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ROUTE LEARNING IN A COMPUTER GAME [1]

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Summary.—The present experiment was conducted to find out whether 20 male and 20 female undergraduates made more errors if their previously learned route were reversed. The results confirmed this expectation, that is, subjects made significantly more errors when they were tested on a reverse route than subjects given the original route. Results were discussed with reference to conceptualization as a "map in the head" and implications for other research were noted.

The term *cognitive map* is generally used to describe the mental representations of spatial environments. The history of research about cognitive maps began very early (Townbridge, 1913; cited by Baird & Wagner, 1983). Tolman (1948) showed some evidence about rats' use of cognitive maps. However, Lynch's well-known book *The Image of the City* (1960) has been considered a milestone of research on cognitive mapping in which both psychologists and geographers began to study mental representations of spatial environments. Although studies of mental maps have been done for more than 40 years, we still know little about how mental maps are formed, stored, and retrieved.

Cognitive maps are believed to include five key features, paths (routes), path intersections (nodes), landmarks, districts, and boundaries (edges); see Evans (1980). These features are the ones that may exist in any map. Are cognitive maps really maps? This question has received considerable attention from researchers. For example, Attneave (1983) argued that "Now, it is entirely possible that a cognitive map is not stored *as* a map in long term memory, but rather in some digital or propositional form . . ." (p. 361; emphasis original). What is propositional in cognitive maps may be the information about the route because routes contain information about order. In other words, routes indicate the *relations* among different scenes in the environment. Therefore, any manipulation that affects route information would tap the propositional code (see Talasli, 1990) and thus, were Attneave (1983) right, route manipulation would affect performance of cognitive mapping.

Although individuals do make almost no errors in real environments when going from one place to another, when they are asked to draw two-di-

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mensional maps, they make errors. Therefore I agree with Kuipers (1982, 1983) that two-dimensional analog structure is not sufficient to explain the mental representations of spatial environments. He replaced the "Map in the Head" with "Atlas in the Head" conceptualization, indicating a huge atlas consisting of many maps on separate sheets but in a unified structure. He also maintained the idea that, since cognitive representations of spatial environments are not two-dimensional, a route can be followed in one direction but not in the other (Kuipers, 1982).

The major purpose of the experiment, then, was to test the argument of Kuipers (1982) and find out whether there would be any problems in route learning when the subjects were asked to remember the route from the last point to the first. If cognitive maps are actually two-dimensional maps, there should be no difference between the number of errors made by subjects in route condition and subjects in reverse-route condition. To avoid the confounding variables from direct experience, a computer game was used in the present experiment.

Method

Subjects

Twenty male and 20 female university students were randomly assigned to four experimental groups. The subjects' average age was 21.4 yr. (SD = 1.72). Two initial subjects (1 male and 1 female) were replaced with two different ones (again 1 male and 1 female) because the man was not suitable for the experimental procedures (he showed an extremely low ability to follow the instructions), and the woman was suspicious about the purpose of the experiment.

Instruments

An Amiga 500 computer connected with a Commodore 1084 monitor, and a Quickshot II Turbo joystick was used as the experimental apparatus. The experiment was carried out by using a computer game called Escape from Colditz (© Gibson Games) which was stored on a Maxell MF2-DD floppy disk.

Procedure

The game was about the story of four men who were in a prison made up of a number of prison cells and a garden. The cell of the fourth man was taken as one of the starting landmarks and the other starting landmark was the garden. This choice was dependent upon a pilot study in which subjects had indicated the fourth-cell-to-garden route as "moderately" difficult. There were seven *separate* scenes on the route between the cell and the garden, and it took about 15 seconds to move from one starting point to another without any errors.

On training trials, subjects were shown one of the two situations. In the first, the four prisoners were in the same cell, and the experimenter took three of them individually to the garden following the same route. To counterbalance the direction a second group of subjects were allowed to see four prisoners in the garden, and again the experimenter took three of them individually to the same cell following the same route. Therefore, there were two conditions of direction, cell-to-garden and garden-to-cell.

A second trained experimenter [2] who was unaware of the purpose of the study used the joystick to move prisoners to the direction in which subjects wanted to go. Subjects were not allowed to use the joystick because the ability to use the joystick properly would have confounded the data. Also, trying to use the joystick might have interfered with the subject's task. For each scene, there were alternative doors (1 to 4) to be chosen, but only one of the doors was correct. After making a mistake, a subject began from the starting point again. Subjects could use 10 trials at most. If they could not find the correct route in 10 trials, then the experiment was terminated for that subject.

The dependent variable was the number of errors subjects made on the test trial. Subjects were also asked whether they had played computer games and whether they had played a game like Escape from Colditz.

Results

A 2(route) × 2(direction) × 2(sex) analysis of variance indicated that subjects in the reverse-route condition made significantly more errors than those subjects in the route condition ($F_{1,38}=41.31$, $p<.0001$); cf. Table 1. Main effects for direction and sex were not significant ($p=.05$); however, there was significant interaction of direction by sex ($F_{1,38}=6.25$, $p<.02$). Further, one-way contrast analyses, performed to clarify this interaction, showed that men whose task was to direct a prisoner from the garden to the cell made significantly more errors than the men who took a prisoner from the cell to the garden ($t=-2.15$, $p<.05$). There were no differences among women or between men and women.

TABLE 1
Mean Number of Errors and Standard Deviations as a Function of Direction and Route

Direction		Condition			
		Route		Reverse Route	
		M	*SD*	*M*	*SD*
Garden to Cell	Men	1.40	1.14	7.00	1.14
	Women	1.20	1.64	3.80	2.17
Cell to Garden	Men	0.20	0.45	3.20	1.30
	Women	1.20	1.30	4.40	2.51

[2]I thank Hülya Kökdemir for her participation as the second experimenter.

Reports of experience with computer games were not analyzed because all the subjects who had played computer games were not heavy users of computers. All of them indicated that they had played computer games only once or twice.

Discussion

As expected, subjects in the reverse-route condition made more errors than those in the route condition. This result can be seen as evidence for Kuipers' (1982) idea that cognitive maps are different from the two-dimensional sketch maps because in a sketch map there would be no difficulty in taking the same route from one direction or from another.

Further, by manipulating the route information, this experiment altered information about the relation of different scenes obtained by propositional codes. This might also be a potential factor underlying the increased number of errors in the reverse route condition; however, it should be noted that this experiment tapped short-term rather than long-term memory, so this experiment showed the importance of propositional codes in short-term memory, not just in long-term memory as reported by Attneave (1983).

It was observed that on entering a wrong cell, subjects immediately realized the choice was wrong. It was apparent that these subjects did not fail to use analog codes, instead, they checked the way they followed by comparing the cell on the screen and what they remembered (the cell in the head). Subjects in the reverse-route condition did not make appropriate use of the propositional codes because they should have reversed the sequence information to finish the task successfully. We can conclude that, when the information obtained from the propositional codes was altered, subjects did not adapt a new propositional structure in short-term memory.

The interaction between direction of route and sex was evident only for men, that is, men made more errors when they were taking the prisoner to the garden but not from the garden to the cell. When the number of available doors was considered, there were nine (3, 4, and 2) alternative doors in the first three scenes following the cell but six (2, 2, and 2) doors in the first three scenes following the garden. Therefore, when the subject took the prisoner to the garden, he first had to tackle more alternative doors and so made more errors. Since subjects first tried to deal with the longer number of alternatives, their memory for the next sequence would be less accurate. Although this explanation seems plausible, it is still not clear why men but not women were affected by the unequal distribution of doors per scene.

This experiment yielded some useful information about the conceptualization of a "Map in the Head," and the results indicated that cognitive maps *may not* contain map-like qualities. There were some problems in this experiment, however; for example, the game used in this study was not de-

veloped for such an experiment and the selection of routes, speed of screen change, colors used, and other game qualities were those in the originally constructed game rather than under the control of the experimenter. Researchers should investigate map-like qualities of cognitive maps under more controlled circumstances and examine the place of analog and propositional codes in the mental representation of spatial environments.

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