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ABSTRACT

Three experiments were conducted to investigate two key assumptions of the conjoint retention (CR) hypothesis. The primary intent was to determine whether the structural information conveyed by maps or the mimeticism of map icons was critical in facilitating the recall of text. A secondary goal was to explore the involvement of the visuospatial sketchpad in retrieving map information. To investigate these two assumptions, researchers manipulated display conditions to evaluate the impact of icon mimeticism, map spatiality, and the two combined on the recall of text. Subjects were 35 student volunteers from a state university. A concurrent task paradigm was used to assess the recognition of spatial displays and the recall of map feature information. The results of all three experiments point to the prominence of icons as the key attributes of maps for facilitating recall, rather than the spatial layout of the map. Furthermore, no evidence was found to indicate that maps are processed in a more spatial manner than are lists. (Contains 1 table, 2 figures, and 22 references.) (Author/SLD)

A Test of the Conjoint Retention Hypothesis for Learning from Geographic Maps: Mimetic Features or Spatial Layout?

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Abstract

Three experiments were conducted to investigate two key assumptions of the conjoint retention (CR) hypothesis. The primary intent was to determine whether the structural information conveyed by maps or the mimeticism of map icons was critical in facilitating the recall of text. A secondary goal was to explore the involvement of the visuospatial sketchpad in retrieving map information. To investigate these two assumptions, we manipulated display conditions to evaluate the impact of icon mimeticism, map spatiality, and the two combined, on the recall of text. We utilized a concurrent task paradigm to assess the recognition of spatial displays and the recall of map feature information. The results of all three experiments point to the prominence of icons as the key attribute of maps for facilitating recall, rather than the spatial layout of the map. Furthermore, we found no evidence to indicate that maps are processed in a more spatial manner than are lists.

A Test of the Conjoint Retention Hypothesis for Learning from Geographic Maps: Mimetic Features or Spatial Layout?

There is considerable evidence that when a geographic map is provided to students as an adjunct display accompanying text, students remember more text information referenced in the map (Abel & Kulhavy, 1986; Kulhavy, Stock, Peterson, Pridemore & Klein, 1992; Kulhavy, Stock, Verdi, Rittschof, & Savenye, 1993; Schwartz & Kulhavy, 1981). In an attempt to explain the facilitative advantage of maps, Kulhavy and his colleagues (Kulhavy, Lee, & Caterino, 1985) developed the conjoint retention (CR) hypothesis. The CR hypothesis is in essence an interpretation of dual code theory (c.f., Paivio, 1986) applied to maps. According to CR, text information referenced in a map is encoded both verbally and spatially, whereas text information not referenced in a map is encoded only in verbal format. Thus, information which is encoded conjointly is more likely to be retrieved because the spatial representation provides an additional code which may be accessed if attempts to retrieve the verbal representation fail. Kulhavy et al. (1992) have proposed that the spatial features of a map serve as a "second stratum cue" that steps up to substitute for inadequate verbal representation.

Recently, Kulhavy and his colleagues (Kulhavy and Stock, 1996; Kulhavy, Woodard, Haygood, and Webb, 1993) have reconceptualized their model explaining the facilitative advantage of adjunct map displays presented during text processing. Their current explanation centers around the computational advantage offered by the interaction of two cognitive factors, control processes and the memorial system. The memorial system explores the impact of representational mode and the limited resources of the processing system, while control processes function to determine how the memorial system should accomplish the task that incited map learning and compare the map to prior knowledge.

Characteristics of the memorial system include the mode of representation (verbal or image) and a limited set of storage and maintenance resources used to process the map representation in memory. Once the meaning of the map has been determined, the map viewer creates a variation of a map image which is suited to the task at hand. There are constraints, however, to the amount and type of information which can be stored in this representation, simply because of limits in the memorial system. The two components of the system which are most directly pertinent to map learning are the representational functions and the computational limits of the system (Kulhavy & Stock, 1996).

Three main points are used to buttress the argument that verbal descriptions which lead to the development of cognitive maps do not possess the same memorial qualities as visual depictions of maps (Kulhavy & Stock, 1996). First, it is virtually impossible to accurately represent the structural and inferential relations contained in even simple maps when learning only from verbal descriptions. Second, the cognitive system processes depictions and descriptions differently, with descriptions processed sequentially while "depictions allow unordered and simultaneous access to visual details" (p. 128). Finally, there is considerable overlap between the neural systems responsible for imagery and visual perception (Farah, 1988; Farah, Hammond, Levine, and Calvanio, 1988). Tippett (1992) notes that visual images possess the perceptual characteristic of "intactness" which is lacking in verbally induced images. The map image created when a visual depiction is viewed contains both feature and structural information. Feature information refers to individual point designations on the map (landmarks, names, etc.) as well as "retinal variables" (Bertin, 1983) of color, shape, and size. Structural information includes the "relations among features and border and path lines that serve as reference points for individual features within the mapped space" (Kulhavy & Stock, 1996, p. 129).

Structural information, which gives a map the characteristic of intactness, can be encoded into the map image if the right conditions exist. The intactness of the map as well as the familiarity of map stimuli as a class allows relatively complex maps to be learned and remembered without overcoming the limits of working memory. That is, the familiarity of geographic maps, combined with the intactness which is lent to the maps by structural information, triggers strategies permitting efficient encoding, storage and retrieval, or which offer a computational advantage (Larkin & Simon, 1987). The computational advantage allows a map viewer to look at the entire map image at once and shift from location to location within the map space without taxing the limits of working memory. It is the structural coherency which defines the spatial properties of a map and leads to the computational advantage that is now included as part of the conjoint retention hypothesis and is seen as the primary reason that geographic maps facilitate the learning of related prose (Kulhavy and Stock, 1996).

In typical map display studies, students have participated in one of three spatial display conditions (geographic map with labeled feature icons distributed within the map space, a list of feature labels placed beside a map, or a control condition in which no maps or features were presented) and then listened to a related text (Abel & Kulhavy, 1986; Schwartz & Kulhavy, 1981). Students who saw the maps recalled more text sentences than students in the other two conditions. In the present study, rather than have students initially view a list of feature labels, we had them view a list of labeled feature icons. If the facilitative advantage offered by maps is due to the spatial layout of the map itself, as suggested by the research on the computational advantage, then students who view a map should recall more text information than those who view a list of labeled feature icons. If, however, the facilitative advantage of maps is due to the visual properties of images within the map's spatial layout, as suggested by dual coding theory, then a list of labeled features should be just as helpful in aiding students' recall as a map displaying the same labeled feature icons spatially.

The CR hypothesis maintains that students create a mental representation of the geographic map as an intact image that aids in recall. A recent study by Robinson, Katayama, and Fan (1996) used concurrent task methodology to investigate whether retrieval processes associated with studying adjunct displays involved use of the visuospatial component of working memory (Baddeley, 1992), which is an assumption of CR. They found that when students attempted to retrieve information after having studied graphic organizers or concept maps their performance on a spatial working memory task was diminished. This spatial interference was not found when students studied outlines or texts. Robinson et al. concluded that the CR hypothesis seems to explain the facilitative advantages of spatial adjunct displays, but not of linear adjunct displays such as outlines. Kruley, Sciama, and Glenberg (1994) also found support for a visuospatial component of working memory. They found that the comprehension of texts accompanied by pictures interfered with the performance of a spatial concurrent task, but not a verbal concurrent task. In the present study, we tested this assumption by investigating the interference of a spatial working memory task under various task recall conditions.

Research suggests that persons use the visuospatial sketchpad to process dot configurations (similar to chess positions) spatially (Baddeley, 1992). In the present series of experiments, students viewed some combination of either a map that contained labeled icons, a list that contained the same labeled icons, a map that contained feature labels only, a list of the feature labels, or simply the title of a fictional county, while listening to someone read five sentences about the county. Students then were shown a spatial memory display (a dot configuration). Kruley, Sciama, and Glenberg (1994) used dot displays in their work with the visuospatial sketchpad, as did Robinson, Katayama, and Fan (1996). The displays in this study are modeled after those used in the aforementioned studies and have retained the characteristics of those displays. After presentation of the dot display, students were asked to recall as many of the five sentences as they could remember, followed by a recognition test of the spatial memory display. According to the CR hypothesis, students should recall more map-related text information when they view maps than when they view either icon lists or nothing. Also in accord with CR, we hypothesized that retrieving information from a mental representation of an intact map would compete for the limited resources of the visuospatial sketchpad with the mental representation of the dot configuration. This would become apparent if students' performance on the spatial working memory task was worse when viewing icon-maps than when they viewed icon-lists or title-displays. In addition, the spatial memory task could inhibit the facilitative advantages of the icon-map by interfering with performance on the recall test. Either of these two scenarios would provide evidence that icon-maps are represented internally as spatial images.

In the following series of experiments, we tested two hypotheses. Our primary interest was to provide a test of a major assumption of CR, the notion that the structural information conveyed by maps is paramount in facilitating the recall of text. To this end, we manipulated map presentation conditions to ascertain if the mimeticism of the map icons or the spatiality of the map display was more important in feature recall. Secondly, we further evaluated a lesser assumption of CR, the role of the visuospatial sketchpad in the processing of map displays. To do so, we utilized a concurrent task paradigm and assessed recall of visual displays.

Experiment 1

Experiment 1 was designed to examine whether the spatial arrangement of mimetic icons (i.e., those icons which mimic the item they represent, or which can be identified without a label just by their visual characteristics) within a map space was the key component in facilitating text recall. To evaluate this assumption, three types of adjunct displays were utilized. Students viewed either a map with five icons dispersed throughout the map space, a list of the same five icons, or a blank page listing only the name of the fictitious county (also displayed at the top of the page for the other two conditions). Students viewed these displays as they listened to a text which included five sentences, each containing a noun represented in the visual display and a noun which was not represented. If the spatiality of the icons was the important factor impacting recall of nouns presented in the text, we would expect students to recall more represented nouns than nonrepresented nouns when viewing the intact maps. If mimeticism was the key factor, then recall would be the same for texts accompanied by both the list of nouns and the intact map, but superior to the page listing only the name of the county.

In this experiment we also examined the use of the visuospatial sketchpad to process spatial information. Robinson, Katayama, and Fan (1996) hypothesized that viewing graphic displays would facilitate the development of spatial mental models which would compete with the representation of a dot configuration display for the limited processing resources of the visuospatial sketchpad. We expected that students would have more difficulty identifying a previously seen dot configuration after viewing an intact map than after viewing a list of icons or no display if the visuospatial sketchpad was used to process icon-maps differentially from icon-lists.

Method

Design and subjects

Two independent variables were examined in a counterbalanced design. Display (icon-map vs. icon-list vs. title-display) and noun (represented vs. nonrepresented) were both manipulated within subjects. The subjects were 35 student volunteers attending a state university in the South.

Materials

Ten lists of five sentences about fictional counties were written. Each sentence made reference to a noun that appeared in an icon-map and icon-list display. We called these "represented nouns" because they were represented in the map and list displays. Each sentence also made reference to a noun that did not appear in the map and list displays, which we called "nonrepresented nouns." An example of one of the sentences was "they saw an acorn being carried by a centipede," where "acorn" was the represented noun and "centipede" was the nonrepresented noun. For each sentence, the represented noun occurred first in the sentence followed by the nonrepresented noun.

For each text, an icon-map, an icon-list, and a title-display were constructed. Each icon-map consisted of a border that surrounded five labeled icons (e.g., castle) and was presented in the middle of an 8.5 x 11 inch page with the name of the county listed at the top of the page. All maps were shaped differently but were approximately the same size (4 x 5 inches). Each icon-list consisted of the same labeled icons as the corresponding map, except that there was no map border and the icons were left-justified and listed top-to-bottom on the page with the name of the county presented at the top of the page. Each title-display consisted of only the county name at the top of the page.

Ten spatial memory displays were constructed. Each spatial display consisted of a rectangular grid, 9 cells by 9 cells, and five solid black dots, each contained within a single cell of the grid. Ten memory tests were constructed consisting of four grid-and-dot configurations with the letters "A" through "D" directly above each. One of the test configurations was the same as the original display (except that the entire pattern was displaced); the other three differed by displacing two of the dots a distance of one cell (above, below, left, right, or diagonally). Packets consisting of a series of adjunct visual displays, spatial memory displays, blank pages to be used for recall tasks, and spatial memory multiple choice tests were prepared on 8.5 by 11 in. plain blue paper (so that students could not see material on the later pages)

Procedure

Students were randomly assigned to one of three counterbalancing conditions according to the packets of materials they received. Prior to beginning the experiment, the packets were ordered by counterbalancing conditions (A,B,C,A,B,C, etc). Packets of materials were then distributed to students individually as they sat in desks in a classroom. Each packet of materials included nine sets of display materials, three for each condition. The experimenter used an overhead projector to take the students through a sample experimental sequence. One set of the ten originally developed icon-maps, icon-lists, title-displays, spatial memory displays, and memory tests was used for this sample. Students were told that they would be attempting to do two things at once and that they should try to do their best at both tasks. First, they would view one of the displays while listening to the experimenter read the text (each type of display was shown to the student at this point, to familiarize them with the three possible conditions). Then they would view a memory display for five seconds. This would be followed by a 90-second free recall test over the text. Finally, students would view a memory test and have 10 seconds to select from a choice of four the representation they had previously seen. This sequence of events was then repeated nine times for the actual experiment. The experimenter kept track of the time allocated for each task by using a stopwatch, and instructed students exactly when to turn pages of their packets.

Each student viewed three icon-maps, three icon-lists, and three title-displays. There were three different counterbalancing conditions so that roughly equal numbers of students would view each type of display with each corresponding text.

Scoring

Spatial memory scores ranged from zero to three for each of the display conditions. Students were awarded one point for each display correctly selected on the multiple choice visual memory test. Three free recall measures (represented nouns, nonrepresented nouns, and sentences) were scored out of a possible 30 points per measure. Each of the recall measures was counted for each adjunct display presented, and scores were aggregated within conditions. Each display condition was presented three times, and each had a corresponding text consisting of five sentences containing a represented noun and a nonrepresented noun, thus resulting in 15 possible correct responses for each free recall measure. Sentence was operationalized as student recall of the represented noun recalled with the corresponding nonrepresented noun from the text. Each of these 15 correct responses was scored as 0, 1, or 2, to result in a total possible of 30 points for each measure. Students were awarded 2 points per measure if they recalled a) the exact name of the represented noun, b) the exact name of the nonrepresented noun or, c) if they remembered the two nouns which appeared together in a sentence. One point was awarded if students partially remembered a noun. An example of a text, a set of student responses, and the scores earned for this display appears below.

Text: They saw mushrooms that grew alongside railroad tracks.
They saw apples that dropped onto bed mattresses below.
They saw a teepee that was built next to a stream.
They saw wheat that was filled with giant grasshoppers.
They saw a forest where a herd of reindeer lived.

Response: raindeer (sic)
wheat field w/ grasshoppers
railroad tracks

Represented Nouns	Non-represented Nouns	Sentence
1 pt for wheat field (the noun was wheat, not wheat field, thus allowing 1 pt only)	2 pts each, reindeer, grasshoppers, railroad tracks	1 pt, wheat field with grasshoppers
= 1 pt	= 6 pts	= 1 pt

Results

All statistical tests were conducted at the alpha = .05 level of significance. For all statistically significant effects that involved a within-subjects factor with more than two levels, Huynh-Feldt adjusted tests were performed and the consistent results provided support for the assumption of sphericity. For ease of interpretation, raw scores have been converted to percent correct scores in all tables and in text.

Represented and nonrepresented nouns

Table 1 presents means (and standard deviations) for scores on the free recall and spatial memory measures by viewing conditions. A 3 (display) by 2 (noun) repeated measures ANOVA was conducted on the numbers of represented and nonrepresented nouns recalled. There was a significant main effect of display, $F(2, 68) = 37.11$, $MSE = 29.32$, $p < .001$. A Tukey HSD test indicated that students recalled more nouns when they viewed either icon-maps ($M = 74.80$) or icon-lists ($M = 70.33$) than they did when they viewed title-displays ($M = 50.13$). There was also a significant main effect of noun, $F(1, 34) = 58.94$, $MSE = 18.94$, $p < .001$. Students recalled more represented nouns ($M = 72.70$) than nonrepresented nouns ($M = 57.50$). Both of these main effects were compromised, however, by the significant interaction effect of display by noun, $F(2, 68) = 12.71$, $MSE = 5.54$, $p < .001$. Although all three tests of simple effects for the effect of noun within each level of display were significant, the effect sizes for the icon-map (1.19) and icon-list (1.18) conditions were much larger than the effect size for the title-display condition (.64). By displaying this interaction graphically in Figure 1, it appears that the difference in recall between represented and nonrepresented nouns within the title-display condition is smaller than the differences within the icon-map and icon-list conditions.

Sentences and Spatial memory scores

One-way repeated measures ANOVAs were conducted on both the number of sentences recalled and the spatial memory scores with display as the independent variable. For recall of sentences, there was a significant difference among the three display conditions, $F(2, 68) = 21.72$, $MSE = 19.93$, $p < .001$. A Tukey HSD test indicated that students recalled more sentences when they viewed either icon-maps or icon-lists than they did when they viewed only title-displays. For recognition of the spatial memory displays, no significant difference was found among the three conditions, $F(2, 68) = .64$, $MSE = .85$, $p = .53$. Contrary to predictions consistent with the CR hypothesis, viewing icon-maps did not interfere more with the spatial memory task than did viewing icon-lists or title-displays.

Discussion

Experiment 1 investigated the CR hypothesis as an explanation for the facilitative advantages of geographic maps. First, we tested to see whether the facilitative advantages of maps are due to the spatial layout of the map or the visual properties of images contained within the map. For recall of represented and nonrepresented nouns, and for recall of sentences where both the represented and nonrepresented noun were recalled as a match, students' recall scores were higher when they viewed either a map or icon-list than when they viewed only a title-display. This suggests that there is nothing special about the physical layout of the map that aids recall. Rather, it is the visual properties of the map image that facilitates recall.

Second, we tested to see whether retrieving information from a mental representation of a map would interfere more with a spatial working memory task than when retrieving information from a mental representation of an icon-list or a title-display. Students did not differ in their performances on the spatial working memory task when they viewed maps, icon-lists, or title-displays. This suggests that maps are not stored in a more spatial format than icon-lists or title-displays. Perhaps the learning task we used, free recall, did not require that students process the maps spatially. However, in studies conducted by Kulhavy and his colleagues, they also used free recall as the learning task when examining the CR hypothesis. To further test these findings, the spatial working memory task was repeated in our second experiment.

Experiment 2

Experiment 1 was designed to test the facilitative effects of maps when learning text, as explained by the conjoint retention hypothesis. The results of Experiment 1 indicated that student recall was facilitated equally well by both maps and lists containing icons, and that both of these conditions were more facilitative than a condition which presented students with the name of a fictional county only. Thus, a text accompanied by an adjunct display is more likely to be recalled than a text presented alone, and it appears that there it makes no difference whether the icons are arranged in a map configuration or in a list. We designed Experiment 2 to further support our notion that mimeticism, rather than physical layout, is the important factor in assisting text recall. The same three conditions which were used in Experiment 1 were used and a fourth condition was added. The fourth condition was a name-list condition, in which the names of the icons were presented in a list format. If there are no differences between the two icon conditions as in Experiment 1, and if both of these conditions improve recall over the name-list condition, then we will have additional support for the advantageous effects of the visual qualities of map images.

Method

Design and subjects

Display (icon-map vs. icon-list vs. name-list vs. title-display) and noun (represented vs. nonrepresented) were again manipulated within-subjects. The subjects were 38 student volunteers attending a state university, different from that in Experiment 1, in the South.

Materials

The materials used in Experiment 1 were again used in Experiment 2. For each of the counties used in Experiment 1, a name-list display was constructed in addition to the displays used previously. The name-list displays consisted of the title of the county at the top and the represented noun names listed top-to-bottom, left-justified.

Procedure

The procedure was identical to that used in Experiment 1 except that two sets of the ten icon-maps, icon-lists, name-lists, title-displays, spatial memory displays, and memory tests were used for the demonstration by the experimenter. Each student viewed two icon-maps, two icon-lists, two name-lists, and two title-displays. There were four different counterbalancing conditions so that roughly equal numbers of students would view each display with each corresponding text.

Scoring

The scoring procedures were the same except that each free recall measure for each condition now ranged from 0 to 20 possible points, since each type of display was viewed twice by each student. Spatial memory scores ranged from 0 - 2 for each condition.

Results

Represented and nonrepresented nouns

Table 2 presents means (and standard deviations) for scores on the free recall and spatial memory measures by viewing conditions. A 4 (display) by 2 (noun) repeated measures ANOVA was conducted on the numbers of represented and nonrepresented nouns recalled. Once again, there was a significant main effect of display, $F(3, 111) = 44.51$, $MSE = 11.19$, $p < .001$. A Tukey HSD test indicated that students recalled more nouns when they viewed either icon-maps ($M = 79.15$) or icon-lists ($M = 79.28$) than when they viewed name-lists ($M = 68.62$), which resulted in higher recall than viewing title-displays ($M = 52.11$). There was also a significant main effect of noun, $F(1, 37) = 43.11$, $MSE = 8.98$, $p < .001$. Students recalled more represented nouns ($M = 75.43$) than nonrepresented nouns ($M = 64.15$). The interaction effect of display by noun was not significant, $F(3, 111) = 1.48$, $MSE = 3.43$, $p = .22$.

Sentences and spatial memory scores

One-way repeated measures ANOVAs were conducted on the number of sentences recalled and the spatial memory scores with display as the independent variable. For sentences there was a significant effect, $F(3, 111) = 27.97$, $MSE = 9.56$, $p < .001$. Identical to the findings for the recall of nouns, a Tukey HSD test indicated that students recalled more sentences when they viewed either icon-maps or icon-lists than when they viewed name lists, which led to higher recall than viewing title-displays. For the spatial memory scores, the effect was not significant, $F(3, 111) = .31$, $MSE = .40$, $p = .82$.

Discussion

Experiment 2 provided additional evidence that the visual properties of map features, rather than the physical layout of the map, assist with recall of related text. Subjects recalled more represented nouns and sentences when presented with either of the icon conditions than when presented with the name list, and earned higher recall scores when presented with the name list than when presented with the title-display only. Although this finding does not support the CR hypothesis, it does provide additional evidence for the facilitative effects of adjunct displays in general, and points to mimeticism as the critical feature in icon displays. As with Experiment 1, no differences were found on the visual memory task. Again, this provides no support for the supposition that maps are stored in a more spatial format than icon-lists, name-lists, or title-displays.

Experiment 3

The findings of Experiments 1 and 2 support the notion that the mimeticism of the map features, rather than the physical layout of the map, assists with the recall of related text. To provide additional support for mimeticism over physical layout we examined a name-map condition. The displays created for this condition were identical to the icon-map displays, except that the icon was deleted leaving only the icon names dispersed in the map space. The title-display condition was omitted since it did not provide any additional information for describing how text is processed and the results of Experiments 1 and 2 supported previous research findings that adjunct displays (versus no adjunct display, as in the title-display condition) facilitate text recall (Darch & Gersten, 1986; Kulhavy, Stock, Peterson, Pridemore, & Klein, 1992; Levie, 1987; Robinson & Kiewra, 1995).

Method

Design and subjects

Feature marker (icon vs. name), display (map vs. list), and noun (represented vs. nonrepresented) were manipulated within-subjects. The subjects were 48 student volunteers attending the same state university in the South as students in Experiment 2.

Materials

Materials used in Experiment 2 were again used in Experiment 3. The title-displays were not used in this experiment and the name-map was substituted instead. The name-maps were constructed by simply deleting the icons from the icon-maps.

Procedure

The procedure was identical to that used in Experiment 2, except that the title-display condition was replaced with the name map condition. Each student viewed two icon-maps, two icon-lists, two name-maps, and two name-lists.

Results

Represented and nonrepresented nouns

Table 3 presents means (and standard deviations) for scores on the free recall and spatial memory measures by viewing conditions. A 2 (feature marker) by 2 (display) by 2 (noun) repeated measures ANOVA was conducted on the number of represented and nonrepresented nouns recalled. There was a significant main effect of feature marker, F (1, 47) = 28.77, MSE = 10.65, $p < .001$. Students recalled more nouns when they viewed icons (M = 64.30) than they did when they viewed names (M = 55.37). There was a significant main effect of display, F(1, 47) = 4.15, MSE = 10.77, p = .047, indicating that students recalled more nouns when they viewed lists (M = 61.54) than they did when they viewed maps (M = 58.13). There was also a significant main effect of noun, F(1, 47) = 40.37, MSE = 26.84, $p < .001$. Students recalled more represented nouns (M = 68.23) than nonrepresented nouns (M = 51.43).

The feature marker by display [F(1, 47) = .44, MSE = 12.01, p = .511] and feature marker by noun [F(1, 47) = .24, MSE = 3.85, p = .623] interaction effects were not significant. However, the display by noun interaction effect was significant, F(1, 47) = 4.05, MSE = 6.31, p = .05 (see Figure 2). Simple effects tests revealed that although students' recall of represented nouns did not differ for maps and lists, F(1, 47) = .20, MSE = 3.40, p = .660; recall was higher for nonrepresented nouns when they viewed lists rather than maps, F(1, 47) = 6.70, MSE = 5.14, p = .013. Finally, the feature marker by display by noun interaction effect was not significant, F(1, 47) = .07, MSE = 2.89, p = .788.

Sentences

A 2 (feature marker) by 2 (display) repeated measures ANOVA was conducted on the number of sentences recalled. The analysis yielded a significant main effect of feature marker, F(1,

47) = 16.69, MSE = 8.81, $p < .001$. Students recalled more sentences when they viewed icons (M = 52.50) than they did when they viewed names (M = 43.75). The main effect of display was also significant, $F(1, 47) = 5.91$, MSE = 10.66, $p = .019$. Students recalled more sentences when they viewed lists (M = 50.99) than they did when they viewed maps (M = 45.26). The interaction effect of feature marker by display was not significant, $F(1, 47) = .54$, MSE = 8.75, $p = .468$.

Spatial memory scores

A 2 (feature marker) by 2 (display) repeated measures ANOVA was conducted on the spatial memory scores. The analysis yielded a significant main effect of feature marker, $F(1, 47) = 4.94$, MSE = .51, $p = .031$. Students correctly recognized more spatial displays when they viewed names (M = 47.40) than they did when they viewed icons (M = 35.95). The main effect of display was not significant, $F(1, 47) = 06$, MSE = .37, $p = .814$. The interaction effect of feature marker by display was not significant, $F(1, 47) = .74$, MSE = .45, $p = .394$.

Discussion

Experiment 3 investigated the impact of spatiality and mimeticism on text recall. Students recalled more represented facts than nonrepresented facts, showed higher rates of recall when viewing icons than when viewing names, recalled more information when viewing lists than maps, and recalled more sentences when they viewed icons than when they viewed lists. Taken together, these findings strongly support the notion that the mimeticism of the icons, not their physical layout, is what is of most importance for facilitating recall of represented text. Furthermore, there was some evidence that students process icons in a more spatial fashion than they process text, since students recognized more spatial displays when they viewed names than when they viewed icons.

General Discussion

Two research questions were investigated in this series of experiments. First, we asked whether it is the mimeticism of map features or their spatial arrangement, as proposed by the conjoint retention hypothesis, which accounts for their facilitative advantage in the recall of related text. Second, we sought to determine if maps are processed more spatially than lists by examining processing in the visuospatial sketchpad.

To examine the first question, we manipulated a series of display conditions. In all three of our experiments, we found that students recalled more represented nouns than nonrepresented nouns, consistent with previous findings on the facilitative nature of adjunct displays in text processing (Darch & Gersten, 1986; Kulhavy, Stock, Peterson, Pridemore, & Klein, 1992; Levie, 1987; Robinson & Kiewra, 1995). In Experiment 1 we found that students recalled more nouns when they viewed an icon-map or an icon-list than when they viewed a title-display, in Experiment 2 more nouns were recalled when students viewed either icon condition than when they viewed a name-list or title display, and in Experiment 3 the icon conditions facilitated recall over a name-list and name-map condition. There were no differences in any of the experiments between the icon-map and icon-list condition. The outcomes of these experiments provide support for the facilitative advantages of the mimetic characteristics of map features rather than the physical layout of the map display as a benefit to text processing.

The CR hypothesis claims that the facilitative advantage offered by maps in text processing is due to the structural coherency which defines the spatial properties of the map and leads to a computational advantage in map processing (Kulhavy & Stock, 1996). Our findings do not support this claim. Our methods, while similar to those of many of the studies which support CR, still differed somewhat from those used in previous studies. In studies investigating maps as aids for text processing, students are often given the map for some period of time (ranging from 45 seconds to 5 minutes) before they are presented with the text they are to learn, and are instructed to use the map to assist them in learning the text (Kulhavy, Stock, Verdi, Rittschof, & Savenye, 1993; Kulhavy, Stock, Woodard, & Haygood, 1993; Stock, Kulhavy, Peterson, Hancock, & Verdi, 1995). We altered this methodology by presenting the map simultaneously with the text, for a period of approximately 20 seconds. This modification was implemented because we believed that the simultaneous presentation of text and a map is more similar to what students experience in classrooms, especially at the post-secondary level, where students are likely to view visual displays while simultaneously listening to verbally presented information. It is possible that the length of time the map was presented did not allow adequate time for encoding the structural features of the map. It appears, then, that with these task demand conditions, maps are no better at facilitating the recall of text than are a list of icons.

Furthermore, unlike previous studies (Kulhavy, Stock, Verdi, Rittschof, & Savenye, 1993; Kulhavy, Stock, Woodard, & Haygood, 1993; Stock, Kulhavy, Peterson, Hancock, & Verdi, 1995) we did not explicitly tell subjects to try to use the displays they viewed to assist them in learning the text. We instructed them that they would be attempting to do two things at once (listening to a list of sentences while viewing a display of some sort), and they should try to do their best at both tasks. It is possible that because we did not tell students to use the displays to assist them in learning the text that they did not take advantage of the potential of the displays for facilitating recall of the text. Thus, one could argue that we did not provide a hard test of the CR model's assumptions. This would especially seem to be the case if there were no differences among the performance of participants in any of the conditions. We did, however, find in all three experiments that students viewing some type of icon display demonstrated better recall of facts than those who viewed a name or title display. Therefore, it seems that students were processing the adjunct information in a manner which allowed for better text recall in some conditions than others. Again, the omission of explicit directions encouraging the learning of a display as a means for remembering text is arguably a likely circumstance in an instructional situation.

Finally, the texts used in our study differed from those used in previous studies of CR (Kulhavy, Stock, Verdi, Rittschof, & Savenye, 1993; Kulhavy, Stock, Woodard, & Haygood, 1993; Stock, Kulhavy, Peterson, Hancock, & Verdi, 1995). While our texts presented a series of facts describing a relationship between a represented and a nonrepresented noun, previously developed texts tended to be more expository and narrative in nature. Kintsch, Mandel, and Kozminsky (1977) found that students were better able to comprehend intact stories than stories presented with their paragraphs scrambled. They attributed this improved recall to the implementation by the students of story schemas which facilitated interpretation of the stories. It is possible, then, that maps are more useful for remembering only certain types of texts, namely those that follow more typical story schemas than the texts we utilized.

We found no support for the notion that maps are processed in a fashion that is somehow more spatial than how lists are processed. In Experiments 1 & 2, there were no differences in spatial memory scores among any of the display conditions. In Experiment 3, however, we found a main effect for feature marker, indicating that subjects recalled spatial displays more accurately when they viewed either maps or lists including names of feature markers than when viewing maps or lists containing icons. There were no differences between the list and map conditions. It seems, then, that perhaps the findings of Experiment 3 support our hypothesis that some visual stimuli are processed more spatially than others. The support, however, is for the more spatial processing of icons than words rather than maps over lists. This finding is consistent with Baddeley's (1992) notion of two slave systems in working memory. That is, it is likely that the icons were processed using the visuospatial sketchpad, thus causing interference with the spatial recall task, while the names were processed using the phonological loop. These findings also support dual coding theory (Paivio, 1986). Of course, it is also possible that the findings of Experiment 3 are spurious. More data need to be collected in future studies before firm conclusions can be drawn about processing in the visuospatial sketchpad.

While we have found strong support for the mimetic characteristics of icons as they facilitate the recall of text, we cannot conclusively say that our findings contradict the conjoint retention hypothesis. It appears from numerous previous studies that the conjoint retention hypothesis does facilitate text processing in certain circumstances. Perhaps the presence of somewhat different, but perhaps more realistic, task demands mitigates the facilitative advantage of structurally coherent maps as an aid in text processing.

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Table 1

Means (and Standard Deviation) for Percent Correct Scores on the Free Recall and Spatial Memory Measures by Viewing Conditions in all Three Experiments.

Experiment 1

	Display Viewed		
Measure	Title-display	Icon-list	Icon-map
Represented Nouns	53.90 (18.62)	80.19 (16.49)	84.00 (9.42)
Nonrepresented Nouns	46.38 (21.55)	60.48 (21.21)	65.62 (16.78)
Sentences	40.67 (22.17)	57.90 (22.20)	63.05 (17.57)
Spatial Memory Score	60.00 (37.73)	59.03 (35.33)	52.37 (34.57)

Experiment 2

	Display Viewed			
Measure	Title-display	Name-list	Icon-list	Icon-map
Represented Nouns	55.92 (17.74)	75.40 (18.76)	85.53 (13.19)	84.87 (11.71)
Nonrepresented Nouns	48.29 (21.26)	61.84 (21.73)	73.03 (18.66)	73.42 (19.70)
Sentences	42.90 (23.82)	59.34 (23.08)	71.19 (17.84)	70.66 (21.35)
Spatial Memory Score	64.45 (30.55)	65.80 (28.70)	59.20 (34.60)	63.15 (38.00)

Experiment 3

	Display Viewed			
	Map		List	
Measure	Icons	Names	Icons	Names
Represented Nouns	72.50 (19.41)	63.13 (19.37)	72.40 (21.17)	64.90 (17.58)
Nonrepresented Nouns	53.86 (22.27)	43.02 (21.01)	58.44 (24.35)	50.42 (22.19)
Sentences	50.42 (23.43)	40.11 (21.87)	54.59 (26.11)	43.40 (23.18)
Spatial Memory Score	38.55 (38.90)	45.85 (33.95)	33.35 (36.20)	48.95 (40.60)

Figure 1 - Display-Noun Interaction from Experiment 1

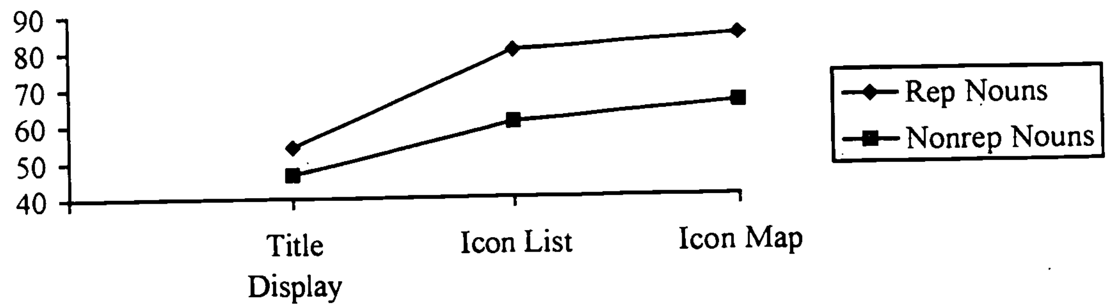
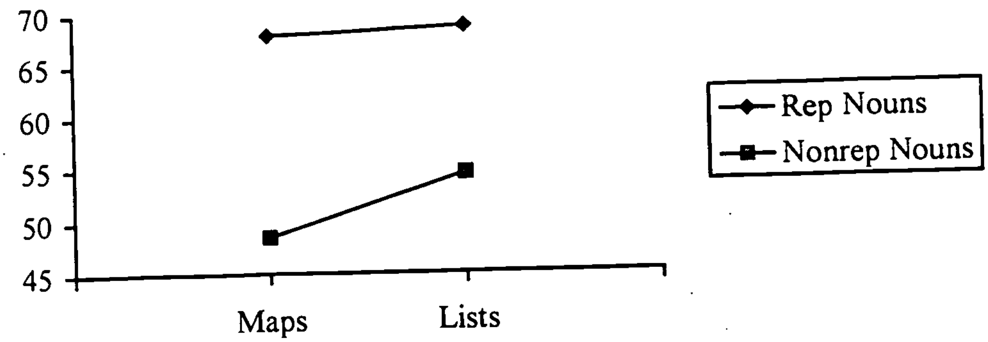


Figure 2 - Display-Noun Interaction from Experiment 3



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