

# The Benefits of Verbal and Spatial Tasks in Contour Map Learning

It has been proposed that the ability to read a map stems from both verbal-analytic and spatial-holistic processes. It has, in turn, been argued that these processes are affected by both spatial ability and gender. This essay presents the results of a study exploring these relationships. Subjects studied a contour map in one of four conditions: a verbal learning group, a spatial learning group, a combined spatial and verbal learning group, and a study-only control group. Contrary to previous reference map learning studies, this study found that the verbal task had no effect upon memory for two-dimensional map information. As predicted, the spatial task did increase memory for three-dimensional map information. In terms of spatial learning instructions, males performed significantly better than females for three-dimensional map information, and females' two-dimensional map memory was better in the non-spatial task groups than in the spatial task groups. There was no effect of spatial ability for map memory. These results suggest limits for the benefit of a verbal learning task in contour map learning.

The cognitive processes involved in map reading and learning are complex and, to date, poorly understood. Previous research has suggested that spatial ability is associated with map reading/learning skills (Kirby and Schofield 1991; Schofield and Kirby 1994; Simutis and Barsam 1983). However, measured spatial ability is a function of subjects' strategies, and in turn have been argued to be associated with gender (Cochran and Wheatley 1989; Allen 1974). A number of studies and theories have pointed to the importance of both verbal and spatial processes in understanding and remembering reference maps (e.g., Kulhavy, Lee, and Caterino 1985). Our purpose in this paper is to examine the effects of verbal and spatial processes, spatial ability, and gender upon performance in contour map reading.

In attempting to discover the strategies that improve map learning, investigators have researched the effects of verbal and spatial processing of map information. It has been shown that the combination of studying a reference map and a related prose passage describing map features leads to enhanced memory for both the map (Shimron 1978; Schwartz and Phillippe 1991) and the prose passage (Abel and Kulhavy 1989; Gilmartin and Patton 1984; Kulhavy, Stock, Peterson, Pridemore, and Klein 1992). These findings support the dual coding theory proposed by Paivio (1986). The dual coding hypothesis states that spatial information, such as map features, and related discourse are stored in separate knowledge codes that complement the encoding and retrieval of one another. Thus, the combination of related spatial and verbal information increases recall probability of either the spatial stimulus or verbal text due to jointly encoded imaginal and verbal representations.

Although the dual coding hypothesis has been supported for reference maps, dual coding may not be beneficial for all types of maps, especially

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## INTRODUCTION

## THE ROLE OF SPATIAL AND VERBAL PROCESSING



contour maps. Given that most contour map reading tasks involve inferring the shape of the terrain, a verbal task may not be an appropriate adjunct to contour map learning. Three-dimensional map features may not be easily verbalized, especially without the use of an extensive and highly technical vocabulary and explicit metric information. Lanca (1992) found that multiple spatial-holistic and verbal-analytical strategies were successfully used to solve a contour map cross-section test (generating a cross-section profile of the map terrain from one point of the contour map to another). However, males, who solved the cross-section test by forming three-dimensional mental representations of the contour maps, achieved higher recognition scores for the contour maps than females, who most likely employed a combination of spatial and verbal processes. These results suggest that an additional spatial, not verbal, task may be most beneficial to learning three-dimensional contour map information and that sex differences and spatial ability may be involved in contour map reading.

#### SPATIAL ABILITY AND MAP LEARNING

It seems plausible that spatial ability is important to contour map learning. Two distinct forms of spatial ability may be involved (e.g., McGee 1979). Spatial relations ability, by which subjects must comprehend the arrangement of elements in a spatial configuration for mental rotation, may be required to retain images of contour map sections and to rotate those images to relate them to other images or objects. In spatial visualization ability, subjects must mentally manipulate spatial stimuli through complex multistep transformations of presented figures; this may be required to transform the two-dimensional map into a three-dimensional image.

Empirical findings suggest that the importance of spatial relations and spatial visualization ability to map reading depends on the map task involved. For example, Schofield and Kirby (1994) found that spatial visualization ability (as measured by the Surface Development test [see Methods section for a description] from the Ekstrom, French, Harman, and Dermen battery [1976]) and verbal ability were good predictors of subjects' ability to locate a position on a contour map, having been shown that position on a three-dimensional model. Card Rotations (see Methods section), a spatial relations measure from the same battery, was not associated with performance on the same test. Lloyd and Steinke (1984) found that spatial relations ability was positively associated with recognition performance for rotated reference maps from previously studied standards. Sholl and Egeth (1982) found neither Cube Comparisons (a spatial relations measure from the Ekstrom, et al. battery) nor the Form Board test (spatial visualization, from the same battery) to be positively related to contour map performance of altitude estimation and terrain analysis. Instead, they found several measures of verbal-analytic ability to be related to performance on the map test. It appears then that both spatial relations and spatial visualization ability can make contributions to contour map learning. The predictors of this association may be the degree of similarity between the spatial ability test and map task and the number of different strategies that can be successfully employed to solve a map task. Verbal ability may also be important to some map tasks.

Spatial ability is in turn related to gender. Many studies have shown males to perform better on some measures of spatial ability than females (for reviews see Linn and Peterson 1985; Maccoby and Jacklin 1974), although the observed differences have been small and exhibited large overlaps (Caplan, MacPherson, and Tobin 1985). Linn and Peterson's (1985) review demonstrated larger sex differences in spatial relations tasks than in spatial visualization tasks. Linn and Peterson also reported

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greater male advantage for complex three-dimensional mental rotation tasks than for two-dimensional tasks. They suggested that females are more likely than males to use a verbal-analytic strategy in spatial tasks (Allen 1974). While this works well in spatial visualization tasks and moderately well in two-dimensional mental rotation, it functions poorly in three-dimensional mental rotation. A verbal-analytic strategy involves encoding the stimulus as a set of discrete parts, which may be labeled verbally, whereas a holistic or spatial strategy requires that the stimulus be encoded as a single entity. This distinction between verbal-analytic and spatial-holistic strategies (or processes) has been made in a number of studies (e.g., Cooper 1976; Kirby and Lawson 1983; Paivio 1986), including map studies. For example, Galea and Kimura (1993) found that females tend to rely upon landmarks in learning a map, whereas males tend to use metric and directional cues. Presumably, the landmarks are more easily verbalized, and the metric and directional cues support spatial-holistic encoding.

Linn and Peterson's conclusions regarding the association between sex differences and spatial ability may also generalize to map tasks. For maps conveying only two-dimensional information, a wide variety of strategies may be successfully employed so that sex differences may not always emerge. Lloyd and Steinke (1984) found that males and females performed equally well in mentally rotating maps to match previously studied maps oriented with north-at-top. Gilmartin and Patton (1984) found a small but significant male advantage in the ability to remember geographic information from studied thematic maps, but this advantage disappeared in a subsequent experiment testing road map reading skills. This may not be the case for maps conveying three-dimensional information, however, where successful map reading strategies may be limited to spatial-holistic processing. Chang and Antes (1987) and Lanca (1992) found that males performed better than females in a topographic map reading task.

The purpose of the present study was to investigate the effects of dual spatial-holistic and verbal-analytic processing upon contour map learning. Specifically, the investigation was intended to explore whether spatial and verbal learning tasks can increase memory for two-dimensional and three-dimensional contour map information. Subjects were asked to study a contour map and complete one of three auxiliary tasks (a spatial, verbal, or combined spatial and verbal task). One-fourth of the subjects were assigned to a control condition in which no additional task was required. Following map study, subjects were tested for their memory of two-dimensional and three-dimensional map information.

It was expected that map learning normally elicits spatial-holistic processing in naive subjects, but that this processing is not very sophisticated in nature. Whereas the dual coding hypothesis predicts that verbal-analytic processing will help map learning, this may not be the case in the present study for three-dimensional map information. Two hypotheses were put forth. First, given that contour maps contain the same two-dimensional information (i.e., place locations, and spatial relations) as reference maps, and that map/prose studies have revealed that dual coding improves reference map memory, it was hypothesized that the verbal task would enhance memory for two-dimensional map information. It was assumed that subjects would disregard the irrelevant contour lines when learning two-dimensional map aspects. The verbal task was not expected to increase memory for three-dimensional map information (such as terrain profiles, relative heights and intervisibility) because

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## PURPOSE AND HYPOTHESES



learning this type of information may require forming a three-dimensional mental representation of the contour map which is difficult given only verbal explanations. Second, it was hypothesized that the spatial task should improve memory for three-dimensional information because it required subjects to mentally visualize the map terrain. Contingent upon the previous two hypotheses being supported, it was believed that the combined spatial and verbal task would produce superior results for both two-dimensional and three-dimensional information.

Previous studies led us to expect that gender and spatial ability would also affect the results. Males should be more adept at spatial-holistic processing, which may emerge as either better memory for three-dimensional spatial information, or better performance when assigned to a spatial task than females. Spatial ability should be positively related to contour map memory; because of the variety of spatial tasks involved, a broadly-based measure of spatial ability was employed, defined by measures of both spatial relations and spatial visualization.

#### METHOD

**Subjects.** Subjects for this study were 80 undergraduate Queen's University student volunteers aged 18 to 25. In attempting to equate prior experience with contour map reading, all subjects were given an introductory tutorial about contour maps (further explanation to follow). To further minimize the potential biases due to formal map training, no geography majors or regular contour map users were tested. Subjects completed two tests of spatial ability. The results of which were used to assign them to one of four experimental groups by stratified random assignment (scores on each test were standardized, the two standard scores were averaged, and subjects were rank ordered on the new variable; the top four students were randomly assigned to groups, then the next four, and so on). The purpose of this procedure was to minimize differences in spatial ability between experimental conditions. Subjects were asked to return for a second session, in which the experimental task was administered; 74 subjects (37 females and 37 males) did so. Three subjects were subsequently eliminated from the analyses because their test scores were two standard deviations below the mean.

**Pre-test Materials.** The two spatial ability tests were Card Rotations and Surface Development (both taken from the Kit of Factor-Referenced Cognitive Tests [Ekstrom, et al. 1976]). Card Rotations is a spatial relations test that requires mental rotation of stimulus figures to compare them to a standard figure and decide if a stimulus is a rotation or a mirror image of the standard. Subjects were given three minutes to complete 80 items. Surface Development is a spatial visualization test in which subjects are required to mentally fold stimuli into three-dimensional objects by matching the edges of the unfolded object to those of a given three-dimensional drawing. Subjects were allowed six minutes to complete 30 items. Scores on each of these tests, which were significantly correlated ( $r = .49$ ), were standardized and averaged to form a composite spatial ability measure.

**Experimental Conditions and Procedure.** Subjects were tested individually or in groups of two to ten. All groups were homogeneous with respect to experimental condition. Subjects were first presented with a brief introduction to contour map reading. Five examples of contour maps (adapted from Simutis and Barsam 1983) were provided in a booklet, each consisting of a simple contour map, a pictorial profile representation of the terrain, and a verbal description of the terrain. The purpose of

*The two spatial ability tests were Card Rotations and Surface Development . . . Card Rotations . . . requires mental rotation . . . Surface Development is matching the edges . . .*

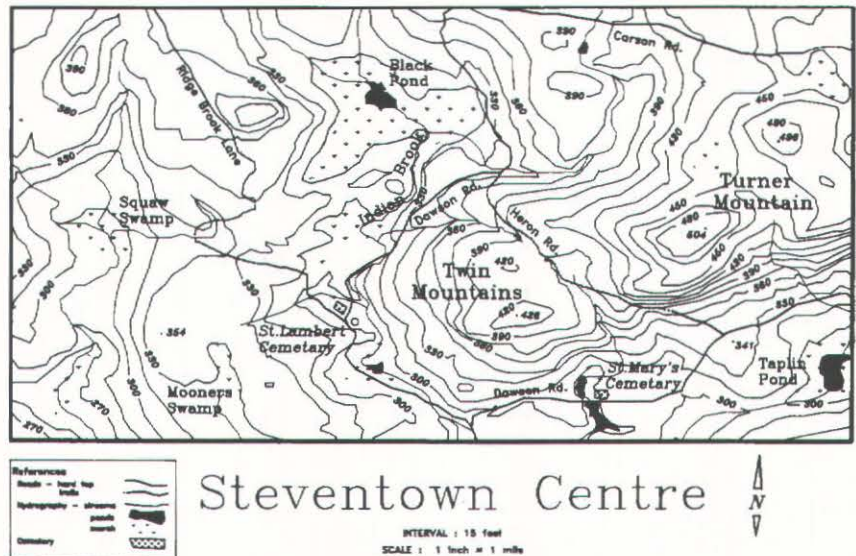


presenting both pictorial profiles and verbal descriptions was to minimize biasing subjects to use one method of learning over the other. Subjects were allowed to study the booklet for as long as they wished before returning it to the experimenter.

In all conditions, subjects were asked to study a 8 1/2 x 11 inch contour map of a fictitious area labeled Steventown Centre (see Figure 1). The map was presented in color; the only differences between the map used and the version shown in Figure 1 were that rivers and ponds were colored blue, roads red, and marshes green. The map had a contour interval of 15 feet, and 1 inch on the map represented 1 mile. All subjects were informed that the purpose of the task was to learn the map as well as possible and that they would later be tested for their memory of the map. Subjects in the control group were asked only to study the map; no guidance was provided about how to do so. Subjects in the other three groups were asked to study the map and to perform a second task at the same time, using the second task as an aid to learning the map. Subjects in each group were given a total of 10 minutes to study the map and, if appropriate, complete the second task. All subjects then performed a 3 minute filler task (completing a questionnaire). This was followed by the post-test. No time restrictions were imposed upon the completion of the post-test.

Subjects in the spatial group answered five questions while studying the map (see Question box on this page). Each question required subjects to sketch a cross-sectional profile view of the terrain (similar to the ones seen in the introductory maps), as it would be seen from a particular point on the map, facing in a given direction. The points and directions were selected in order to cover most of

Figure 1. A Black-and-White version of the contour map (reduced to 46% of its original size).



### Questions

1. Imagine that you are at the point where Ridge Brook lane becomes a trail. You are observing the landscape to the southeast. Sketch a profile of the terrain that you see.
2. Imagine yourself at Squaw Swamp looking north along the river. Draw a profile of the terrain that you see.
3. You are at the northernmost tip of Black Pond and you are facing south-east admiring the landscape. Sketch a profile of the terrain.
4. Imagine you are at Taplin Pond looking north. Sketch a profile of the terrain that you see.
5. Imagine yourself at the highest point of Turner Mountain. Draw a profile of the terrain as you look north-east, then another looking south-west.



### *The Prose Passage*

*Every Labour Day weekend the Cory and the William families reunite for a fishing trip at Black Pond, in the popular Steventown Centre area. Steventown Centre is a very popular retreat area famous for its two main hiking trails: Heron Road trail that cuts through Twin Mountains, and the Ridge Brook Lane trail that is reportedly very scenic.*

*On the Friday before Labour Day weekend the Corys arrive in Steventown Centre from the north-west along Ridge Brook Lane. They park their car at the point where Ridge Brook Lane becomes a trail, and follow the trail south to St. Lambert's Cemetery. The Cory children, Pete and Susie enjoy this part of the hike to Black Pond the most because the terrain is relatively flat and their mother and father always make a detour to show them Squaw Swamp. Squaw Swamp is especially beautiful because of the three large streams which join in the marshy area and also because the entire swamp is populated by many ducks.*

*Once the Cory family arrive at St. Lambert Cemetery, they follow Indian Brook until they reach Black Pond. This is the less popular portion of the trip due to the marshy lands which make walking difficult. However, all is forgotten upon arriving at Black Pond. Being the first family to arrive, it is customary that the Corys prepare dinner for the Williams who usually arrive late in the evening.*

*The Williams family, who are very athletic, always leave on Thursday so that they could spend an extra day windsurfing on Taplin Pond. They arrive in Steventown Centre from the east along Dawson Road eager to begin windsurfing. The high winds from the north from Turner Mountains make Taplin Pond a windsurfing haven. The following day, the Williams get ready for the hike through Twin Mountains towards Black Pond. Beforehand, however, they always drive down Dawson Road to St. Mary's Cemetery whereby they pay respects to Grandma Betty William, leaving flowers by her grave. They drive back up the road to the junction of Heron Road and Dawson Road where they leave their car in an abandoned parking lot. Given the high altitudes of Twin Mountains the hike along the Heron Road trail takes most of the day. Shortly after passing the northern junction of Dawson Road and Heron Road, the Williams always stop for a swim in Indian Brook to cool down and rest for awhile. The children tease their parents about being out of shape, and joke about hiking to the top of Turner Mountain the following year.*

*By the day's end, the Williams reunite with the Corys at Black Pond. The weekend is filled with much fishing, relaxation, and reminiscing of past experiences.*

the map. Sketches were drawn on blank sheets of paper, which were collected before the post-test. It was intended that these cross-sectional sketching questions would require subjects to visualize the terrain in three dimensions. Theoretically, each profile sketch involved translating two-dimensional contour map information to a three-dimensional representation, then mentally rotating the representation from an aerial perspective to a profile perspective. Although subjects were not given feedback on the correctness of their drawings, and the sketches were not assessed for accuracy, the experimenters verified that subjects had drawn profile sketches. It was believed that the exercise itself would enhance terrain shape knowledge, regardless of absolute pictorial accuracy.

Subjects in the verbal group were presented with a prose passage to read while studying the map (see Prose Passage box on this page). The prose passage was designed to reflect a geographically valid verbal description of two families' hiking trip in the area represented by the map. The 500 word narrative described the families' travels through the different areas of the map, making reference to the locations and place names on the map and elaborating upon the nature of the terrain (e.g., river, mountain, marsh). The text was designed to draw attention to important two-dimensional and three-dimensional map elements and provide sequential, narrative associations between elements. Among the locations referred to in the text were those used in the spatial condition as points from which to visualize. Subjects began by studying the map briefly and then reading the passage, referring to the map to locate names of places. Subjects were reminded that they were supposed to study the map in addition to reading the text.



Subjects in the combined group performed a composite of the spatial and verbal tasks while studying the map. They read the same narrative text as the verbal task group and were asked to answer the same five visualization questions as the spatial task group. The questions were embedded meaningfully in the text; for example, when a character in the text reached a given location, subjects were asked to draw the profile that the character would see when facing a given direction.

The post-test assessed knowledge of two-dimensional and three-dimensional information about the map. In the post-test, a version of the map in which all names, rivers, marshes, ponds, heights and contour lines had been removed was presented. Only roads remained, and the capital letters A to Y. The letters were positioned to correspond to features or locations on the original map. The two-dimensional questions concerned the names and locations of map elements within the two-dimensional plane; these questions included "Which letter indicates the location of Taplin Pond?" and "Which two letters represent the peaks of Turner Mountain?" The three-dimensional questions addressed the shape of the terrain; questions included "Which letter indicates the highest peak of Twin Mountains?" and "Would one be able to see P from point F?" For four three-dimensional questions, subjects were asked to select a cross-sectional profile which corresponded to that between two given letters on the map (not the same questions as those used in the spatial exercise). The post-test consisted of ten two-dimensional questions and ten three-dimensional questions. Each answer was scored according to a two point scale; one point was awarded if answers were partially correct (e.g., if one of two locations was correct), and two points were awarded if the answer was completely correct.

Although the two-dimensional and three-dimensional questions were randomized and combined into one test, for the purposes of analyses, the questions were separated to form two tests—named the 2-D test and 3-D test. These tests were not significantly related to each other ( $r = .18$ , n.s.).

Table 1 (page 10) presents the means and standard deviations of the 2-D test and 3-D test for females and males in each group. Contrary to expectation, the addition of a verbal task (combined and verbal groups) did not seem to improve memory for the two-dimensional map information. However, both male and female performance on the 3-D test seemed to be helped by the spatial task. Female performance on the 2-D test seemed to suffer when the spatial task and especially the combined task were conducted.

A four-way between-subjects multivariate analysis of variance (MANOVA) was conducted in which the independent variables were spatial task (participated or not), verbal task (participated or not), subject gender (male or female), and spatial ability (high or low) (see Tabachnick and Fidell 1989 for one description of this analysis). The dependent variables were the 2-D test and the 3-D test. With the use of Wilk's Lambda criterion, the combined dependent variables yielded a significant effect of spatial task ( $F [2, 54] = 4.26$ ,  $p < .05$ ); the interaction between spatial task and subject gender ( $F [2, 54] = 5.01$ ,  $p < .05$ ); and the interaction of spatial task, verbal task, subject gender, and spatial ability ( $F [2, 54] = 3.62$ ,  $p < .05$ ). To investigate the impact of each effect, a four-way between-subjects analysis of variance (ANOVA) was computed for each dependent variable. Post-hoc comparisons were computed, when appropriate, with Spjøtvoll and Seline's modification of the HSD test. This procedure is recommended when there is a small to moderate imbalance of sample sizes.

## POST-TEST

## RESULTS

*Contrary to expectation, the addition of a verbal task (combined and verbal groups) did not seem to improve memory for the two-dimensional map information.*

Condition	Sex	N	2-D Test		3-D Test	
			M	SD	M	SD
Control	Male	9	11.22	2.54	11.11	3.14
	Female	8	12.13	4.94	11.38	2.26
Verbal	Male	9	11.89	3.37	11.33	3.20
	Female	7	12.71	.95	12.14	2.04
Spatial	Male	9	11.11	3.82	13.68	2.87
	Female	10	10.70	3.30	12.50	2.68
Combined	Male	9	13.22	3.83	14.89	1.97
	Female	10	9.90	2.60	11.10	2.23

Table 1: Means and Standard Deviations for Scores on Two-dimensional (2-D) and Three-dimensional (3-D) Spatial Tests for Males and Females within Experimental Conditions.

The additional verbal task, for the verbal and combined groups, did not improve map memory for either 2-D ( $F [1, 55] = .193$ ,  $MSe = 1.96$ , n.s.), or 3-D, ( $F [1, 55] = .136$ ,  $MSe = .975$ , n.s., information; thus, the dual coding hypothesis was not supported. The hypothesis that the spatial task would improve memory for three-dimensional information was supported ( $F [1, 55] = 5.20$ ,  $MSe = 7.16$ ,  $p < .05$ ). Subjects completing the spatial task (those in the spatial and combined groups) ( $M = 12.97$ ) performed significantly better on the 3-D test than subjects not completing the spatial task (subjects in the control and verbal group) ( $M = 11.46$ ).

The hypothesis that males would perform better than females on the 3-D test given spatial training was also supported, [ $F (1, 55) = 7.18$ ,  $MSe = 7.16$ ,  $p < .05$ ]. Figure 2 shows that, of the subjects who completed the spatial task, males ( $M = 14.28$ ) performed significantly better than females ( $M = 11.8$ ) on the 3-D test. Females ( $M = 11.73$ ) performed better than males ( $M = 11.22$ ) in the no spatial task group, but this difference was not significant. The spatial task ( $M = 14.28$ ) also significantly increased male performance in the 3-D test as compared to the non-spatial task ( $M = 11.22$ ).

Figure 3 shows that females performed significantly better on the 2-D test in the non-spatial task groups ( $M = 12.4$ ) than in the spatial task groups ( $M = 10.33$ ) ( $F [1, 55] = 4.47$ ,  $MSe = 10.15$ ,  $p < .05$ ).

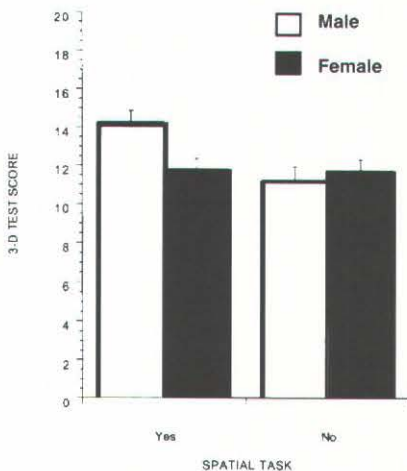


Figure 2. Interaction of spatial task and subject gender on the 3-D test. Bars indicate the standard error of the mean.

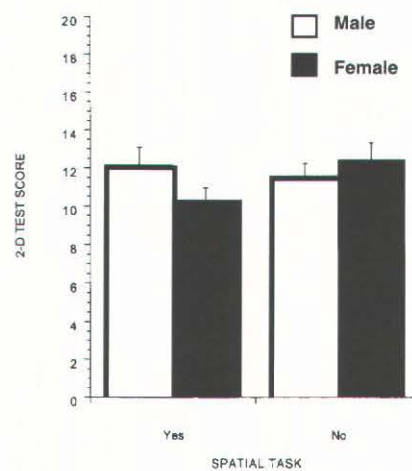


Figure 3. Interaction of spatial task and subject gender on the 2-D test. Bars indicate the standard error of the mean.



Males ( $M = 12.17$ ) performed better than females ( $M = 10.3$ ) on the 2-D test, although this difference was not significant. These results indicate that males benefited from the spatial task for subsequent memory of three-dimensional spatial information but not two-dimensional information. The spatial task was detrimental for female performance in the 2-D test and was no help for the 3-D test. There was no main effect for male superiority for either the 2-D or the 3-D test.

There was a significant interaction between spatial task, verbal task, subject gender, and spatial ability for the 2-D test ( $F [5, 55] = 2.30$ ,  $MSe = 23.033$ ,  $p < .05$ ). However, given the small cell sizes ( $N = 2 - 6$ ), these results are largely uninterpretable.

We advanced two hypotheses regarding the effects of the verbal and spatial tasks: a) the verbal task should significantly improve learning two-dimensional map information but not three-dimensional map information, and b) the spatial task should significantly improve learning three-dimensional map information. Contrary to the first hypothesis, the verbal task did not increase memory for two-dimensional information. It may be that the two-dimensional information in the prose passage did not adequately complement the two-dimensional map information, which, according to the dual coding hypothesis, prevents subjects from forming associative links between the information in the verbal and spatial codes. Alternatively, memory for the two-dimensional information may have been affected by the presence of the contour lines. Research has shown that the interpretative framework of a map (that is, those aspects such as boundaries, coordinate systems, and grids that allow a viewer to place individual features into a spatial context) can be a critical feature in determining what and how much a person remembers from a map (Kulhavy, Schwartz, and Shaha 1982). In the present case, the contour lines may have been given encoding priority, resulting in the two-dimensional features being overlooked or even distorted in memory.<sup>1</sup>

There is some disagreement in the literature regarding the cognitive process of map information acquisition. One view is that, when studying a road map, the routes and paths are learned first; landmarks and locations are learned subsequently and in relation to the encoded paths (Hart and Moore 1973; Garling, Lindberg, and Nilsson 1981). An extension of this theory might predict that contour information would also take precedence over two-dimensional landmark and location information. The alternative proposal is that primary nodes or reference points such as place locations are encoded first; paths are learned afterwards, forming links among known landmarks (Siegal and White 1975; Golledge 1978). In this case, contour lines describing terrain shape would be learned subsequent to location information. Recently, MacEachren (1992) attempted to distinguish between these two views by manipulating the order of map information subjects viewed while studying a map. Results supported the former view; subjects who learned route information and then landmarks performed better for map knowledge than subjects who received the reverse order of information. Thus, in the present study, if the encoding priority was placed on the three-dimensional elevation information and

## VERBAL AND SPATIAL PROCESSING

*There is some disagreement in the literature regarding the cognitive process of map information acquisition*

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<sup>1</sup> Subjects' encoding of place locations may have also been perceptually distorted by the contour lines. Nelson and Chaiklin (1980), among others, found that people tend to misremember dots closer to enclosing boundaries in simple figures. Bryant and Subbiah (1994) found that people can adopt encoding strategies that bias perception of points towards physical and imagined landmarks.



route information before landmark and location information, the verbal task may not have aided learning of 2-D knowledge because subjects may not have had sufficient time to learn terrain shape as it was not extensively explicated in the prose passage.

As expected, the verbal task did not improve memory for three-dimensional information. This is not surprising given that the prose passage, while mentioning three-dimensional map features, focused on sequential, narrative associations between two-dimensional map elements. The prose passage was meant to reflect a geographically valid verbal description of a contour map, which may not have been appropriate for contour map learning. Perhaps, a more elaborate verbal description of the three-dimensional map features with explicit metric information may be needed to enhance 3-D map information.

The second hypothesis was confirmed. The spatial task significantly improved performance on the 3-D test and not on the 2-D test, suggesting that a complementary spatial exercise is beneficial for learning three-dimensional contour map information.

There was no significant support for the advantage of dual processing (represented by the combined group). It is possible that the combined task was too difficult or too long to adequately complete within the allotted time, resulting in competition for resources at encoding rather than memory facilitation.

#### THE ROLE OF SPATIAL ABILITY

No interpretable evidence was found that spatial ability was associated with map learning. This is somewhat surprising, especially given the usual characterization of map learning as a spatial task and given the broadly-based measure of spatial ability used in this study. To ensure that the composite measure of spatial ability was not responsible for the lack of effects, we also performed analyses with Card Rotations and Surface Development as separate independent variables. These analyses (not reported here) also failed to show any significant spatial ability main effects or interactions.

It is possible that the absence of spatial ability effects in this study, and the contradictory findings regarding spatial ability and map learning in the literature, are due to variability of subjects' strategies in spatial tasks (e.g., Kyllonen, Lohman, and Snow 1984). Contour map learning may allow several successful approaches, calling upon different mental abilities and producing an unreliable relationship between particular spatial ability measures and performance. This is consistent with the relative success of the female subjects in the present study when they were not forced to perform the spatial task; in other words, the latter may have interfered with their successful strategy.

#### MALE - FEMALE DIFFERENCES

No general tendency for males to perform better than females was observed; inspection of the means (Table 1, page 10) shows that females attained slightly higher scores in the control and verbal conditions. The lack of an expected overall sex difference on a spatial task is worth noting by itself. As Caplan, et al. (1985) have argued, such effects may be published less often than they are found.

The sex effects attaining significance were the interactions with spatial task. Results indicated that the additional spatial processing, while improving male performance on the 3-D test, had no effect upon female performance and had a detrimental effect for females on the 2-D test. This result may be due to a tendency for females to have less holistic spatial ability, or it may be due to females' preference for verbal (as opposed to spatial-holistic) processing. Ability and preference may also be a function



of experience, suggesting that females may require much more extensive training in spatial-holistic processing.

The purpose of this study was to examine the effects of verbal and spatial processing, spatial ability, and gender upon contour map learning. Contrary to hypotheses derived from dual coding theory, verbal and combined verbal and spatial tasks had little effect upon map memory. Instead, an additional spatial task seems best suited to improve memory for three-dimensional information. Spatial ability was not interpretably related to map memory, but gender was an important factor when subjects were asked to perform an additional spatial task. These results demonstrate limits for the benefit of a verbal learning task and suggest that further spatial training may be most beneficial for contour map learning. Future research should attempt to find out what, if any, verbal descriptions of contour maps can benefit dual processing of contour maps.

#### SUMMARY AND CONCLUSION

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#### AUTHORS' NOTES