Effects of viewing angle on performance of wayfinding and cognitive-map acquisition

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Abstract

Effects of different viewing angle, namely an oblique-angle view and a straight-angle view, on performance of wayfinding and acquisition of cognitive map was investigated in virtual environment. It was found that performance of wayfinding is significantly better with oblique-angle viewing condition than with straight-angle viewing condition. On the contrary, quality of acquired cognitive map was significantly better with straight-angle viewing. It suggests that contents of visual field during exploration has different effect on two aspects of environmental learning.

Key words: Wayfinding, Cognitive map, Oblique-view display, In-vehicle route guidance system

1. Introduction

When we find a way in an environment, we use both an egocentric information and an exocentric information. The egocentric information for wayfinding is a real-time change of sight from our own point of view. The exocentric information for wayfinding is a mental representation of the environment. The exocentric representation is also entitled as a cognitive map, since it is supposed to be like a map of the environment.

It is believed that we learn the exocentric representation of an environment by integrating egocentric views that are perceived while exploring the environment (Weisman, 1981; Passini and Proulx, 1988). A Landmark-Route-Survey Map model (LRS model) is the most well-accepted model for describing how the exocentric representation of environment is acquired from the egocentric information (Siegel and White, 1975; Thorndyke and Hayes-Roth, 1982).

When we encounter an unfamiliar environment at the first time, we acquire descriptive information about a few landmarks (Landmark stage). Then, by using these landmarks as markers, we develop information about specific route (Route stage). This information is a set of paths and turns to reach a specific destination. Finally, we learn cognitive map, or survey map, of the environment and are able to take, for example, a short cut easily (Survey Map stage). Therefore, final understanding of a real-world environment is achieved by acquisition of cognitive map of the environment. It has been assumed that these representations are acquired successively as we have more experience in the

environment.

In the real world, however, we not only develop the exocentric representation of the environment from the egocentric views through exploration, but also have access to plenty of artificial information such as a road map and a in-vehicle route guidance system. Therefore it is practically more important to understand effects of these artificial information on wayfinding and acquisition of cognitive map.

A semi-bird's eye display with oblique-angle viewing becomes so popular in the in-vehicle route guidance system. The oblique-view display has been introduced to facilitate wayfinding in unfamiliar environment. However, effects of the oblique-view display on acquisition of cognitive map have not been thoroughly investigated. Since the oblique-view display makes wayfinding easier, it could disrupt learning process of cognitive map. In this research, we investigated effects of viewing angle during exploration of the environment on performance of wayfinding and on acquisition of cognitive map in virtual environment.

2. Experiment

Method

A real-world environment was simulated by a maze with a hexagonal layout in a virtual environment. Landmark illustrated by different color or numeral was placed at each corner of intersections in the maze. There were two sizes of virtual maze. The small maze, of which example is shown in Figure 1, had five intersections. The large maze had seven intersections.

The egocentric view of observers was transformed according to their location in the maze. There were two viewing conditions: straight-angle viewing and oblique-angle viewing conditions. Egocentric view with straight viewing angle at an intersection is depicted in Figure 2. Only landmarks at the immediate intersection were visible. Egocentric view with oblique viewing angle at an intersection is depicted in Figure 3. Landmarks at other intersections as well as at the immediate intersection were visible.

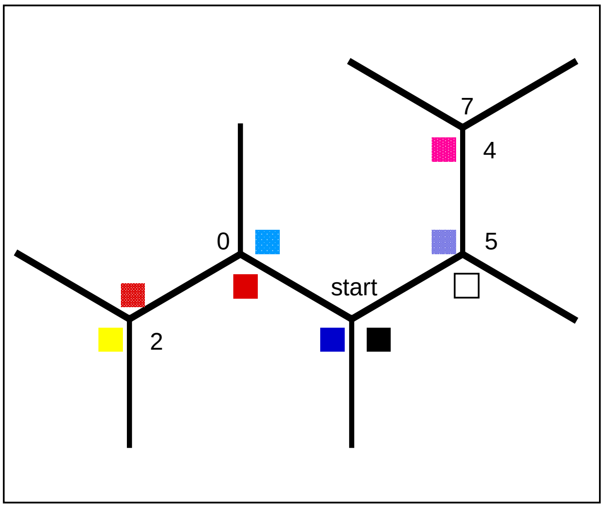

Figure 1 Top view of the virtual maze

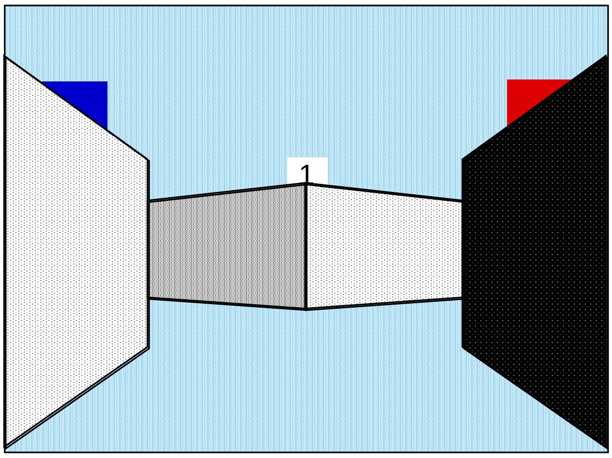

Figure 2 Egocentric view of the virtual maze with straight viewing angle

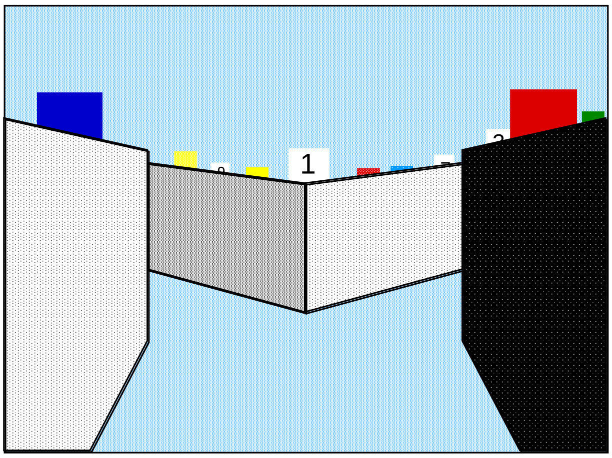

Figure 3 Observer's egocentric view of the virtual maze with oblique viewing angle

The virtual maze was created by a real-time graphical simulation application (WalkThrough Pro, Virtus) on a personal computer and was presented on a 21" computer monitor.

Procedure

Observers explored the maze consecutively by following instruction of the experimenter who verbally directed color or symbol of a landmark to which observers found a way to reach. Immediately after observers reached the landmark, color or symbol of next landmark was instructed. Time to spend for wayfinding from the start to the final landmark was measured.

After observers reached the final landmark, they were asked to draw cognitive map of the virtual maze that they acquired during exploration. The quality of drawn cognitive map was assessed by number of correct landmarks and streets in the drawn map.

Five kinds of maze with the same shape and with different disposition of landmarks were presented. There were twenty trials, namely two sizes of maze, two viewing conditions and five kinds of maze. Sequence of twenty trials was in random order. Fourteen undergraduate students participated as an observer.

3. Results

Time to spend for wayfinding from the start to the final landmark did not vary systematically for five mazes with the same size and viewing condition. Since there was no significant difference among observers neither, data were averaged among observers for each condition.

Averaged time to spend for wayfinding are shown with standard error in Figure 4. Each column shows value for two sizes of maze and for two kinds of viewing angle. Time for wayfinding was shorter with oblique-angle viewing than with straight- angle viewing for both sizes of maze.

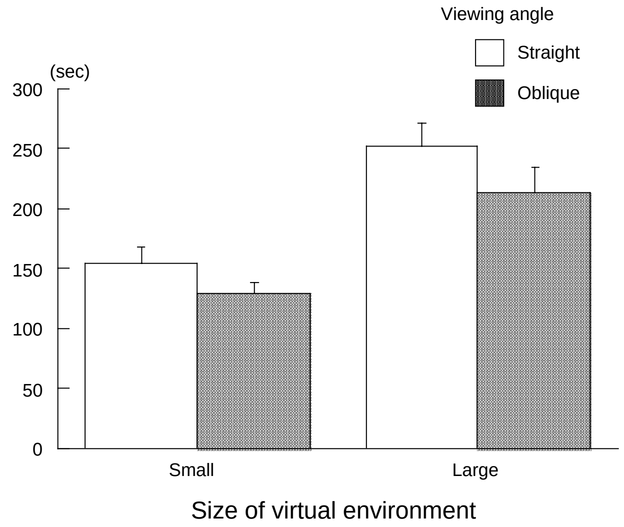

Figure 4 Averaged time to spend for wayfinding

There were statistically significant effects of viewing angle and of size of maze on time to spend for wayfinding. Since it is trivial to take more time for wayfinding in larger maze, the result means that performance of wayfinding is significantly better with oblique-angle viewing condition than with straight-angle viewing condition for both sizes of virtual maze.

Percent correct of cognitive map drawn by observers did not vary systematically for five mazes with the same condition. Since there was no significant difference among observers neither, data were averaged among observers for each condition.

Averaged percent correct of cognitive map are shown with standard error in Figure 5. Each column shows value for two sizes of maze and for two kinds of viewing angle. The quality of acquired cognitive map was better with straight-angle viewing than with oblique-angle viewing for both sizes of maze.

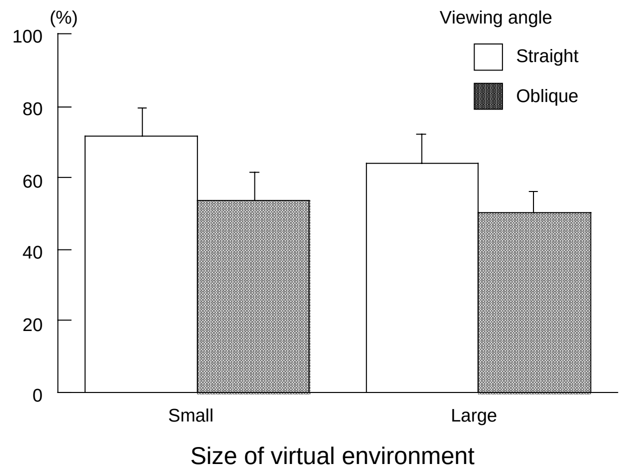

Figure 5 Averaged percent correct of cognitive map

There was statistically significant effect of viewing angle on percent correct of acquired cognitive map. The result means that, on the contrary to performance of wayfinding, observers acquired significantly better cognitive map of virtual maze with straight-angle viewing condition than with oblique-angle viewing condition for both sizes of virtual environment.

Since it took more time for wayfinding with straight-angle viewing condition, it might be argued that improvement of quality of cognitive map was due to longer exploring time. However, quality of each cognitive map drawn by observer after seventy trials with longer exploration time was not significantly different from that drawn after seventy trials with shorter exploration for both small and large mazes. Therefore, it is more likely that better cognitive map is acquired by exploring environment with straight-angle viewing rather than by spending more time in environment.

4. Discussion

It is concluded from the results that contents of visual field to be presented during exploration of new environment has different effect on two indispensable aspects of environmental understanding. It is rather surprising that acquisition of cognitive map is not improved by presenting more visual contents by oblique-angle viewing, even though performance of wayfinding is facilitated. Gillner and Mallot (1998) reported similar effects of amount of visual contents on acquisition of cognitive map. Their account that the amount of knowledge acquired was determined not by its availability but by the different needs in the task would explain our unexpected results.

On the other hand, the process for developing exocentric representation of environment from temporally changing egocentric information requires information about observer's orientation. Orientation could be obtained through sensation of self-motion (Asakura, Ohmi & Suzuki, 1999) or by information about observer's relation with landmarks and heading (Ohmi, 1999). Less contents in straight-angle viewing condition would force observer to remember spatial relationship among intersections of maze more carefully. Therefore, sense of orientation could be facilitated more in straight-angle viewing condition.

It has been reported that people can be grouped by a preference of environmental representation (Ohmi, 1998). Almost half of people prefer a route representation and memorize environment as a set of paths and turns from a start to a destination. Other half of people prefer a survey map representation and memorize environment as a map. Although it was reported the performance of wayfinding was not significantly different for both groups, results of this research suggest that acquisition of cognitive map could be different between these two groups.

In order to investigate individual differences among observers, they were asked after experiment which viewing angle they preferred for wayfinding task and for cognitive map task. Not surprisingly, all observers reported that they preferred oblique-angle view for wayfinding task. On the other hand, for cognitive map task nine observers reported that they preferred straight-angle view and five observers reported they preferred oblique-angle view.

Left panel of Figure 6 depicts averaged percent correct of cognitive map for observers who preferred straight-angle viewing. It shows that these observers acquired better cognitive map by exploring environment with straight-angle viewing. The difference of percent correct of cognitive map between two viewing conditions was statistically significant.

Right panel of Figure 6 depicts averaged percent correct of cognitive map for observers who preferred oblique-angle viewing. On the contrary to their preference, quality of acquired cognitive map was similar for both viewing conditions. It means that there is no advantage of oblique-angle viewing on learning of cognitive map even if observer claim that they prefer it.

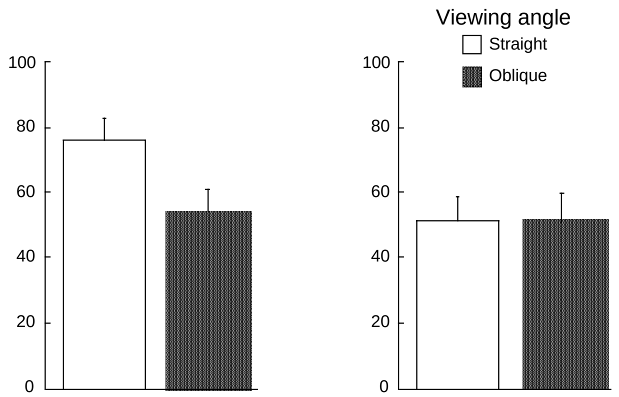

Figure 6 Averaged percent correct of cognitive map for two groups of observer

Our results suggest that brain mechanism for finding a way in environment is distinct from that for acquiring cognitive map of environment. For more practical point of view, presenting semi-bird's eye view in in-vehicle route guidance system is not necessary a good idea, because it would disturb acquisition of cognitive map of environment, which is essential for civilized life.

5. Conclusion

1. Performance of wayfinding is facilitated by presenting egocentric view with oblique viewing angle.

2. Acquisition of cognitive map is disrupted by presenting oblique-angle view during exploration.

3. It would suggest that brain mechanism for finding a way in environment is distinct from that for acquiring cognitive map of environment.

4. Semi-bird's eye display in the in-vehicle route guidance system is not necessary a good idea since it would disrupt acquisition of cognitive map of environment, which is essential for civilized life.

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