the related text for Marta Point was "rolling fields where thousands of olive trees are grown by local farmers." However, the phrase, "fields where farmers grow olive trees," was considered acceptable. Each correctly recalled event was given 1 point. For purposes of scoring feature location, we placed a transparency of the map over each student 's reconstruction and counted a feature as accurately located if it overlapped at least 50% of the original location on the transparency. We determined correct feature placement on the basis of a 1/2-in. circumference around the original spot on the map and whether the name of the feature was present. Each correct placement was also given 1 point. Three scorers who were unaware of the predictions made for the study did the original scoring. A fourth person regraded random sample of protocols, eight from each of the four experimental conditions. An 87% percent agreement was found between the two scorings.

Results

We used a series of planned contrasts to test the predictions. PROC GLM irk SAS (SAS Institute, Inc., 1990) was used for the planned contrasts. See Table 3 for means and standard deviations. All statistical tests reported were significant at the $p < .05$ level. The participants who viewed the flat map recalled statistically significantly more feature names, $F(1, 178) = 3.44$, *ES* = 0.36, than did those who viewed a one-point perspective map and text facts, $F(1, 178) = 6.37$, *ES* = 0.46, and those who viewed a two-point perspective map. The effect sizes for Study 2 would be considered moderate to small according to Cohen (1988). Those who viewed a flat map recalled statistically significantly more feature—fact matches (participant scored correctly on both) than did those participants who viewed either a one-, $F(1, 178) = 5.34$, *ES* = 0.42, or a two-, $F(1, 178) = 7.22$, *ES* .= 0.49, point perspective map. No difference was observed, however, for participants who read either the ordered-top or the ordered-bottom text, regardless of map type. The results from Experiment 2 did not support the previous observations by Johnson and her colleagues that perspective maps are associated with increased recall.

TABLE 3
Means and Standard Deviations for Correct Recall of Information in Study 2

Recall information	Map type/text format											
	Flat/ ordered-top		Flat/ ordered-bottom		1 pt/ ordered-top		1 pt/ ordered-bottom		2 pt/ ordered-top		2 pt/ ordered-bottom	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Feature name	12.23	4.40	12.22	3.93	11.30	4.43	10.16	4.33	11.36	4.03	11.21	3.75
Text facts	10.36	5.16	8.74	3.85	7.43	3.66	8.93	3.37	7.56	4.39	7.71	4.09
Match	9.20	5.39	8.06	4.07	6.50	4.30	7.06	4.01	6.53	4.47	6.39	3.95
On map	13.50	4.23	14.22	3.97	12.96	3.67	13.23	4.19	13.13	3.74	14.00	3.44

Note. See Table 1 for definitions of recall information.

GENERAL DISCUSSION

Kulhavy and colleagues have argued that participants who view intact organized spatial displays such as maps can and do create intact images that aid in the recall of information from a related text (Kulhavy & Stock, 1996). By creating an intact image and storing it in long-term memory, individuals create additional retrieval

Cues that can be used in aiding in the recall of related text when that text is learned in conjunction with the map. Both studies demonstrated that the type of map viewed by individuals can affect the number of facts recalled.

The predictions of Experiment 1 were confirmed, and the results supported the argument of Kulhavy and colleagues. The intact map was superior to the five segmented maps for the recall of information. An explanation for that observation on the basis of the mode] is that the intact map is encoded as one chunk of information, whereas, like the text, the five segmented maps are encoded in a serial order. Because the segmented maps may not be available for access simultaneously, they may absorb more working memory than the single intact map, thus causing a reduction in the amount of information recalled (Kulhavy, Stock, Woodard, & Haygood, 1993). The results supported the argument of Kulhavy, Stock, Woodard, and Haygood (1993), within the theoretical model, that the intact map provides a computational advantage for accessing information.

One might argue that because all participants were required to complete the intact map for the reconstruction, having the segmented group complete five separate maps during the reconstruction may have negated the observations. Although that idea is interesting, it raises two concerns. First, we designed this study to examine how changing the presentation of material affects recall. Second, if the segmented group had completed the reconstruction with five different maps, the two groups would not have been comparable, because their recall tasks were different. Obviously a future study in which segmented maps are varied by recall type may answer that question. The consistency of results does lead to the conclusion that intact maps facilitate recall. Simply stated, those who viewed the intact map recalled more feature names and more text facts related to the features, they had more feature name—text fact matches, and they reconstructed the map more accurately. Not just one difference in dependent measures was statistically significant: All four were.

The result concerning Prediction 2 of Experiment 1 provided initial support for the argument of Johnson and her colleagues, based on Brandt (1945) and on Winn (1991), that the scanning pattern and subsequent text construction are important. The implication of that finding is that the organization of the text must be incorporated into the theory. The educational implication, therefore, is that the serial flow of the text should be matched with the scanning pattern of the map.

The predictions for the second experiment were not confirmed and, for the last prediction, the reverse was observed. The observations from this study did riot provide support for the argument of Johnson et al. (1995) that a perspective map may provide a richer encoding base, thereby increasing recall. One reason for the apparent disparity in results may be the different maps used. Ten of the 23 items on the map used by Johnson and her colleagues were located on the bottom one third of the display, whereas the features on the map used in the second experiment of this study were more evenly distributed across the map. The difference in distribution of features might be one explanation for the bottom-of-the-map scanning pattern, the richer coding base, and the nonsignificant findings in the present experiment. A second plausible reason might be that the scanning pattern is not as important as the clustering of the features in the text. In the ordered-top and -bottom texts, the features that are close to each other on the map are clustered together in the text paragraphs. Therefore, what might be important is the clustering of the feature items in the text on the basis of their spatial locations on the map. More studies must be conducted that examine the consistency of that observation and other reasons for the disparity, such as map and text differences. Future work examining eye-scanning patterns is underway.

Obviously, there seems to be a contradiction between the results of our two experiments. The first study seems to support the argument concerning the scanning pattern, but the second does not. A flat map was used in both studies, but the texts differed in arrangement. A random text seems to negatively affect recall, and an ordered text to enhance recall. Possibly, as long as the text is ordered (as discussed earlier) and the items are clustered, the students will perform better.

Overall, these experiments showed that the type of map and text may affect recall of information. There remain several questions concerning the maps and the texts used. Theoretically, with regard to componential advantage, the first experiment lent support to the Kulhavy model. In general, the model predicts that a map will aid the retention of information. Hut final judgment has to be withheld concerning the effects of the perspective maps. The present results did not provide support for the idea that perspective maps "provide a richer encoding base" (Johnson et al., 1995, p. 458); other factors must be accounted for before one can reach a final decision.

Future Research

As stated previously, more explicit studies of the eye-scanning patterns of people viewing different types organized spatial displays are underway. Further research needs to be performed on the effects of different lengths of texts, complexity of text and map, clustering of text, and procedural differences on recall.

Importance of the Present Findings

The information gained from this experiment is important in three ways. First, the results of this study extend the current knowledge base concerning organized spatial displays and information recall. Second, the observations lead to interesting questions that should be resolved. Last, the information from this study and similar studies will enable instructors who use organized spatial displays and related text to increase the amount of information learned by their students. When using flat maps, an instructor can increase the amount of information retained by aligning the serial order of the text material with features of the spatial display. Clustering the material may also improve recall of information. As an instructor, I am continually searching for methods that will assist students in increasing their retention of material. The present studies provide one more avenue for creating materials to help increase learning.

Teachers can use the information from this and similar studies to reorganize information from textbooks that they regard as inconsiderate. They could also have their students study the maps in the textbook before they read the textual information. Alternatively, teachers can have the students create their own maps and write texts for those maps based on information from the textbook and on information gleaned from studies such as this one. All of those activities would help increase students' general recall of information and may possibly help with higher order thinking skills (e.g., synthesis of material with an organized spatial display).

Limitations

The first limitation of this study concerns the recall of factual material. We did not look at the possible effect of maps on higher order thinking skills, although that research area is potentially interesting and rich. Second, there is a concern with ecological validity. Although the maps used here are of real places, it is clear that by using those maps the experimenters tested the participants with materials that might not be exactly what is used in the classroom. It is also clear that some factors in these experiments may not have replicated exactly what students do in their classrooms. For instance, one could argue that the experiment forced the participants into an unrealistic learning situation because the map and the text were viewed in isolation from one another. We have observed, however, that in several textbooks used in schools those materials are often spatially separated. The organized spatial displays frequently used in textbooks serve only as decorations and have little if any educational significance (Tyner, 1992). That is unfortunate, because the displays could have educational value. In addition, the positioning of the displays within such texts does not encourage students to use them in conjunction with each other but rather to use them as separate materials, as they did in the present experiments. The students are not encouraged to simultaneously use the figures and diagrams appearing in textbooks and the relevant textual information because the figures are often found on different pages than the text passages that describe them. That is an issue for further research that might help teachers step in and create better materials for their students.

Notes:

[1] In cartographic terms, a plan view represents three degrees of freedom in terms of symmetry: The plane is symmetrical about the x-, y., and z-axes. Tipping one edge of the plane, in this ease the z plane, results in a one-point perspective view. Therefore, a one-point perspective has two degrees of freedom in terms of symmetry: the y- and z-axes.

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