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ABSTRACT

A study investigated the effects of a spatial adjunct aid--maps--upon probed comprehension and free recall with respect to a text in which map-related information (macropropositions) could be clearly distinguished from more abstract information (micropropositions). Forty-eight tenth grade students were randomly assigned to either a control group or a map processing group. assigned to either a control group or a map processing group. Approximately half of the students in each group were of average and half above average reading ability. Students in both groups were instructed to read a 775-word story carefully so that they could answer questions about it afterwards. The students in the map processing group were told to complete a map as they read. After reading, students in both groups participated in 10 minutes of filler activities, then were told to write as much of the story as they could remember. Next, they completed a multiple-choice comprehension instrument. Results indicated that the map processing affected text comprehension in several distinct ways. In free recall, it increased overall recall of details and main ideas, but this superiority largely concerned map-related information that by itself was not important for the central meaning of the text. In fact, map processing resulted in a decline in the recall of some abstract macropropositions, particularly for the average readers. In terms of comprehension, map processing resulted in higher scores for inferential questions, but this was largely due to better performance on two spatial questions and was in spite of worse performance on one abstract question. Less able readers did worse on one elaborative inference after map processing. (The map used in the study is appended.) (FL)

Effects of map processing upon text comprehension

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EFFECTS OF MAP PROCESSING UPON TEXT COMPREHENSION

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Considerable research demonstrates that adjunct aids can facilitate text processing. Most adjunct aids are verbal in nature, for example advance organizers or questions. In this study, a spatial organizer was employed, specifically a map. Subjects were randomly assigned to either a control or map processing condition. Both groups read a 775 word story concerned with a religious pilgrimage, the map processing group being required to also complete a partial map relevant to the story. All subjects were then required to produce a free recall of the story, and answer 18 multiple choice questions. Results indicated that map processing subjects recalled more micropropositions and more macropropositions, and answered more inferential questions correctly. Detailed analyses indicated that the map processing group's superiority was mainly in spatial content, and at the expense of some of the more important abstract content. The discussion examines the ways in which maps could affect memory and comprehension, and how they could be used to overcome comprehension problems. Specific issues considered include individual differences in reading abiiity, individual differences in spatial ability, and training in map studying techniques.

Instructional text aids are devices such as organizers, summaries, inserted questions or diagrams which are intended to repeat, explain or elaborate upon information conveyed in the text, and thereby increase comprehension. Whereas these aids are common in expository text, they are seldom used in more narrative text. One of the few exceptions to this rule is the use of geographical maps in certain types of narratives. Presumably in these cases maps are intended to serve the same functions as the other instructional aids. Yet little information exists about how maps are used, how individual differences may contribute to their use or non-use, and how they affect text comprehension.

There are two theoretical views of what the effects of maps should be, which can be termed distraction theory and elaboration theory. Each is based in non-map research, but elaboration theory has subsequently accumulated some map research support.

According to distraction theory, maps would constitute an additional, nonessential amount of learning material; given constant learning time, attention will be diverted from the central material and learning thus lessened. Distraction theory makes considerable intuitive sense when the additional stimulus is irrelevant to the central learning task, but is also supported by a number of studies of the effects of relevant illustrations upon the learning of early readers (e.g. Willows, 1978). These studies show that even relevant illustrations can draw attention away from the verbal material thus lessening comprehension.

Hidi, Baird and Hildyard (1982) demonstrate a similar effect in purely verbal material, in which particularly interesting text segments

drew attention awa' from more important material. Similarly, Reder and Anderson (1980) found that text summaries were more effective for learning than were the original, elaborate and detailed texts.

This could be the case with maps in narrative text, in which the map repeats some text information and embellishes it, but in so doing decreases the attention given to other information in the text, and the details recalled from the map do not allow generation of that other information. If this other information is important, comprehension could be decreased by inclusion of the map. Of course, map-related comprehension should be assisted or at least not hurt.

Elaboration theory would suggest instead that maps would contribute to a rich contextual encoding of the text, providing a schematic framework which should enhance text comprehension. This theory is derived from research such as that concerned with advance organizers (e.g. Ausubel, 1968; Mayer, 1979), and would argue that any instructional aid which directs the encoding of text material should facilitate information retrieval and comprehension. In this way memory for a geographical sequence could act as a cue for retrieval of a text event, which could then be used to guide reconstruction of the story's meaning. Maps and other spatial aids would have the additional advantage of utilizing a nonverbal cue system, decreasing the possibility of overloading the verbal system (cf. Brooks, 1968; Paivio, 1971). Elaboration theory would argue that maps would enhance the comprehension and recall of information unrelated to the maps, by enhancing general text comprehension.

Dean and Kulhavy (1981) investigated the effects of map processing on text learning, and found results supportive of elaboration theory. Their "map processing" subjects were forced to write in missing labels on a map, while reading a narrative text related to the map. These

subjects later recalled more text information than subjects who had either had no map or who had been supplied with a complete map. Dean and Kulhavy found that map processing was more facilitative of recall for their subjects (college students) of lower verbal ability. This was particularly true for the recall of information that could be derived from the map alone. Unfortunately the Dean and Kulhavy study does not provide sufficient information about the text or the comprehension questions which were used in order to determine whether recall was enhanced only for map-related information or whether the effect was more general. Only the latter result would fully support elaboration theory.

In a second study, Schwartz and Kulhavy (1981) attempted to clarify this question by examining free and cued recall of both map-related and map-unrelated information. While their map group did recall considerably more map-related information, results for nonfeatural information were less clear. Overall there was no significant increase (or decrease) in nonfeatural recall for the map group; however, inspection of their Table 1 shows trends for the map group to remember less nonfeatural information than the control group in free recall, but somewhat more than the control group in cued recall. Because no indication is given of the relative importance of the nonfeatural information recalled, it is difficult to assess the effects of the map upon comprehension of the text's central meaning.

The present study was designed to investigate the effects of map processing upon probed comprehension and free recall, with respect to a text in which map-related information could be clearly distinguished from more abstract information. The text was analyzed to determine important units of information (macropropositions, or main ideas), to guide construction of comprehension questions and scoring of free recall

protocols. Comprehension items were of three types (factual, text-constrained inferential, and elaborative-inferential), to determine the extent and generality of any map effect. Furthermore, to investigate individual differences more fully, it was decided to use a sample of high school students who had been selected to be of average or above average reading ability.

Method

Subjects

Fifty grade 10 high school students were randomly assigned to either a control or a map processing group. Approximately half of each group were of average reading ability (stanines 4, 5 and 6 on the Progressive Achievement Test of Reading Comprehension, A.C.E.R., 1970) and half of above average reading ability (stanines 7, 8 and 9). Below average reading ability students were omitted because of likely difficulties in understanding the text. Two subjects were subsequently lost from the map processing group because they were unable to complete the experiment. There were 13 subjects in the Average-Control group, 12 in the Average-Map group, 12 in the Above-Control group, and 11 in the Above-Map group.

Materials

Text. A 775 word story about a religious pilgrimage was constructed. This story described the route taken by a tribe from their homeland to a religious shrine. While a considerable amount of the story described the geographical features that defined the route, an equal amount described the tribe's purpose in travelling, incidents along the way, and requirements for a successful pilgrimage. This story was analyzed to contain 79 micropropositions or idea units, and 18 macropropositions or main ideas.

Of the macropropositions, 9 were spatial and 9 were more abstract in nature.

Questions. Eighteen comprehension questions were written for the story. Six of these questions were factual, addressing information directly stated in the text; 6 were defined as "text-constrained inferential", because they required the combination of separate statements from the text to form an inference; and 6 questions were termed "elaborative-inferential" because they required extrapolation from the text. Each question was either spatial or abstract in nature, spatial ones being defined as those which were map-related and abstract ones being the remainder. Of the factual questions, 2 were spatial; 4 of the text-constrained inferential items were spatial; and all of the elaborative inferences were abstract.

Map. Subjects in the map processing group were supplied with the map shown in Figure 1, on a separate sheet of paper. The map was missing nine labels which corresponded to major features mentioned in the story.

Procedure

Control and map processing groups were tested separately in vacant classrooms. Each group was instructed to read the story carefully, in order to be able to answer questions about it afterwards. Map processing subjects were requested to fill in the missing labels on the map as they read the story. (Subsequent inspection of the completed maps showed that all subjects had done this correctly). Ten minutes were provided for the reading of the text, which also included map completion time for the map processing group. When the study time was over, all materials were collected. Subjects then engaged in 10 minutes of filler activity.

After that, blank sheets of paper were distributed, and subjects asked to write as much about the story as they could remember. Ten minutes were allowed for this free recall, which was sufficient for all subjects. Then the free recall protocols were collected and the multiple choice comprehension questions were distributed. Again 10 minutes were allowed for completion of these questions, sufficient time for all subjects.

Results

A series of 2 (Group) x 2 (Reading Ability) analyses of variance were performed, the dependent variables being the total number of micropropositions recalled, the total number of macropropositions recalled, total number of spatial and abstract macropropositions recalled, individual macropropositions recalled, the number of questions answered correctly (total, factual, text-constrained inferential, and elaborative-inferential), and individual questions answered correctly.

Free Recall Measures

Free recall means are shown in Table 1. Subjects in the map processing group recalled more micropropositions, $F(1,44) = 4.31$, $p<.05$, and more macropropositions, $F(1,44) = 7.86$, $p<.01$, than those in the control group. These analyses also yielded significant reading ability effects, in favor of the better readers; for micropropositions $F(1,44) = 6.95$, $p<.05$, for macropropositions $F(1,44) = 5.38$, $p<.05$. When macropropositions were divided into spatial and abstract groups, map processing subjects recalled more spatial macropropositions, $F(1,44) = 35.76$, $p<.0001$; for abstract macropropositions, the better readers recalled more, $F(1,44) = 4.93$, $p<.05$, but the group effect was not significant, $F(1,44) = 2.25$, $p<.15$. These effects are illustrated in Figures 2 and 3. Although Figure 3 appears to show an interaction, with average readers recalling fewer

abstract macropropositions after map processing, this effect is not significant, $F(1,44) = 1.26$, $p>.2$.

Each of the 18 macropropositions was also analyzed separately, to provide more specific information about the source of these effects. Of the nine spatial macropropositions, five yielded significant group effects in favor of the map processing group. Two others showed interactions, one indicating that only above average readers improved after map processing, the other that only average readers improved after map processing. These results are convincing evidence that map processing produces increased recall of spatial information.

For the abstract macropropositions, there was only one reading ability effect, in favor of the better readers. Two group effects showed lower performance for map processing subjects, and for one of these there was a tendency ($p<.07$) for the less able readers to decline more. (This latter proposition concerned the purpose of the tribe's journey). These results demonstrate no elaborative effect of map processing, in that map subjects do not recall more abstract propositions. Although not consistent, if anything there was a tendency for map subjects, especially the less able readers, to recall fewer abstract propositions after map processing.

Multiple Choice Questions

Mean scores for these variables are presented in Table 2. Above average readers answered more questions correctly than did the average readers, $F(1,44) = 12.01$, $p<.01$. When the questions were divided into the three categories, this effect was only significant for the factual, $F(1,44) = 4.95$, $p<.05$, and elaborative-inferential questions, $F(1,44) = 6.31$, $p<.05$. Map processing subjects answered more text-constrained inferences correctly, $F(1,44) = 4.05$, $p = .05$.

When the questions were analyzed separately, reading ability effects were found for two factual questions and one text-constrained inference, all of which tapped spatial content; better readers in each case obtained higher scores. Three group effects were found, each for a text-constrained inference. For the two spatial questions, map subjects answered more correctly than control subjects; for the abstract question, map subjects were less often correct than control subjects. Two group-ability interactions were also found. For an abstract factual question, there were reading ability differences in the control condition, but not in the map condition. For an abstract elaborative-inferential question which concerned the purpose of the tribe's journey, this effect was reversed: the ability groups did not differ in the control condition, but the better readers were more likely to be correct in the map condition.

Performance on the comprehension questions was less affected by map processing than was free recall. Map subjects did do better on two of the four spatial text-constrained inferences, and the less able readers improved in the map condition for one factual question. Map subjects performed worse on one of two abstract text-constrained inferences, and the less able readers did worse on one important elaborative inference in the map condition. Again these results demonstrate greater comprehension of spatial information after map processing, but no elaborative effect upon abstract comprehension. A tendency was observed for map processing subjects, particularly the less able readers, to answer important abstract questions less correctly.

Discussion

The results of this study have shown that map processing affects text comprehension in several distinct ways. In free recall, map processing increased overall recall of details and main ideas, but this superiority largely concerned map-related information that by itself was not important for the central meaning of the text. In fact, map processing resulted in a decline in the recall of some abstract macropropositions, particularly for the less able (average) readers. The free recall results support the distraction theory described in the beginning of this paper, and often no evidence in favor of elaboration theory.

The results for the comprehension questions were less clear-cut. Map processing resulted in higher scores for text-constrained inferences, but this was largely due to better performance on two spatial questions and was in spite of worse performance on one abstract question. The less able readers performed worse on one elaborative inference after map processing. These results can be interpreted either as weakly supporting distraction theory, or as supporting neither distraction nor elaboration theory.

Considering both forms of comprehension assessment, distraction theory would seem to be favored. An alternative interpretation could be that map processing did not affect comprehension or memory at all, but rather that it did affect the process of recall, by focussing subjects' attention on their memories for more spatial information. While the results for several specific comprehension questions suggest that there were memory differences between the two groups of subjects, it is possible that recall-focussing occurred as well. Even if there were no initial memory differences, the effects of retroactive recall-focussing should eventually produce memory differences, as details which are perceived

as less important fade with time. In the practical case of students' studying of a text, the perception of the map information as important would lead to increased attention to this information after initial encoding, and thus ultimately to poorer recall of abstract information.

How Maps Affect Comprehension

The text employed in this study was designed so that the spatial and abstract information were relatively separate, given the constraints of a coherent narrative. Thus it was possible to show an increase in map-related learning and independently assess whether there was any general facilitation of comprehension. Results indicated clearly that map processing did have an effect, but that there was no general facilitation of comprehension. Clearly different results would be predicted if there were closer relations between the spatial and abstract information of the text employed.

This issue really concerns the relationship between micropropositions and macropropositions. As Reder and Anderson (1980) point out, some theories of text structure argue that micropropositions (details) are subordinate to macropropositions; the latter can be used to access details, but a detail will not lead to a macroproposition with any certainty. The degree to which a detail can access a macroproposition should depend upon the relative importance of the detail, in other words, the centrality of that detail for the macroproposition. For example, if the macroproposition were "Half the tribe died of thirst in the desert", the detail "They came to a desert" may well access the macroproposition, while the detail "They wore long coats" wouldn't. By this argument maps will only have an elaborative effect in particular circumstances, and only in relatively narrow ways. What needs to be assessed is not whether map processing

in general facilitates comprehension, but rather whether recall of a specific map detail helps in the reconstruction of an otherwise absent abstract macroproposition.

In the more general situation, maps can at best be expected to increase the microstructural base of information that subjects possess, though this may be at the expense of crucial abstract macropropositions. Thus in free recall, map processing subjects would be at a disadvantage, due to the lack of extra cues pointing towards missing macropropositions. This would account for the free recall results of this study, and those of Schwartz and Kulhavy (1981) who found a (nonsignificant) decrease in free recall for map subjects.

For map subjects to attain abstract performance equal to that of control subjects, extra cues would be required. To some degree this situation exists in probed recall (Schwartz & Kulhavy, 1981) or in multiple choice questions (this study). Thus it is not surprising that map subjects did not score very differently from control subjects in this study. Perhaps map subjects could have scored even better than control subjects on abstract questions, if the questions had been designed to provide more cues. This may be what happened in Schwartz and Kulhavy's (1981) probed recall task, thus leading to a (nonsignificant) superiority for map subjects on nonfeatural questions.

Individual Differences in Text Comprehension

While it would not be surprising to find free recall differences between good and poor readers, these should be less likely at the level of macrostructural recall. Presumably if a text is within the subjects' reading abilities and is reasonably straightforward, then all subjects should recall most of the main ideas of the text (e.g. van Dijk, 1979). However, it is likely that good and poor readers would differ with respect

to their recall of details. For example, Beck, Perfetti and McKeown (1982) found that subjects given intensive vocabularly instruction recalled more noncentral information from a text than did control subjects, but not more central information.

Theories of text comprehension might account for these results in terms of working memory differences between good and poor readers (Kintsch & van Dijk, 1978; Miller & Kintsch, 1980). The probability of a detail's recall would be a function of the number of times, or the amount of time, it had been in working memory. If better readers have more available working memory space in reading (Daneman & Carpenter, 1980), and if there is a threshold of working memory activation required for recall, then good readers should recall more details than poor readers. While this may not provide any advantage in determining the main ideas of the relatively simple texts often studied in text comprehension experiments, it would be very helpful in the more complex and less well-structured texts encountered in the real world (such as the text employed in the present study).

If map processing can increase the micropropositional knowledge base, which occurred for both average and above average readers in this study (cf. Table 1), then it could be a first step in improving the text comprehension of poorer readers. For success, however, the extra micropropositions recalled would have to lead to access of the relevant macropropositions. Thus instructional aids would have to be designed to prime key details, selected because of their strong connections to frequently omitted central ideas. This approach to improving comprehension would contrast with that which suggests the provision of higher-level text aids, such as advance organizers (Kirby & Cantwell, 1984; Mayer, 1979).

How Map Processing Works

An important step in understanding whether and how map processing facilitates comprehension is to understand how subjects process the information contained in a map, and how that information is related in memory to verbal text information. This is a step which appears to have eluded current map research in text processing, perhaps because our theories of memory and cognition are more suited to verbal, or at least verbalizable information.

It is probable, for instance, that subjects differ greatly in their competence in studying a map (see Thorndyke & Stasz, 1980). A subject who examined the overall structure of maps during map processing would be expected to know more about the map than would a subject who merely looked for the next blank to fill in. Before the effect of map processing can be accurately assessed, it may be necessary to instruct subjects in how to process a map. For example, imagery or visualization training may improve map learning by directing subjects toward a better information processing strategy. Individual differences in spatial abilities may limit the degree to which some subjects can benefit from map processing.

Conclusion

This study has shown that map processing can affect text comprehension, but that this is due to the recall of spatial information and may be at the expense of more central abstract information. Accordingly some caution should be exercised in employing map-like illustrations in text. However such instructional aids do have some promise in contributing to improved comprehension if they are carefully designed to emphasize crucial information, and if subjects are trained in their use. An important task for future research is to determine how skilled subjects learn from maps, in order to guide the training of the less skilled.

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Table 1

Mean Number of Propositions Recalled

Variable	Control Group		Map processing Group	
	Average Readers	Above Average Readers	Average Readers	Above Average Readers
Micropropositions (total)	14.46	19.75	18.83	22.18
Macropropositions (spatial)	1.46	2.50	4.58	4.64
Macropropositions (abstract)	4.38	5.08	3.33	4.73
Macropropositions (total)	5.84	7.58	7.92	9.36

Table 2

Mean Number of Questions Answered Correctly

Variable	Control Group		Map Processing Group	
	Average Readers	Above Average Readers	Average Readers	Above Average Readers
Factual	3.15	4.42	3.75	4.00
Text-constrained inferential	3.08	3.58	3.75	4.27
Elaborative-inferential	4.23	4.58	3.83	4.55
Total	10.46	12.58	11.33	12.82

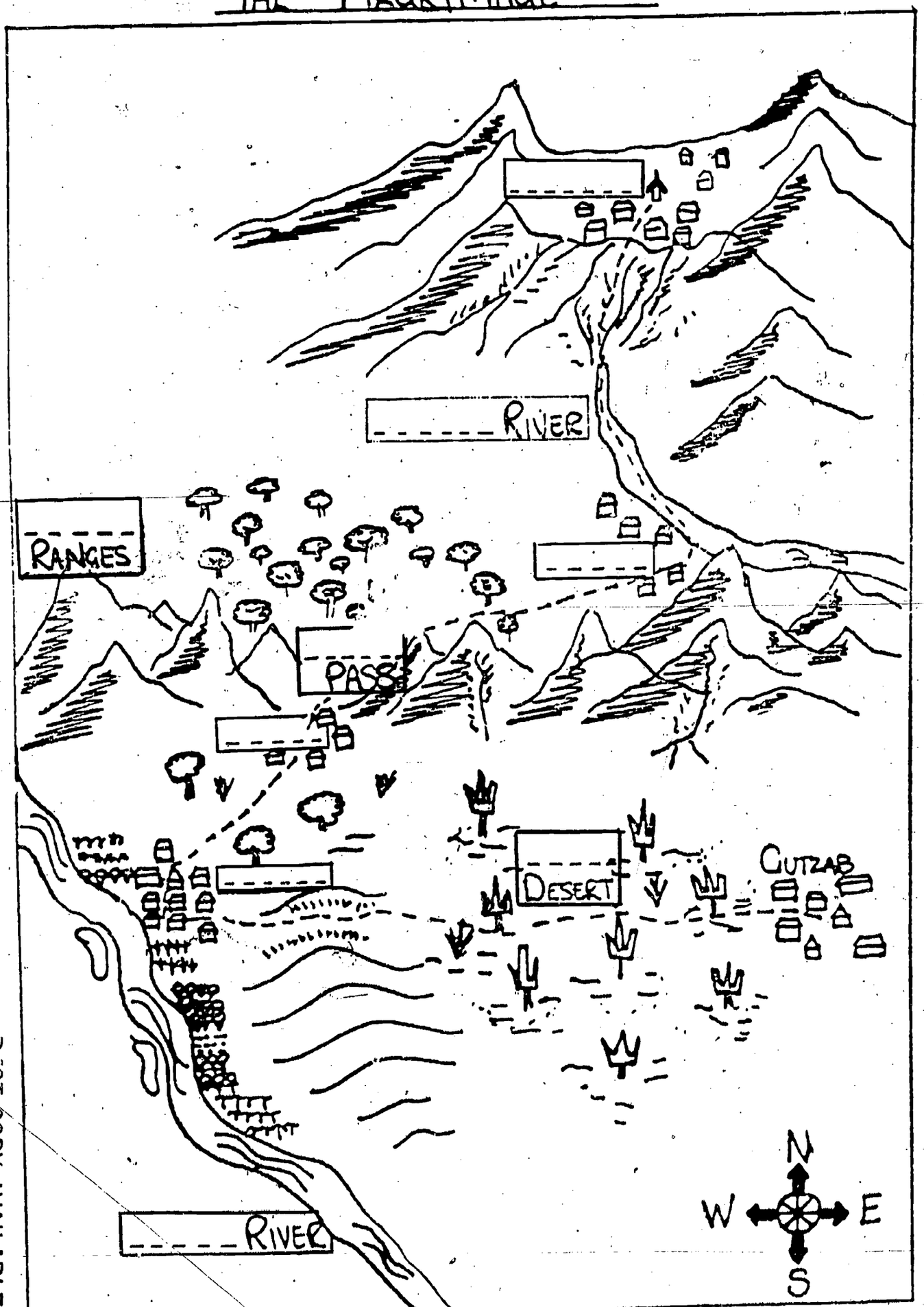
Figure Captions

Figure 1. Map used in map processing condition.

Figure 2. Mean number of spatial macropropositions recalled by subjects.

Figure 3. Mean number of abstract macropropositions recalled by subjects.

"THE PILGRIMAGE"



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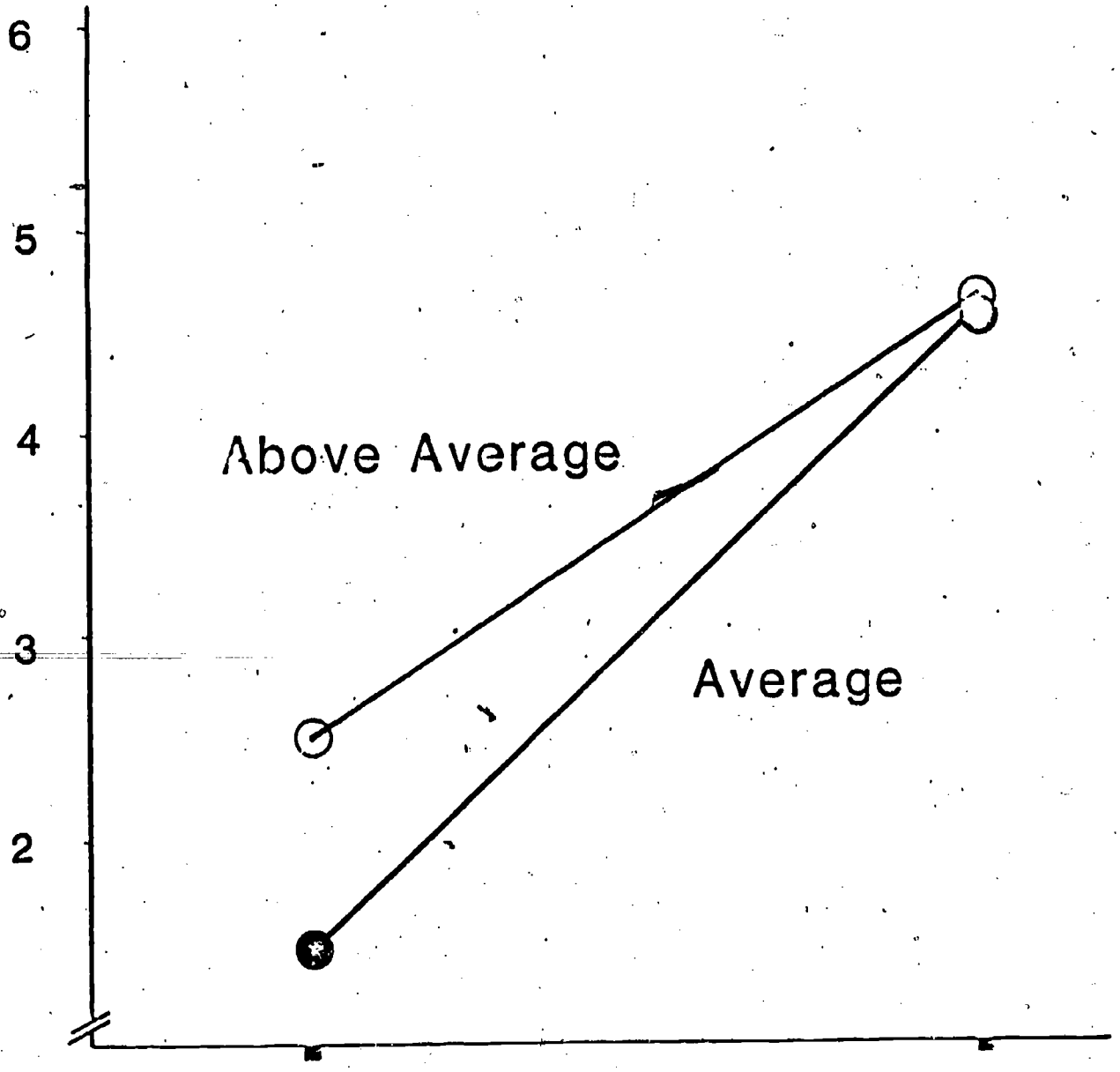

ABSTRACT