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MAP ORIENTATION AND PRIOR KNOWLEDGE IN LEARNING MAPS AND TEXT

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This investigation examined the effects of map orientation and prior knowledge on learning and remembering cartographic maps. The effects of three map orientations (upper left- lower right, upper right-lower left, and neutral) and two kinds of map features (common map places and common surnames) on feature recall and location were examined. A total of 60 high school students (49 male and 11 female) participated in the study. Subjects were randomly assigned to one of the six experimental conditions based on the order in which they arrived for the experiment. Each student wrote a description of the map while studying it for 20 minutes, and then had 10 minutes to recall and correctly locate the features on a blank outline of the map originally studied. The results indicated that there were no significant differences in feature recall ($p = 0.85$) or location ($p = 0.62$) due to map orientation. Students who studied maps with place names (e.g., waterfall) recalled and located significantly more features than those who studied maps with surnames (e.g., Smith) ($p < .001$).

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PREFACE

The research described in this report was conducted at the Aircrew Training Research Division of the Armstrong Laboratory and investigated the effects of map orientation and prior knowledge on learning and remembering cartographic maps. This effort was conducted under Work Unit Number 1123-B2-13, Unit Level Training Research Applications. The work unit principal investigator was Dr Richard A. Thurman; project scientist was Ms Rebecca B. Brooks.

The authors wish to acknowledge the support and expertise provided by Dr Wilhelmina Savenye, Division of Psychology in Education, Arizona State University (ASU); Dr Robert Haygood, Division of Psychology, ASU; and Dr David Hubbard, Hughes Training, Inc., Training Operations (HTI). A special word of thanks is extended to Ms Margie McConnon (HTI) for her invaluable assistance in creating the maps used in this effort.

MAP ORIENTATION AND PRIOR KNOWLEDGE IN LEARNING MAPS AND TEXT

INTRODUCTION

This experiment investigated the effects of map orientation and prior knowledge on learning and remembering cartographic maps. Due to their organized spatial displays, maps have proved to be useful stimuli in the investigation of how people store, process, and use information. Kulhavy and Stock (in press) state that mapped spaces have three separate identities: the space itself, the cartographic transformation of the space into a map, and the transformation of the map into an image. This experiment focused on the actual cartographic stimulus or "map."

There is considerable evidence that when people study a geographic map, they use the information to help them remember related text material (Kulhavy, Stock, Werner-Bellman, & Klein, 1993; Kulhavy, Stock, Woodard, & Haygood, 1993; Peterson, Kulhavy, Stock, & Pridemore, 1991; Stock, Kulhavy, Peterson, Hancock, & Verdi, 1995). Research has consistently shown that people who study maps recall more facts than people who study unstructured arrays of landmarks, lists of landmark labels, and/or icons and that people who reproduce maps accurately recall more facts than people who do not.

The facilitative relationship between maps and text has been found using a variety of instructional materials and with student populations ranging from elementary school students through college undergraduates (Amlund, Gaffney, & Kulhavy, 1985; Collins, Adams, & Pew, 1978; Davis & Hunkins, 1968; Kirby & Schofield, 1990; Kulhavy, Lee, & Caterino, 1985; Kulhavy, Stock, & Kealy, 1993). This finding holds true whether subjects read or listen to the text (Abel & Kulhavy, 1986), and the effect occurs with tests that require multiple-choice, free-recall, or completion behaviors (Gilmartin, 1982; Mastropieri & Peters, 1987; Scevak, Moore, & Kirby, 1993).

The facilitation between maps and text can be explained in terms of Paivio's (1986) dual-coding theory which suggests that verbal and visual information is stored in separate, functionally distinct codes. Associative links connect the visual imagery and verbal coding systems. Improved recall is a result of these associative connections linking the map image to the representation of the text. If linguistic cues do not lead to retrieval, the map image provides additional cues for text retrieval via these associative links.

Kulhavy and Stock (in press) have extended Paivio's dual-coding theory in the development of their model to explain how people learn maps and text together (Kulhavy, Stock, Woodard, & Haygood, 1993; Stock, Kulhavy, Peterson, Hancock, & Verdi, 1995). The Kulhavy and Stock (in press) model maintains that images of maps capture two categories of information. The first is feature information which includes individual map landmarks, icons, drawings, and topographical symbols, along with attributes (Bertin, 1983) like color and shape. The second is structural information dealing with spatial relations among landmarks, including map coordinates (e.g., cardinal direction) and boundary systems that can be used as reference points for features (Kulhavy, Stock, Verdi, Rittschof, & Savenye, 1993).

The Kulhavy and Stock model states that maps are encoded as intact entities in which structural information provides a framework for individual features. Kulhavy, Stock, and Caterino (1994) suggest that because structural information is included in the image, feature information becomes simultaneously available during working memory operations at retrieval. Intact map images have a computational advantage (Larkin & Simon, 1987) which allows learners to switch attention from location to location without exceeding working memory capacity. During recall, learners are able to use information from map images to cue retrieval of related text content in the verbal store (Kulhavy, Stock, Peterson, Pridemore, & Klein, 1992). This cross-code retrieval accounts for the improved recall that results when maps and text are learned together.

Kulhavy, Woodard, Haygood, and Webb (1993) found that an intact map led to better overall memory for features and more accurate location of features in map reconstruction tasks. Using the accurate location of features in map reconstruction as an index of structural accuracy within the map image, they found that better structural encoding was directly related to memory for text events. When students encode a map in a structurally accurate fashion, they are more likely to be able to use the map information to cue recall of associated verbal content.

Stock, Kulhavy, Peterson, Hancock, and Verdi (1995) found that images formed from maps have different spatial-visual characteristics than images formed from verbal descriptions of the same maps. Studying a map led to higher fact recall and more accurate map drawings than studying a verbal description of the same map. We suggest that higher fact recall in the map group was due to an integrated image of the map in memory, with structural information being an important element of this image. We conclude that the structural information of a map may be more important than feature information.

The shared characteristics between visual displays and images that result from them occur because there is considerable overlap between the neural systems responsible for visual perception and for the production of mental images (Farah, 1988; Levine, Warach, & Farah, 1985). When people form an image of a map (especially when they intend to use it at a later time), they are able to encode it in a form that preserves its essential spatial qualities. The degree to which people retain structural properties in their map image directly predicts the recall of related text content, and it is clear that the spatial qualities of a representation have a potent influence on how that representation can be used to accomplish various cognitive tasks (Kulhavy, Stock, Werner-Bellman, & Klein, 1993). Although maps can be encoded and remembered in a variety of ways (Hirtle & Jonides, 1985; McNamara, Ratcliff, & McKoon, 1984; Tversky & Schiano, 1989), structural information is of utmost importance when the intent is to learn related text (Kulhavy, Stock, Werner-Bellman, & Klein, 1993).

As structural information has a significant impact on the encoding of the map image and subsequent recall of associated text, it is an important area of investigation. Two structural variables that have attracted little study to date are map orientation and prior knowledge. The structural orientation of a map and an individual's prior experience with a specific map or maps, in general, may influence the amount of structural information encoded in the image, the intactness of the image, and the manner in which the information is processed. These factors have direct impact on the recall and location of map features.

Map Orientation

Rock (1974) stated that assigning an orientation to a figure is an inseparable part of perceiving it, and stressed that the same figure is interpreted differently when its orientation is changed. For example, an equilateral rectangle is perceived as a square when its sides are parallel to the sides of its frame of reference, but is perceived as a diamond when it is rotated 45 degrees. When a figure is ambiguous, its orientation with respect to a frame of reference alters its perception (Palmer, 1980; Palmer & Boucher, 1981). If orientation alters our perception, it may alter the images we form of the perceived stimulus. Research suggests that maps are encoded as intact images, and that the more structural information in the image, the greater the recall (Kulhavy & Stock, in press; Kulhavy, Stock, & Caterino, 1994; Kulhavy, Woodard, Haygood, & Webb, 1993).

O'Donnell (1994) examined the impact on learning of the horizontal and vertical orientations of knowledge maps, which are two-dimensional node-link networks that interrelate important concepts. She found that low vocabulary learners using vertically organized maps performed as well as their high vocabulary counterparts. The low vocabulary learners using horizontally organized maps, however, performed very poorly. O'Donnell suggests that the format may promote a differential emphasis on the spatial or verbal processing system, and that the left-to-right format (horizontal) may force the reader to use a more verbal strategy and not benefit from spatial processing. O'Donnell's superior results with the vertical orientation may be due to the fact that people across cultures and ages prefer the vertical orientation of simple figures with the focal features at the top (Braine, 1978).

Winn (1991) investigated the order in which we process diagrams and suggested that we process maps and diagrams like we process text: from left to right and from top to bottom. When Winn reversed the natural steps of a diagram from left-to-right to right-to-left, the subjects' ability to recall sequences and classify components into correct categories was significantly reduced (Winn, 1982). Winn (1983) observed eye movements of students as they studied conventionally arranged and reversed diagrams and found that subjects initially scanned from left-to-right and top-to-bottom, even with reversed (right-to-left and bottom-to-top) diagrams. Winn's stimulus materials were diagrams rather than maps, which may not be learned in the same manner. When people view a diagram, but are told to treat it as a map, they tend to recall much more of the diagram (Verdi, Jones, Sherman, & Kulhavy, 1994; Kealy & Webb, 1995).

Johnson (1994) also investigated the order in which people process maps in her examination of how people learn perspective maps. Perspective maps differ from standard plainimetric (plan) maps in that the spatial relations of each location are rotated so as to appear three dimensional with a one-point perspective. Johnson found that learners using the plan map processed top-down as Winn (1991) suggested; however, learners using the perspective map processed bottom-up. She concluded that perspective maps provide more structural information during encoding which resulted in a more intact image and a computational advantage as suggested by Larkin & Simon (1987) and Winn (1991).

The structural orientation of a map could influence the amount of structural information encoded in the image, the intactness of the image, and the manner in which the information is processed. The effect of map orientation on the recall and location of map features is unknown.

Prior Knowledge

Kulhavy and Stock (in press) state that an interaction between control processes and the memorial system determines the final form of the map image restulting from viewing a map. They believe that control processes first identify an optimal image for meeting task demands and then work within constraints imposed by the memorial system to develop an image that fulfills as many optimal image characteristics as possible. Kulhavy and Stock (in press) state that control processes operate in a context that is defined by the prior knowledge an individual has about maps. The control processes select the study strategies that allocate attention and study time. They also state that what people know about maps influences how they learn new maps when they encounter them, and suggest that there are two kinds of prior knowledge. General map knowledge refers to the use of maps in general, and specific map knowledge is specific to a particular mapped space.

General Map Prior Knowledge

In the United States, children are exposed to maps at an early age and, therefore, gain experience and develop a knowledge base for map learning. By the age of four, children are capable of comprehending aerial photographs (Blaut & Stea, 1971), can accurately label coordinates and retain information about the angle and direction of map objects (Blades & Spencer, 1989; Landau, 1986), and demonstrate an understanding of the relationship between map space and world space (Ottosson, 1988).

Kulhavy and Stock (in press) state that exposure to maps establishes a prior knowledge base that distinguishes maps from other spatial displays less familiar to children (flowcharts, graphs, and diagrams). Later, map use becomes what Tulving (1983) calls an "act of semantic memory." Prior experience guides the perception of map elements such as border shapes, cardinal direction, and landmark distributions. Kulhavy and Stock (in press) suggest that strategies are developed that specifically facilitate learning map information and these strategies probably include learning to form images of maps and encoding them as areal units. They conclude that learning geographic maps is a familiar task and that most people in the United States have developed processing skills for acquiring map-based information.

Kulhavy, Stock, and Kealy (1993) state that when people study a map, they form an image and store it in long-term memory. The content of the image seems to depend on what people expect to do with the information after they learn it (Shepard, 1984). In the absence of instructions, people form distorted map images in which orientation and distance vary from those contained in the actual map (McNamara, Ratcliff, & McCoon, 1984; Moar & Bower, 1983; Phillips, 1984; Tversky, 1981). When students expect to use a map for a specific purpose, such as to remember related text, they are able to encode it so that the match between the actual map and their image of the map is very close (Kulhavy, Stock, Woodard, & Haygood, 1993).

Specific Map Prior Knowledge

In addition to general map knowledge, people have varying degrees of familiarity with particular maps, and experience with a specific map will influence the image they construct from viewing it. Research has shown that students viewing maps of a particular space they are familiar with tend to distort map information in relation to some knowledge-weighted conceptual scheme. Images of familiar maps are modified by related information in long-term memory, resulting in "knowledge-weighted" images. These images are formed from the perceptual stimulus, the conditions under which the map was initially learned, and the ways in which this information has been used following the original exposure. Common distortions with familiar maps include: Rotating features to cardinal points, or right angle bearings (Lloyd & Steinke, 1984; Tversky, 1981), using borders as reference points for features (Lloyd & Steinke, 1986), and distorting judgments of distance and area (Kerst & Howard, 1978; Moyer, Bradley, Sorensen, Whiting, & Mansfield, 1978; Wilton, 1979).

As prior knowledge of specific maps can lead to distortions, only prior knowledge of general maps will be addressed in this research effort. It has been suggested that the basic skills necessary to read and remember map information develop prior to the start of formal schooling (Wood, 1984), and that exposure to maps establishes a prior knowledge base that distinguishes maps from other spatial displays. Therefore, this prior knowledge base for maps should be well-developed by the time an individual enters high school. This means that high school students should be very familiar with the common features (for example, mountain) found on most maps. Kulhavy and Stock (in press) suggest that the more "maplike" the stimulus, the more efficient the learning. Common last names are very familiar, however, they are not "maplike." According to Kulhavy and Stock (in press), common last names would not be "maplike" and would not be expected to be learned in the same manner as common map places which would be "maplike."

Research Hypotheses

This research examined the effects of three map orientations (upper left-to-lower right, upper right-to-lower left, and neutral) and two kinds of features (common places and surnames) on feature recall and location. The first hypotheses proposed for this effort is that when learning map and text, the recall of features and their locations will be higher for those learners who study maps with an upper left-to-lower right orientation than for those who study maps with an upper right-to-lower left or a neutral orientation. This hypothesis is based on Winn's (1991) suggestion that people process maps from left to right and from top to bottom. If students do process maps like they do text and diagrams as Winn (1982, 1983, 1991) suggests, feature recall and location should be higher for subjects in the upper left-to-lower right orientation than for those in the upper right-to-lower left orientation. The performance of those who viewed maps with a neutral map orientation should fall somewhere between the performance of the subjects viewing the other orientations.

According to the Kulhavy and Stock (in press) model, it is the structural information in the images that allows learners to create intact images. These intact images have a computational advantage (Larkin & Simon, 1987) which allows learners to switch attention from location to location on a map without exceeding working memory. This increased efficiency of working memory allows access to more map image information that can be used to cue retrieval of associated text, and results in increased recall and location. Therefore, the map orientation that provides the most structural information during encoding should result in the highest feature recall and location.

The second hypothesis is that the recall and location of map features will be higher for learners using maps with places than for those using maps with surnames. This hypothesis is based on Kulhavy and Stock's (in press) statement that prior knowledge affects map learning because the more "maplike" the stimulus, the more efficient the learning. They state that exposure to maps establishes a prior knowledge base that distinguishes maps from other less familiar spatial displays such as diagrams or graphs, and that people in the United States develop strategies to facilitate learning map information. Kulhavy and Stock suggest that these strategies probably include learning to form images of maps and encode them as areal units.

This prior knowledge base that Kulhavy and Stock (in press) describe is comprised of common places such as a mountain that would normally be found on a map. As a map with places such as a mountain would seem "maplike" and a map with surnames would seem "unmaplike," the Kulhavy and Stock (in press) model would predict that recall and location of map features will be higher for learners using maps with places than for learners using maps with surnames.

Although Paivio's (1986) dual-coding theory would also predict higher performance for students using maps with places than for students using maps with surnames, the explanation is somewhat different. It is easier to form an image of a concrete object or word such as mountain than it is to form an image of an abstract word such as Smith (Paivio, 1971). If recall and location of map features is higher for students using maps with places than for those using maps with surnames, further research will be required to determine if this is due to prior knowledge as Kulhavy and Stock (in press) suggest or to the concrete nature of most maps, which makes them easier to image and recall.

METHOD

Pretest of Map Knowledge

A pretest was administered prior to data collection to assess the subjects' prior knowledge of maps. The pretest determined if the students could match a list of the names of the Southwestern United States with their locations on a US map, and match physical features on a map with their verbal meaning. Instructions were read aloud, and the participants circled their responses. Students were allowed as much time as they needed.

Design

The design was a two by three factorial (common places vs common surnames; upper left-to-lower right, upper right-to-lower left, and neutral orientations). Subjects were randomly assigned to one of the six conditions based on the order in which they appeared for the experiment. The experiment was run in a large conference room. Small groups of ten or less students were used to discourage the possibility of copying one another's answers. Once seated as far apart as possible, the subjects were given a packet of materials from a randomly shuffled stack which assigned them to one of six conditions.

Subjects

The subjects were 60 high school students enrolled in the Air National Guard's Project Challenge at Williams Gateway Air Park (formerly Williams Air Force Base). All of the students who participated in this research were high school dropouts. Project Challenge is a five-month residential program which includes living and training in a military environment. The goal of Project Challenge is to significantly improve the life skills and employment potential of selected high school dropouts while they acquire GED certificates. All students were volunteers for Project Challenge, drug-free, and were not in trouble with the law. Approximately 40% of the students in this program are expected to continue on to college. Participating in this research was viewed as a reward for good behavior by the Project Challenge administration and students. All students in this experiment were just beginning the second month of the five-month program. Most of the students in the sample were males (49 males and 11 females). On the average, they were 16.9 years old and had completed 9.6 years of school.

Procedure

Encoding

Following the pretest, subjects were given the stimulus materials and told to read the instructions silently while the experimenter read them aloud. The instructions directed the subjects to study the map and then describe the map in writing while it was still in front of them. They were told that they would have 20 minutes and that their written description should mention each feature. The purpose of writing the description was to ensure adequate depth of processing of the material (Dean & Kulhavy, 1981). The subjects were instructed to try to remember as many map features and their locations as possible; however, they were not told that they would need to recall the map information on a test. They were instructed to sit quietly if they finished early. The students' map descriptions were collected, however, they were not analyzed for this research.

Reconstruction

At the end of the 20-minute encoding period, all subjects were then given an outline of the map they had just viewed. This map was the same orientation as the map originally studied, however, it did not contain feature locations or names. Instructions directed the subjects to mark an X where each feature was located on the map studied and to write the name of the feature below the X. The subjects had 10 minutes to complete this task.

Questionnaires

Finally, the subjects were given a brief questionnaire with items on their background, prior map experience, and their opinion of the exercise. They were allowed as much time as they needed to complete the questionnaire.

Instruments

Pretest of Map Knowledge

Because the subjects used in this experiment were former high school dropouts, a pretest was administered to determine if they had some prior knowledge of general maps. Subjects were not eliminated from the experiment based on their pretest scores. The pretest established that the subjects had prior knowledge of maps in general. They could match a list of the names of the five Southwestern states with their locations on a map of the United States and match physical features (e.g., river) with their topographical representations on a map. The pretest is located in Appendix A.

Stimuli

Six maps (three orientations and two types of features) were used in this experiment. Figure 1 shows the six combinations of map orientation and feature names. These stimuli were based on the map of Malta used by Johnson (personal communication, March 15, 1995). Three different orientations of this map were produced by rotating the map about its center to produce three visually distinct orientations. The 20 features in each of these three maps were then assigned either common map names such as cemetery or common surnames such as Miller. The same feature locations were used for all six maps and, within a given feature name condition, the same name was always assigned to the same location.

Feature names were selected from a world atlas. Ten of the most common surnames in the United States were selected from Ash (1994) and the remaining 10 surnames were selected from the Phoenix telephone directory. Each of the surnames selected from the telephone directory had at least three pages of listings for that name.

Figure 1. Map orientations for places (a-c) and surnames (d-f).

Maps were individually printed on 8.5 by 11-inch paper. Each map measured approximately 3.5 by 7 inches in size. Features were depicted by small solid circles. The corresponding feature name was printed horizontally adjacent to the circle. The maps used for encoding the place and surname features are shown in Appendix B.

The instructions for encoding were printed on a separate sheet of 8.5 by 11-inch paper. They informed the students that they would have 20 minutes to study the map and describe it in writing while it was still in front of them. The students were told to mention each map feature in their description and to sit quietly if they finished early. The encoding instructions are in Appendix C. After completing their map descriptions, students were given instructions on map reconstruction.

Reconstruction Instructions

The instructions for map reconstruction were printed on 8.5 by 11-inch paper. They informed the students that they would have 10 minutes to recall as many of the map features as possible and locate them in their original location. These instructions are in Appendix D.

Reconstruction Maps

Tests of feature recall and location were conducted using a map of Malta with the same orientation as the map originally studied, however, the names and locations of the map features were omitted. These maps were printed on 8.5 by 11-inch paper. Figure 2 shows the three reconstruction maps.

Questionnaires

Following the map reconstruction task, a brief questionnaire with items on subject background, prior map experience, and the subject's opinion of the exercise was administered. This questionnaire may be found in Appendix E.

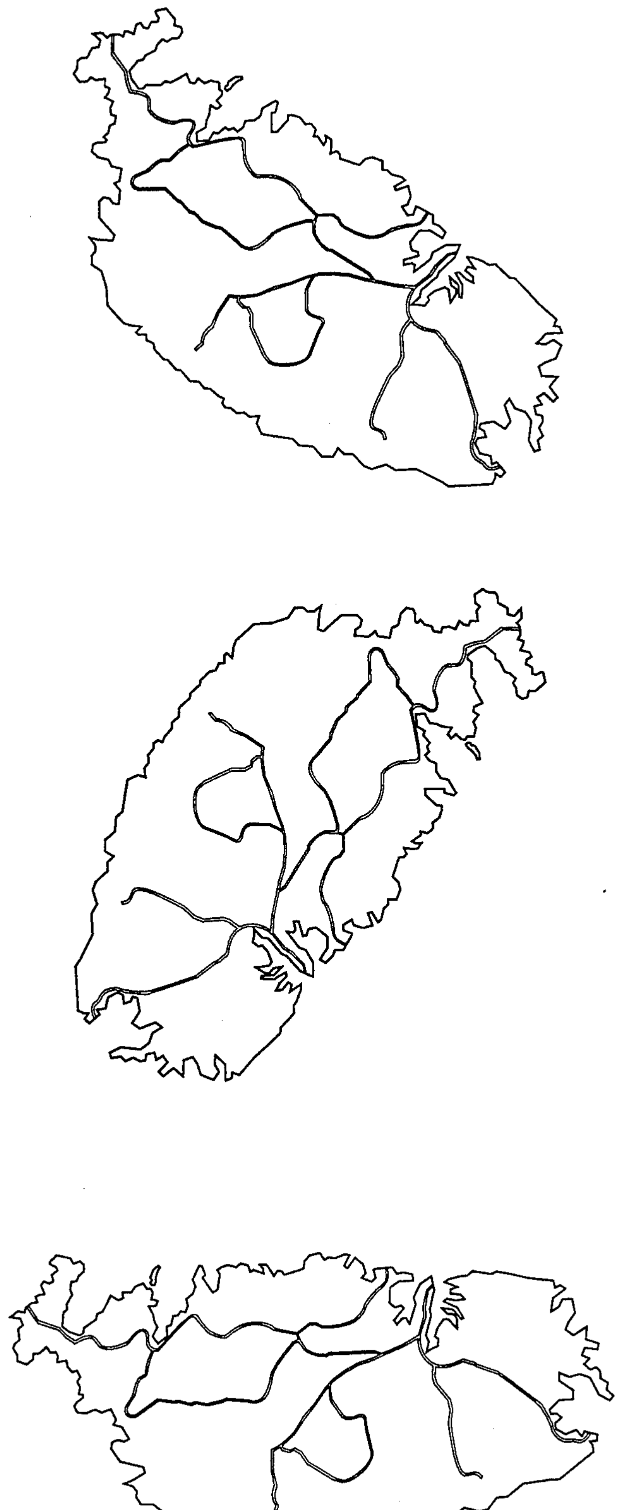

Figure 2. Reconstruction maps.

RESULTS

Pretest of Map Knowledge

Of the 10 items on the pretest, the mean number correct was 9.1 with a standard deviation of 1.6. These 10 items contained six items concerning identification of southwestern states (mean = 5.6, standard deviation = .96), and four items concerning identification of geographic features (mean = 3.5, standard deviation = 1.10). A perfect score on all of the pretest items was obtained by 68.3% of the students.

In general, students seemed to be more familiar with the southwestern states than with physical features on a map; however, the stimulus map with the physical features could have been more difficult for the students to interpret. The students had the most trouble with the mountain (probability correct = .80) and river (probability correct = .78), results which could have been caused by the lack of color that would have made the altitude legend easier to read, or the manner in which the river was labeled on the stimulus materials.

Map Reconstruction Scoring

Feature recall was scored by assigning one point for each feature from the stimulus map that appeared on the reconstruction map regardless of whether of not it was in the correct location. A feature was scored as correctly located if it fell within a one half-inch radius of the center of the feature location on the stimulus map. The features correctly located were divided by the total number of features recalled to determine the percent correctly located and these percentages were used for analyses. The probability of Type I error was fixed at .05 in all statistical analyses.

Analyses

Feature Recall

Table 1(1) on the following page displays the means and standard deviations for features recalled by type of map feature and orientation.

Table 1

Features Recalled

(1) *Means and (Standard Deviations)*

Feature Type	Orientation: Left-Right	Neutral	Right-Left	Average
Places	9.50 (3.41)	12.10 (5.13)	8.60 (3.64)	10.07 (4.39)
Names	5.50 (3.01)	4.30 (2.87)	6.90 (3.75)	5.57 (3.40)
Average	7.50 (3.79)	8.20 (5.70)	7.75 (3.79)	7.82 (4.53)

(2) *ANOVA Test Results*

Source	df	SS	MS	F	p
Type of Feature	1	303.75	303.75	19.88	.000
Orientation	2	5.03	2.52	.17	.850
Type x Orientation	2	94.90	47.45	3.11	.053
Error	54	825.30	15.28		

As shown in Table 1(2), the difference in students' recall of places and names was statistically significant ($p < .001$). As predicted, students were more likely to recall places than names. Table 1 also shows that there was no statistically significant difference in feature recall as a function of map orientation. In other words, the original hypothesis that recall and location would be highest for maps with a left-right orientation, and lowest for maps with a right-left orientation was not supported by the results. The interaction of type of feature and map orientation was also not statistically significant ($\alpha = .05$).

As shown in Table 2, the places that were most likely to be recalled were the cemetery (n = 25), school (n = 23), and lighthouse (n = 20); the surnames that were most often recalled were Miller (n = 17), Smith (n = 16), Wood (n = 12), and Allen (n = 12).

Table 2

Number of Students Who Recalled Each Place and Surname

Place	Number Recalled	Surname	Number Recalled
Cemetery	25	Miller	17
School	23	Thomas	3
Lighthouse	20	Davis	7
Campgrounds	18	Jones	10
Volcano	17	Smith	16
Church	16	Wilson	9
Waterfall	16	Brown	7
Airport	15	Martin	2
Cave	15	Young	11
Desert	15	Hall	6
Forest	14	Williams	9
Canal	13	Johnson	6
Dam	13	Lane	6
Ferry	13	Olson	9
Mountain	13	Anderson	9
Park	12	Allen	12
Tunnel	12	Cook	6
Swamp	11	Wood	12
Lake	10	Adams	2
Mine	8	Gray	8

Feature Location

The means and standard deviations for feature location are displayed in Table 3(1) on the next page. In order to be scored as correctly located, a feature had to first be recalled, therefore, proportions were used in this analysis. The finding that location was higher for map places than common surnames confirms the original hypothesis. As shown in Table 3(2), subjects studying maps with places correctly located significantly more features than subjects studying maps with surnames (p = .013).

Table 3

Proportions of Features Correctly Located

(1) *Means and (Standard Deviations)*

	Orientation			
Feature Type	Left-Right	Neutral	Right-Left	Total
Places	.64 (.20)	.68 (.27)	.70 (.27)	.67 (.25)
Names	.43 (.32)	.43 (.38)	.56 (.24)	.47 (.32)
Total	.54 (.29)	.55 (.35)	.63 (.27)	.57 (.31)

(2) *ANOVA Test Results*

Source	df	SS	MS	F	p
Type of Feature	1	.60	.60	6.58	.013
Orientation	2	.09	.04	.48	.622
Type x Orientation	2	.03	.01	.16	.856
Error	54	4.90	.09		

There was no significant difference in feature location between the three map orientations, as shown in Table 3(2). In other words, the original hypothesis that feature location would be highest for maps with a left-to-right orientation was not supported by the findings.

There are several possible explanations for the finding that places seemed to be easier to locate than surnames. Kulhavy and Stock (in press) suggest that prior knowledge of general maps has caused people to develop strategies probably include learning to form images of maps and encode them as areal units. This would result in increased structure in the image which would result in enhanced memory for text (Kulhavy, Woodard, Haygood, & Webb, 1993). An alternative explanation for the higher location accuracy of map places is that concrete words such as lake are easier to image than abstract words such as Martin (Paivio, 1971; 1986). The concrete nature of the map places may have facilitated the formation of an intact image which could have permitted additional structure to be encoded. Encoding additional structure in the image would result in increased recall and location accuracy.

Further Analyses

Although these contrasts were not included in the hypotheses for this experiment, additional analyses of variance were conducted to determine if there were differences in feature recall/location due to location of the feature on the map. These analyses contrasted the recall of features located: (a) at the top and bottom of the map, and (b) on the coastline and interior of the map. None of the differences in mean levels of recall as a function of feature location was statistically significant ($\alpha = .05$).

Questionnaire Results

As noted earlier, the questionnaires included items focused on: (a) map knowledge, (b) the shape of the map, (c) students' level of enjoyment in doing this activity, (d) the amount of time students were allowed to study the map, (e) whether or not they tried to do the task, and (f) perceptions of the difficulty of the task. The results may be briefly summarized as follows:

(1) Students indicated that they had used maps an average of 8.6 times in the 12 months prior to the study. Judging from the results of both the pretest and the questionnaire, this group of students seems to have had some prior knowledge of maps in general.

(2) More than half (53%) of the students indicated that the shape of the map reminded them of nothing at all.

(3) Most seemed to enjoy the activity, with only 13% indicating that they did not enjoy the experience.

(4) Approximately 69% of the students indicated that they needed more time to learn the map. The students were allowed 20 minutes to learn the maps, and the experimenter observed the majority of them studying the maps for only about 10 of the 20 minutes allowed. This finding could be due to a lack of a clarity in the instructions of what the learner would be required to do with the acquired map information. Kulhavy and Stock (in press) state that people create map images that match their perception of what the map will be used for at some future point in time. How an image is accessed may depend on the particular task demands and the expectations of the subjects. In this experiment, the instructions directed the students to try to remember the map information; however, they did not explicitly tell the subjects that they would have to recall and locate the map features on a test.

(5) Approximately 82% of the students indicated that they tried to do the best they could to learn the map, which seems to indicate a high degree of motivation. Nevertheless, the students did not perform at very high levels on this task. Many of the students recalled only one or two features, and eight of the students did not write the description of the map as directed. Some of the students chose to trace the map, draw a picture, or to simply list the features. Although the students' map descriptions were collected, they were not analyzed. Additional time for encoding/reconstruction and more detailed instructions may have been required than those presented in the experiment. If the instructions had stated that the students would be required to use their acquired map information to recall and locate the map features on a "test," perhaps the results would have been different.

DISCUSSION

This research examined the effects of map orientation and prior knowledge on subjects' recall and location of map features. Three map orientations (upper-left-to-lower-right, upper-right-to-lower-left, and neutral) and two types of map features (places and common surnames) were investigated.

Orientation

The research hypothesized that feature recall and location would be higher for maps with an upper-left-to-lower-right orientation than for maps with an upper-right-to-lower-left or neutral orientation. The three map orientations that were considered in this effort did not have a differential effect on students' recall of map features or locations. A number of factors may have contributed to this finding, including: The stimuli, the amount of structural information encoded in the image, the intactness of the image, and the effect of the structural information on the order of processing.

The Kulhavy and Stock (in press) model suggests that map images contain both feature and structural information and that it is the structural information found within the images that allows students to create intact images. The accurate location of reconstructed map features has been used as an index of structural accuracy of the map image, and better structural encoding has been shown to be directly related to improved memory for text (Kulhavy, Woodard, Haygood, & Webb, 1993). The map orientation that provided the most structure should have resulted in the highest recall and most accurate location of map features. As the three orientations used in this experiment did not differentially effect feature recall or location, they may all contain the same amount of structural information.

The lack of a significant difference in feature recall or location due to orientation may mean that the orientations used in this experiment did not affect the order in which the features were processed. Further research with an eye tracking device is required to resolve this issue. These results may also be due to other factors such as the amount of encoding time, subject motivation, the unique subject population, and impact of the directions on learner intent. If the learners had known a priori that they would have to recall and locate the map features, they might have encoded the map differently. Intent causes a greater likelihood of encoding the map as an intact unit that retains both its geometry and metric (Kulhavy, Schwartz, & Shaha, 1983).

Prior Knowledge

As hypothesized, recall and location of map features was higher for the maps with places than for those with surnames. A number of factors could explain this result, including: The "maplikeness" of the stimuli, the amount of structural information encoded in the image, the intactness of the image, the impact of the instructions on intent of the learners, and the ease of imagery of the features.

"Maplikeness"

Kulhavy and Stock (in press) state that the more "maplike" the stimulus, the more efficient the learning due to activation of the skills and strategies in the prior knowledge database for general maps. They suggest that the prior knowledge map strategies we have developed to facilitate learning map information probably includes learning to form images of maps and encode them as areal units. If the maps with places such as lake seemed more "maplike" than those with surnames such as Martin, perhaps the subjects activated their prior knowledge databases and associated encoding strategies. If they formed images and encoded the map as areal units as suggested by Kulhavy and Stock, these encoded images would have more structure, resulting in enhanced memory for text (Kulhavy, Woodard, Haygood, & Webb, 1993).

These prior knowledge map skills and strategies can sometimes be activated by merely calling a graphic a map. Kealy and Webb (1995) found that recall was significantly higher for learners who believed they were using a map than learners who studied the identical graphic but were told it was a diagram.

The precise nature of the requirements for activating these prior knowledge map skills is unknown.

Dual Coding Theory

An alternative explanation for the higher location accuracy of map places is the fact that concrete words such as lake are easier to image than abstract words such as Martin (Paivio, 1971; 1986). Paivio's (1971) dual-coding approach to memory and cognition distinguishes two independent but interconnected symbolic processing systems--a verbal system and a nonverbal or imagery system. The verbal system deals with relatively abstract information such as language, and the imagery system specializes in processing concrete, perceptual information such as nonverbal objects or events. Paivio (1983) states that concrete items are easier to image than abstract items and that the images serve as supplementary memory code for retrieval.

Clark and Paivio (1991) state that imagery can unify multiple objects into an integrated image, and that this imagery depends on the imagery value or concreteness of the material being studied (along with the instructions) and individual differences. The concrete nature of the map places may have facilitated the formation of an intact image, and the abstract nature of the surnames may have interfered with image formation. The intact image of a map with concrete places may have allowed additional structural encoding which would have resulted in more accurate location of features.

Interference

The recall and location performance of the subjects viewing maps with surnames may have been impacted by interference which could have impaired the positive effects of prior knowledge of general maps in forming a structurally accurate, intact image. If this interference prevented the encoding of an intact image, working memory would have an increased workload due to the loss of the computational advantage described by Larkin & Simon (1987). This is an interesting phenomena since many maps today have names of cities that are comprised of parts of first or last names such as Jamestown or Sharon.

Instructions

The fact that the instructions for this experiment did not indicate that the subjects would face the task of recalling and locating the map features in a subsequent test may have affected the way they studied the maps and the nature of the images they encoded. The content of this map image seems to depend on what the students expects to do with the information once it is learned (Shepard, 1984). The fact that the students were not told that they would have a test was an attempt by the experimenters not to influence the content of this mental image. However, it may have resulted in the students forming distorted map images because they did not know what would be expected of them following the map learning session.

The way in which learners encode and remember spatial displays is determined by the amount of past experience they have and what they intend to do with the information once it is learned (Kulhavy, Stock, & Kealy, 1993). When the intent of the experiment is known, students will study maps in a certain way for a specific purpose, and they will form an image in a way that attempts to satisfy that demand. Intent causes better memory for one type of map or another (Webb, Thornton, Hancock, & McCarthy, 1992), as well as a greater likelihood of encoding the map as an intact unit that retains both its geometry and metric (Kulhavy, Schwartz, & Shaha, 1983).

As previously mentioned under map orientation, these data may also be due to inadequate encoding time, lack of thorough processing (demonstrated by many students not following directions in writing a description of the map), and the unique subject population.

Conclusion

As the degree to which people retain structural properties in their map image directly predicts the recall of related text content, further investigation is needed to determine how to increase the amount of map structure encoded in the image. Research is also needed to determine precisely how we judge a graphic to be "maplike" and what it takes to activate the map-learning strategies in our prior general map knowledge database. Finally, research is needed to investigate the effects of imagery concretenesss and its impact on prior knowledge of general maps.

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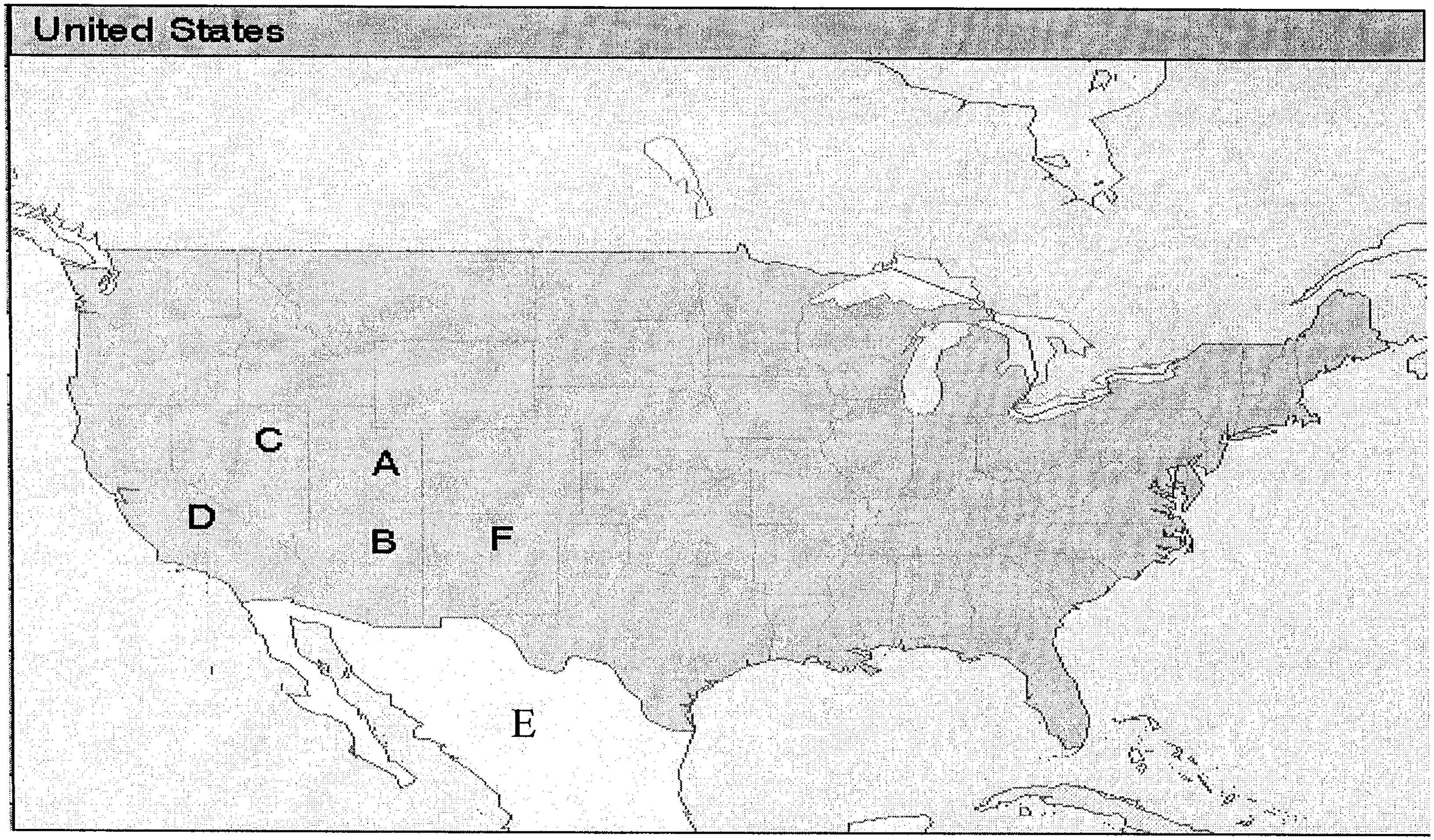
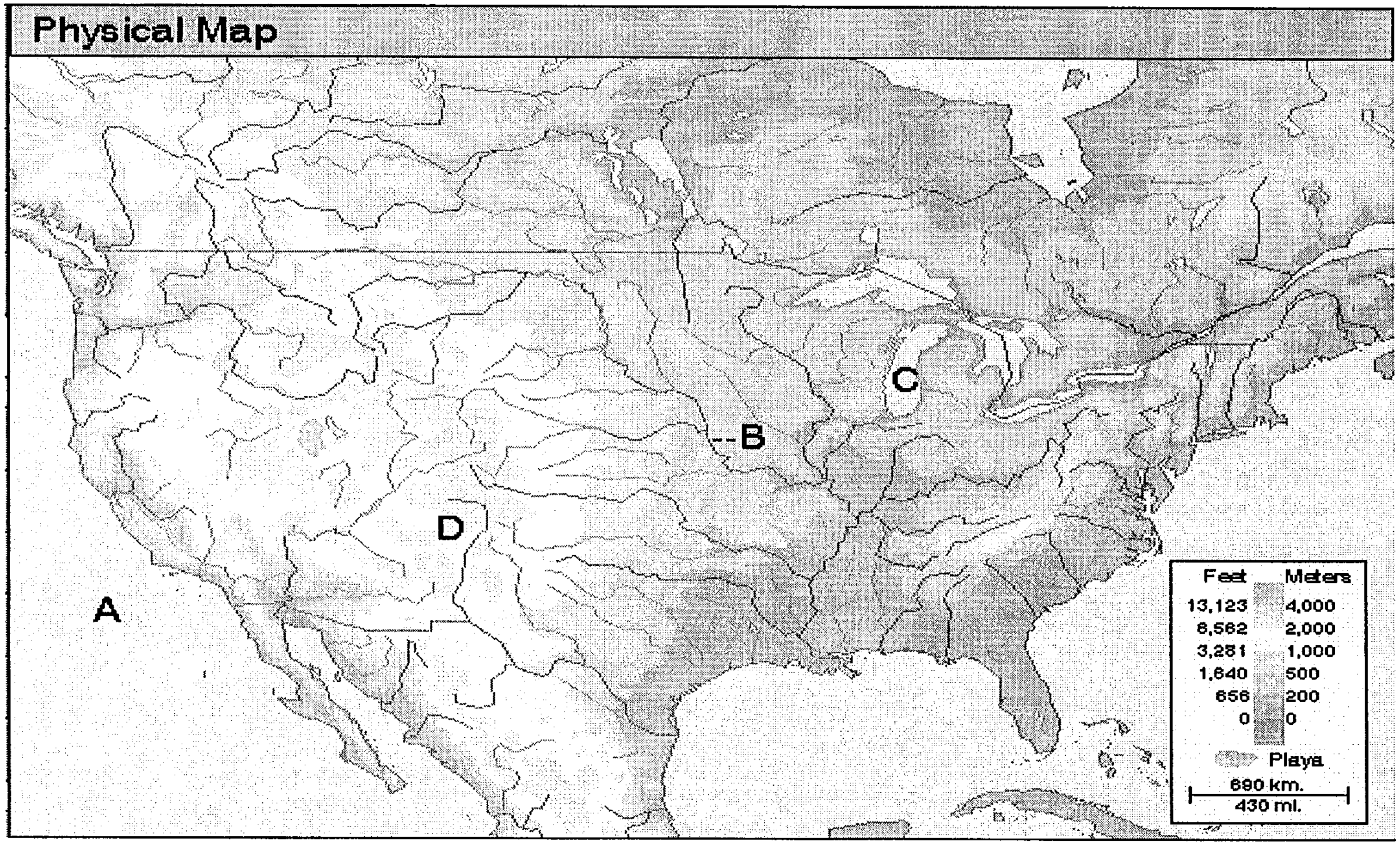
APPENDIX A: PRETEST



Directions: Draw a circle around the letter you think stands for the following:

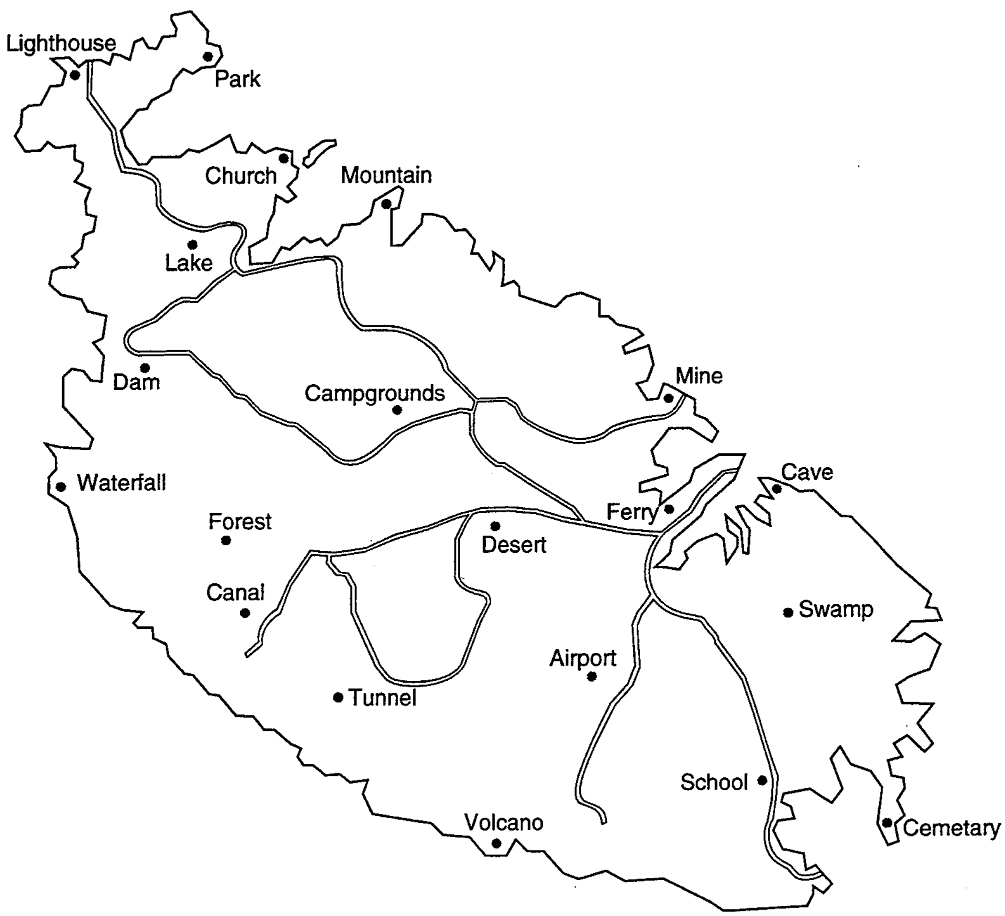
Utah	A B C D E F	Arizona	A B C D E F
California	A B C D E F	New Mexico	A B C D E F
Mexico	A B C D E F	Nevada	A B C D E F



Directions: Draw a circle around the letter you think means the following:

Lake	A B C D	Mountain	A B C D
Ocean	A B C D	River	A B C D

APPENDIX B: ENCODING MAPS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Park
Church
Mountain
Lake
Dam
Campgrounds
Mine
Waterfall
Forest
Ferry
Cave
Desert
Canal
Swamp
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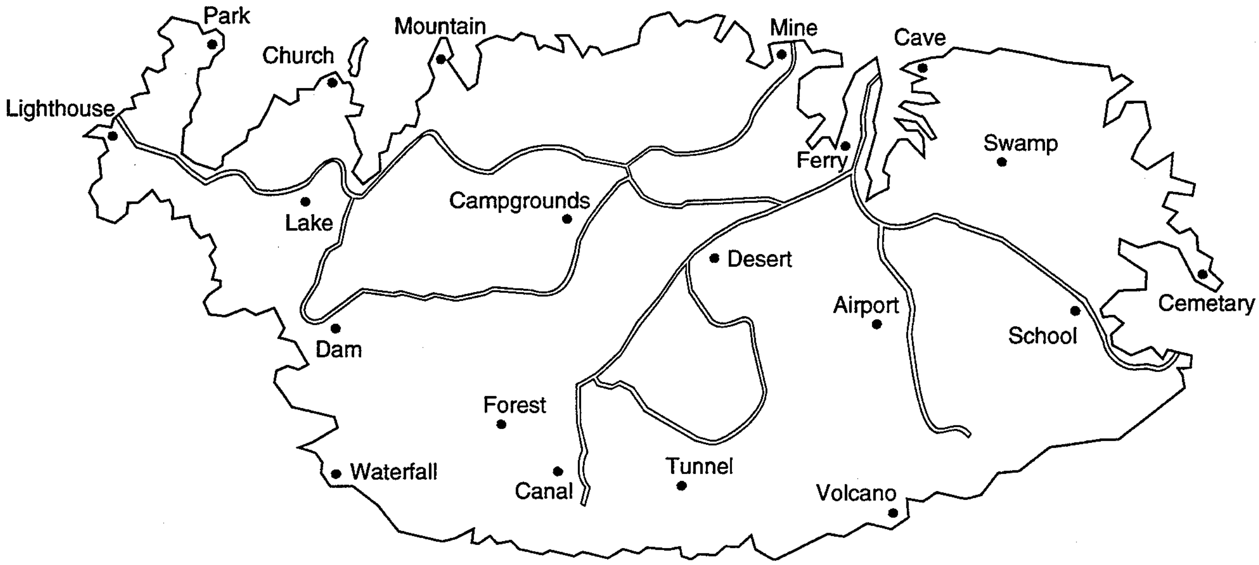
Tunnel
School
Volcano
Cemetary


Park
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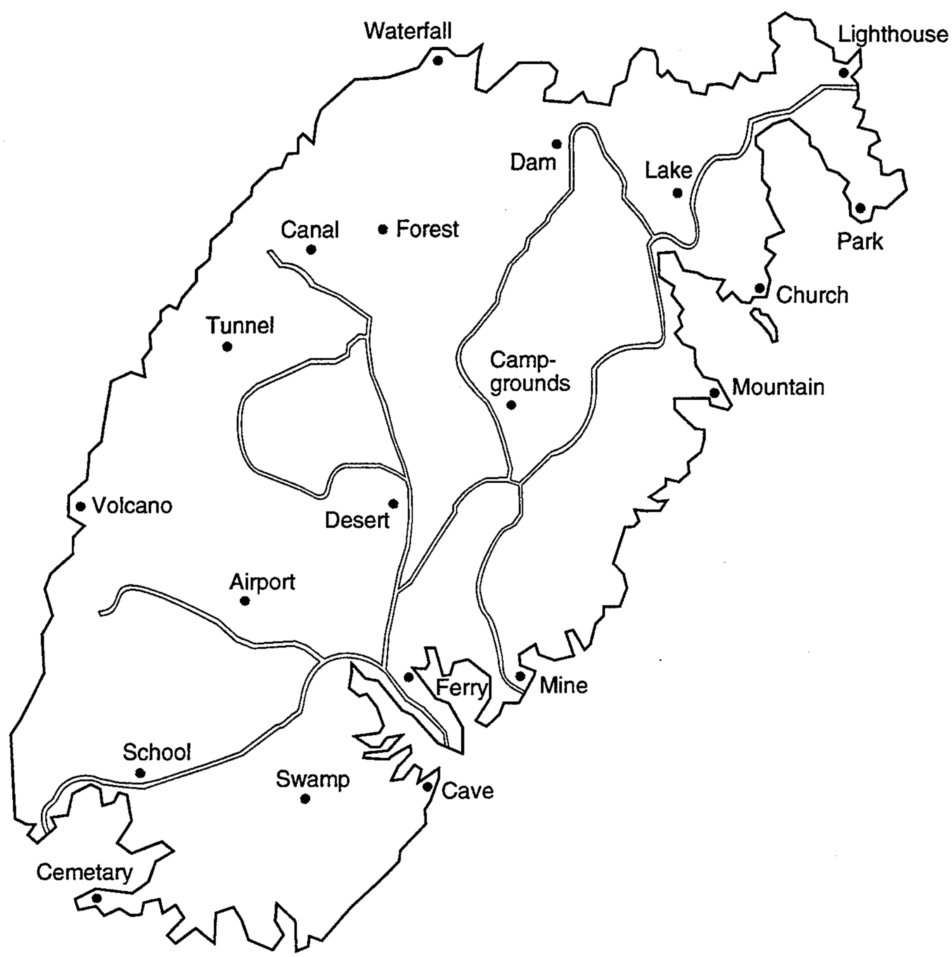
Waterfall
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Park
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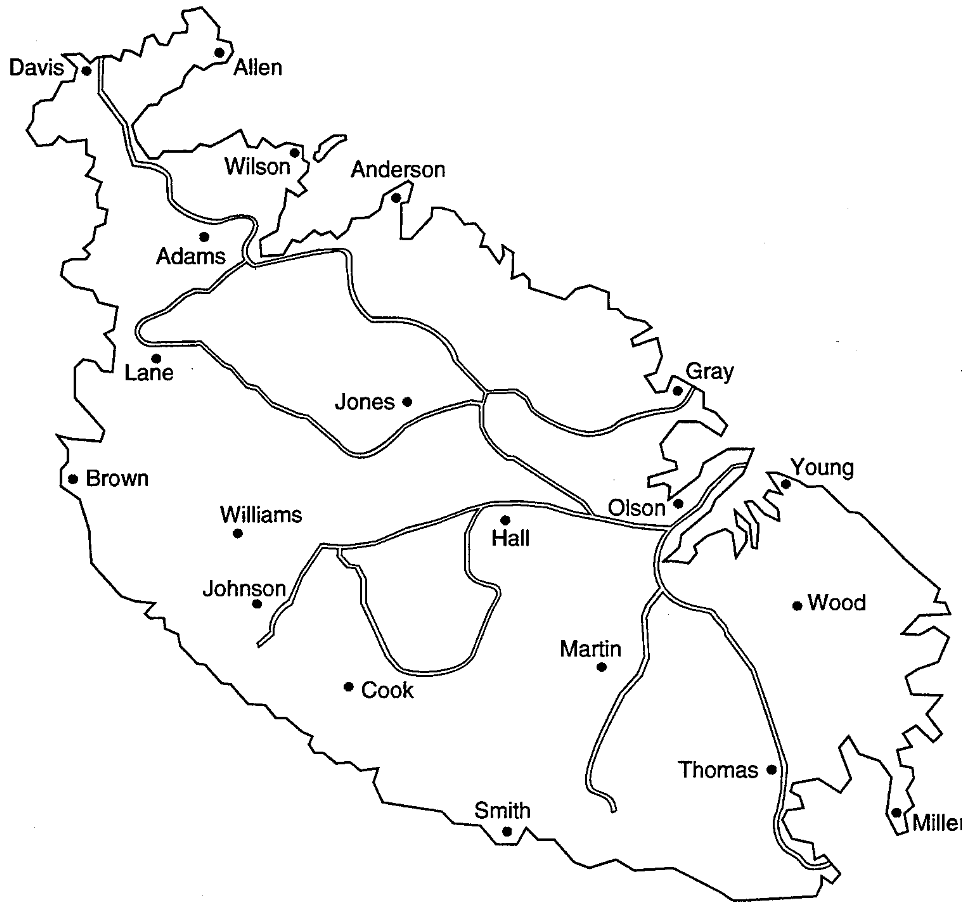
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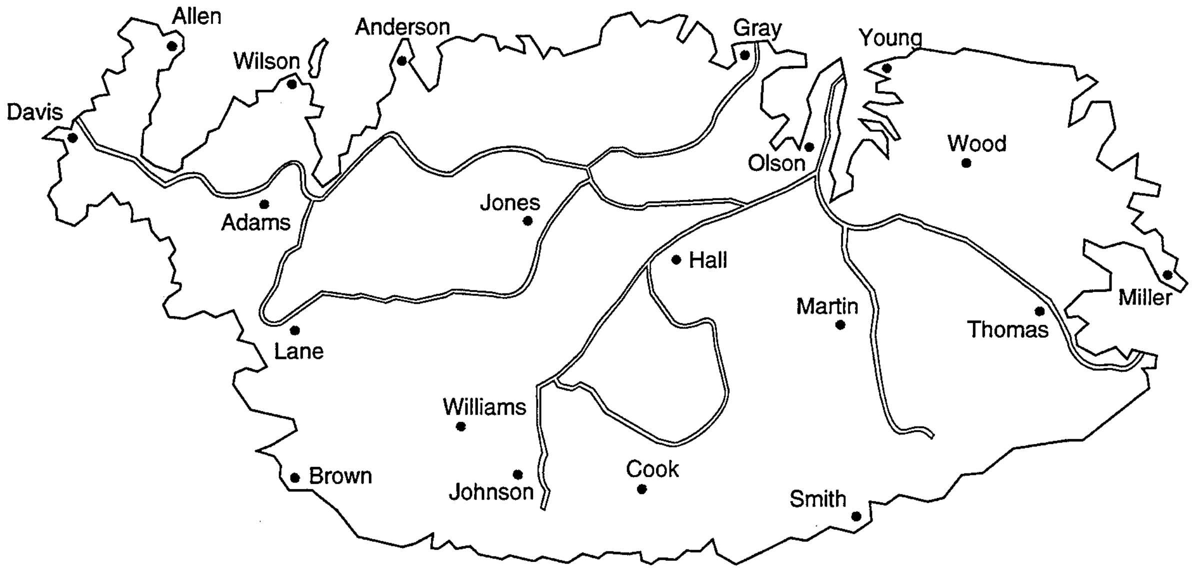
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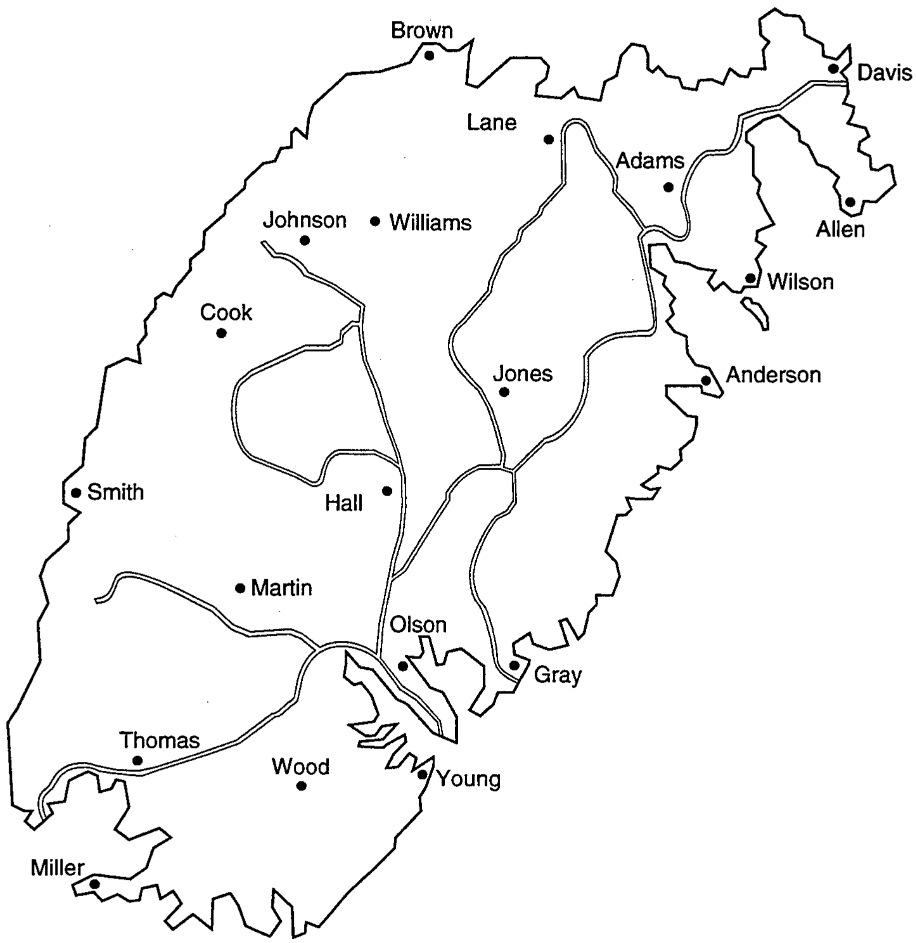
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Young
Miller

APPENDIX C: ENCODING INSTRUCTIONS

ENVELOPE 1

INSTRUCTIONS

Carefully study the map presented in front of you. Try to remember as many of the names and locations as possible. While studying this material, write a description for a friend **making sure you include each name.** Your description should be complete enough that your friend can visually see the same thing you do. Be sure to include as much detail as possible.

Blank sheets of paper are provided for you in this envelope. You will have 20 minutes to write the description.

If you must ask questions, please do not ask them out loud. Raise your hand and I will come to help you individually. If you finish early, sit quietly so that you do not disturb others.

Remember: Study this material carefully and write a description for a friend.

DO NOT TURN THIS PAGE UNTIL TOLD TO DO SO.

N

ENVELOPE 1

INSTRUCTIONS

Carefully study the map presented in front of you. Try to remember as many of the names and locations as possible. While studying this material, write a description for a friend **making sure you include each place.** Your description should be complete enough that your friend can visually see the same thing you do. Be sure to include as much detail as possible.

Blank sheets of paper are provided for you in this envelope. You will have 20 minutes to write the description.

If you must ask questions, please do not ask them out loud. Raise your hand and I will come to help you individually. If you finish early, sit quietly so that you do not disturb others.

Remember: Study this material carefully and write a description for a friend.

DO NOT TURN THIS PAGE UNTIL TOLD TO DO SO.

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APPENDIX D: RECONSTRUCTION INSTRUCTIONS

ENVELOPE 2

INSTRUCTIONS

On the following page you will find an outline of the map you just studied. Your task is to recall the names and show where each name was located on the map. Place an X at the original location of each name. Then, under each X, write the name that appeared at that location on the map you studied. Be sure to include all of the names you can remember.

Remember: Place an X where each name was located and write the name under it.

You will have 10 minutes to complete this task. If you finish early, please sit quietly so that you do not disturb the others.

DO NOT TURN THIS PAGE UNTIL TOLD TO DO SO.

N

ENVELOPE 2

INSTRUCTIONS

On the following page you will find an outline of the map you just studied. Your task is to recall the places and show where each place was located on the map. Place an X at the original location of each place. Then, under each X, write the name that appeared at that location on the map you studied. Be sure to include all of the places you can remember.

Remember: Place an X where each place was located and write the name of the place under it.

You will have 10 minutes to complete this task. If you finish early, please sit quietly so that you do not disturb the others.

DO NOT TURN THIS PAGE UNTIL TOLD TO DO SO.

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APPENDIX E: QUESTIONNAIRE

Questionnaire

Instructions: For each question below, circle one response that best expresses your answer.

1. It was easier for me to remember the names on the map than to remember where they were located.

Strongly Agree	Somewhat Agree	Undecided	Somewhat Disagree	Strongly Disagree

2. This learning activity was difficult for me.

Strongly Agree	Somewhat Agree	Undecided	Somewhat Disagree	Strongly Disagree

3. I needed more time to learn the map.

Strongly Agree	Somewhat Agree	Undecided	Somewhat Disagree	Strongly Disagree

4. I tried hard to do the best I could to learn the map.

Strongly Agree	Somewhat Agree	Undecided	Somewhat Disagree	Strongly Disagree

5. I enjoyed this learning activity.

Strongly Agree	Somewhat Agree	Undecided	Somewhat Disagree	Strongly Disagree

6. The shape of the map reminds me of:
   a. A whale
   b. A genie coming out of a bottle.
   c. Nothing in particular
   d. Other (Please describe here)

For the following questions, write your answer in the space provided.

7. How many times have you studied maps at school during the past year? ____

8. How many times have you used the following kinds of maps in the past year?
   a. City map _____
   b. State map _____
   c. World Map _____
   d. Other Map (Please indicate the kind of map here)

9. How many times have you used a map to find your way to a specific location in the past year? _____

10. Sex: Male Female

    Age: 14 15 16 17 18 19
    Other (please write your age here)

11. Highest grade completed: 8 9 10 11 12