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Gender Differences in Spatial Navigation

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***Abstract*—**This study aims to investigate the gender differences in spatial navigation using the tasks of 2-D matrix navigation and recognition of real driving scene. The results can be summarized as followings. First, female subjects responded faster in 2-D matrix navigation task than male subjects when landmark instructions were provided. Second, in recognition task, male subjects recognized the key elements involved in the past driving scene more accurately than female subjects. In particular, female subjects tended to miss peripheral information. These results suggest the possibility of gender differences in spatial navigation.

***Keywords*—**Gender differences, Spatial navigation, 2-D matrix navigation, Recognition of driving scene.

I. INTRODUCTION

GENDER differences in spatial navigation has been commonly observed in the previous studies . Compared with men, women usually show the difficulties in routine spatial navigation tasks, such as wayfinding with map, driving, parking, or getting good sense of direction. We tried to examine the gender differences in wayfinding and driving which are representative situations of spatial navigation. For this purpose, two tasks of 2-D matrix navigation and recognition of real driving scene were used.

The convergent result of gender differences in cognition is men's superiority in spatial ability [5], and many researches showed also that men's spatial memory is better than that of women [8], [13], [17]. The results of meta-analysis by Voyer, Voyer, and Bryden, who reviewed the results of 286 papers from 1974 to 1993, showed that distinctive gender differences in spatial cognition ability. They categorized about 15 sub spatial tasks as three distinct tests. *Mental rotation* was defined as the ability to rotate quickly and accurately 2- or 3 dimensional figures in imagination, *spatial perception* as the ability to determine spatial relations despite distracting information, and *spatial visualization* as the ability to manipulate complex spatial information when several stages are needed to produce the correct solution. Typical male advantage was overall reported in 78 experiments of mental rotation, 92 experiments of spatial perception, and 116 experiments of spatial visualization.

Gender differences in navigation or wayfinding ability have often been examined by using pencil-and-paper route-learning tests [3], route-learning tasks using photographs [4], or tasks requiring navigation in a virtual environment [14]. In all of these instances, males have outperformed females, performing the tasks more quickly and/or making fewer errors. However, females demonstrate an enhanced knowledge of landmarks, both on- and off route, whereas males tend to have enhanced knowledge of the Euclidean properties of the environment [3].

Saucier and Green [16] investigated whether males and females are equally adept at using either Euclidean or landmark instructions when navigating in the real world. When navigating, women typically focus on landmarks within the environment, whereas men tend to focus on the Euclidean properties of the environment. However, it is unclear whether these observed differences in navigational skill come from disparate strategies or disparate ability. To remove this confound, they required participants to follow either landmark- or Euclidean-based instructions during a 2-D matrix navigation task. Men performed best when using Euclidean information, whereas women performed best when using landmark information.

Driving requires multitasking. Drivers should scan and check in-vehicle instruments and response properly with quick and accurate judgment while processing the various stimulus in outside. Several factors verified to influence on the driving performances include age [6], [12], gender [19], [20], driving experiences [11], [21], drivers' personality [2], [15], fatigue [7], [10] or alcohol [1], [7].

Among these factors, gender differences are easily observed in daily life. For example, female drivers have tendencies to pull out with danger, shift lane against the flow of traffic, and get more difficulties to park. Loan [9] suggested that female drivers' collision accident is due to perceptual or judgment error within spatial perception area. In addition, female drivers showed lower confidence of driving.

II. EXPERIMENT 1

In Experiment 1, previous study performed by Saucier and Green [16] was replicated. The purpose of the Experiment 1 was to investigate the gender differences in spatial navigation using the 2-D matrix navigation task. The task required participants to follow directional instructions (either Euclidean or landmark) in a 10 x 10 matrix, with each cell containing one of 10 repeated nameable symbols (see Fig. 1). Workload to influence on perception processing was manipulated by the

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levels of memory load. In the low memory load condition, participants navigated on matrix while listening instruction, in otherwise, participants should navigate on matrix after listening whole instruction in the high memory load condition. Reaction time to a goal cell, error rate, and recognition scores of symbols presented were measured as dependent variables.

It was hypothesized that if women are less able to use Euclidean strategies to navigate, then increases in reaction time and errors should be observed when they followed Euclidean instructions. Also, it was predicted that if men are less able to use landmarks to navigate, then reaction times and errors should be increased when they are forced to use a landmark strategy.

A. *Method*

Participants. A total of 43(male 20, female 23) participants at the Pusan National University completed both of the tasks on Experiment 1 and 2. The participants received course credit in exchange for participation.

Apparatus and stimulus. The navigation environment consisted of a laminated 10 × 10 grid (21cm × 19cm) with each cell containing a symbol (see Figure 1). All tasks were programmed by SuperLab Pro 2.0, and Pentium IV computer (2.65GHz, 512MB) and 17" monitor were used to generate the displays and record data.

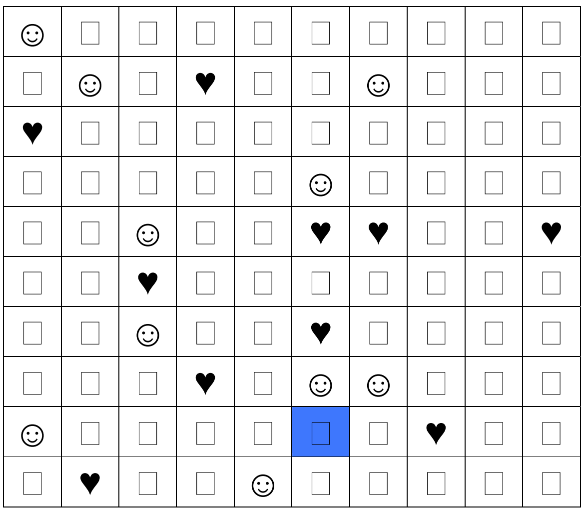

Fig. 1 2-D navigation matrix. A blue-colored cell (appeared gray-colored in this paper) indicates starting point

There were two kinds of instruction; Euclidean or landmark instruction. Each participant was assigned either in a Euclidean (cardinal directions and distances in “blocks”) or landmark format (landmarks and relative positions such as up, down, left, or right). Each question consisted of three directional statements. A sample Euclidean question would be, “Starting at the blue-colored cell, go East 2 blocks, then go North 4 blocks, then go West 4 blocks. What symbol is to your immediate West?” A sample landmark question would be, “Starting at the blue-colored cell, go right to the ♥ , go up until the □., turn left and go until you see the □. Which symbol is to your immediate left?” In this sample question, the correct answer was ☺.

Procedure. Before starting the 12 test trials, participants completed 4 practice trials to familiarize themselves with the procedure. The procedures for both the practice and test trials were identical, except feedback was only provided for the practice trial. A blue-colored cell indicating the starting position for each question was placed on the matrix. Participants were instructed as “Starting at the blue-colored cell, and complete the series of three instructions without touching or pointing at the matrix. Once you complete these instructions, you will be asked to circle your answer on the sheet provided.” Participants were encouraged to complete the task as quickly and accurately as possible. All trials were self-paced. The time to answer each question and the number of errors made was recorded for each trial. An error score was calculated on the basis of total number of errors made over the 12 trials.

After the matrix navigation task, participants were presented with an array of 20 symbols (10 symbols that appeared in the matrix and 10 distractors). Participants were required to press "yes" or "no" button on a keyboard based on the pre-displayed symbol or distractor.

B. *Results and Discussion*

Similar to the results found by Saucier and Green [16], gender differences in 2-D navigation task were partly observed. Experiment 1 demonstrated that men and women differ in their ability to use Euclidean or landmark directional information during navigation. A 2 x 2 x 2 ANOVA, with gender, type of instructions (Euclidean or landmark), and memory load as between-subjects factors, was performed on the mean RT score for the 12 matrix navigation trials. There was a marginal significant interaction effect between gender and the type of instruction, $F(1,39)= 1.83$, $p<.10$. Women who followed landmark instructions with lower memory load outperformed men. But there were not significant gender differences in number of errors and recognition score.

The different levels of difficulty in navigation task might provide a possible explanation of these results. That is, too easy or too difficult navigation tasks may attenuate the effect of gender difference. Therefore, this result should be reflected in following study.

III. Experiment 2

Experiment 2 aims to compare gender difference in spatial navigation using situation recognition tasks of real driving scenes. Participants were seated on the driving simulator and observed various driving scenes. They were required to drive the simulator as if they were driving in the presented driving situations. Three types of stimuli for situation recognition task were provided; foveal stimuli contained the cars which were traveling in the front of the participants’ simulator sharing the same lane; peripheral stimuli were the cars in the other lanes of the participants’ vehicle or in the road shoulder; and the sign stimuli consisted of various road signs and traffic signals which should be processed by the participants during the experiment.

The rates of hit and false alarm were compared with regard to gender and stimuli types.

A. *Method*

Participants. The same drivers in the Experiment 1 also completed the Experiment 2.

Apparatus and stimulus. The driving scenes were recorded using a digital camcorder (SONY DCR-TRV40), and edited into four clips of 90 seconds long adopting the Windows Movie Maker(ver. 2.1). Each clip was edited to contain all the three types of stimuli mentioned above. The clips were projected on the screen(4×3m) located at 1.5m ahead of the driving simulator using a projector (EIKI, LC-7000U). This screen provided 50×40 degrees of visual angle. Examples of stimuli in the clips were shown in the Fig. 2.

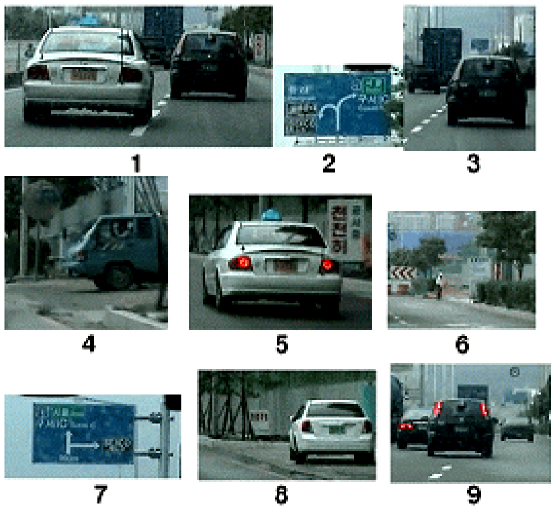

Fig. 2 Recognition task. Each captured image was comprised of real driving scenes. Total 9 small images were 3 foveal stimulus (appeared in center area), 3 peripheral stimulus (appeared in other lane or shoulder), and 3 road signs

Procedure. On arriving at the driving simulation facility, participants were given an information summary and informed consent form documents and were briefed on the operation of the simulator vehicle. They were instructed to drive the simulator as if they were driving in the presented driving scenes. For example, they should manipulate the accelerator, brake pedal and steering wheel properly according to the changes in the driving scenes. Four clips were presented randomly to each participant. After they completed the driving, the screen was blanked out and the 9 experimental stimuli were presented on the same screen. Participants' tasks were to select all the stimuli they recognized as they have seen in the previously presented driving scene. Hit rate (i. e., the percentages of correct selection) and false alarm rate (i.e., the percentages of incorrect selection) were calculated and analyzed in terms of 2 X 3 mixed factorial design where gender difference was between-subject variable, whereas stimuli type was within-subject variable.

B. *Results and Discussion*

As Fig. 3 shows, each gender group significantly differed in the hit rate and false rate. More specifically, male participants showed higher hit rates than female participants, $F(1,41)=17.49$, $p<.001$, whereas female participants showed higher false alarm rates than male participants, $F(1,41)=16.67$, $p<.001$. Female drivers also showed lower performance in recognizing the driving scenes they have observed regardless of the types of the stimuli. That is, female participants showed relatively lower correct rates than male participant in all the stimuli conditions (Fig. 4). In particular, female participants seemed to have difficulty in recognizing the peripheral elements in the driving scenes. This implies that some driving behavior such as changing lanes in complex traffic condition might be more dangerous to female drivers than male drivers.

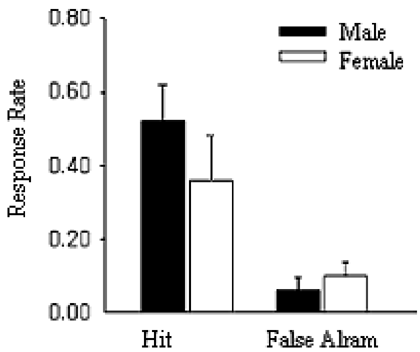

Fig. 3 Gender differences in the recognition of real-road task

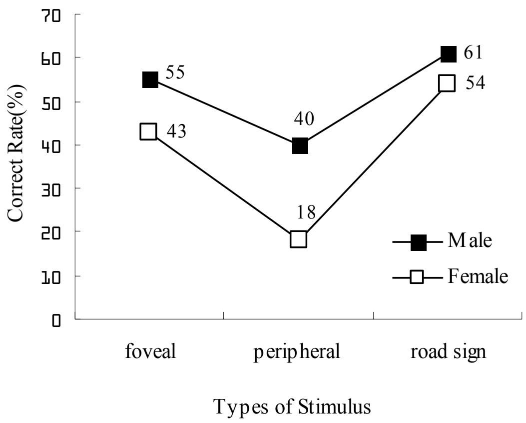

Fig. 4 Correct rate of recognition on the type of stimulus

IV. General Discussion

In this study, gender difference in spatial navigation tasks was compared using tasks of 2-D matrix navigation and recognition of real driving scenes. The results can be summarized as followings. First, female subjects responded faster in 2-D matrix navigation task than male subjects when landmark instructions were provided. Second, in recognition task, male subjects recognized the key elements involved in the previous driving scene more accurately than female subjects. In particular, female subjects tended to miss peripheral information.

The results of this study suggest that spatial navigation abilities for male and female can be differently observed according to task requirements. That is, when the static-spatial navigation materials such as 2-D navigation used, females appeared to show better performance than males although the overall difference between the two genders was relatively small. However, in the dynamic navigation tasks such as driving, female drivers tended to suffer in recognizing previously observed scenes. In particular, female drivers missed the vehicles traveling next lanes more frequently than male drivers, which imply female driver's potential difficulty in lane changes and higher risks of road accidents relating to this type of task.

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