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Development of portable driving simulator system

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ABSTRACT

Purpose: In accordance with aging of populations in many developed countries, number of drivers who suffer from mild cognitive impairment (MCI drivers) is increasing. Since it has been reported that driving skill of the MCI drivers are deteriorated, it is important to train themselves in driving situation to preserve their driving skills. The present study was conducted to develop the simple driving simulator system, and to examine the effect of training in this system.
Design/methodology/approach: Nineteen university students (8 males and 11 females) participated in this study. After the habituation period (approximately 5min), three trials (approximately 12 min) were conducted. Experimental situation imitated the real highway course. During trials, dangerous situation that would be resulted in car accident is randomly appeared and participants were required to avoid the car accidents. To avoid the possible car accidents are considered as correct response.
Findings: Mean percent of correct responses for male and female were 75.2% and 56.6% in 1st trial and 95.7% and 72.6% in 3rd trial, respectively. Two-way analysis of variance revealed that the main effect of sex ($F(1, 14) = 7.84$, $p < .05$) and trials ($F(2, 34) = 10.19$, $p < .001$). These results indicate that numbers of car accidents are dramatically decreased and the driving skills of male are superior to that of female.
Practical implications: Although the present study revealed the differences in driving skills between the sexes, their driving history was not considered. Driving history of each participant should be examined in future study.
Originality/value: Since the improvement of driving skills is revealed, our experimental design is expected as the tool for the preservation of driving skills in the MCI drivers.
Keywords: Safety and health management; Driving simulator

1. Introduction

To drive a car, cognitive skills including attention, memory, and information processing is indispensable [1-3]. These cognitive skills are known to decline with aging [4-6], and if elderly drivers involved in crash, they are more likely to suffer from injury or result in death [7-9]. In addition, according to population aging of many developed countries, number of drivers who suffer from mild cognitive impairment (MCI drivers) is increasing. Since the MCI drivers are reported to increase a risk of car crash compared with age-matched drivers [10], it is reasonable to conclude that cognitive impairment negatively affect the driving technique. In Japan, driver's license is held for life, and the drivers are not subject to driver's aptitude test. However, Japanese police administration is revising the Road Traffic Act, and the bill is expected to approve within this year. In this bill, suspension of driver's license is incorporated when the

older driver is diagnosed as cognitive impairment. Even if they are diagnosed as cognitive impairment, they often drive car without any hindrance. In some case, driving per se restrain the progress of cognitive impairment. Therefore, uniform suspension of driver's license raise another problem, i.e., the cognitive ability of the older driver with primarily modest cognitive impairment would be deteriorated.

As a countermeasure, it is important to drive usually for the MCI drivers. However, driving a motor vehicle attend with much difficulty or dangerousness. From this point of view, the driving simulator has been used as an alternative method [11-15]. But the institution that employs a driving simulator is not too many and the utilization is strictly limited. Thus, development of a driving simulator, which is always available if they need, is necessary.

In the present study, we developed a portable driving simulator system that is intended to train the MCI drivers's skill at home in the future. Based on the developed portable driving simulator, we examined the effect of training on driving skills in university students.

2. Materials and methods

2.1. Participants

Nineteen university students (8 males and 11 females) participated in this study. Mean age were 22.5 years (±1.29 S.D.) for male and 23.0 years (± 2.51 S.D.). They were active drivers with a valid driver's license. All experiments were performed in accordance with the Doshisha University guidelines for human experiments, which is in compliance with the ethical standards of the American Psychological Association.

2.2. Apparatus

As software for portable driving simulator, the software that is originally developed for National Research Institute of Police Science (NRIPS) is improved and applied. The driving simulator used by NRIPS is designed to move both driving sheet and display together, and they were sustained by a trembling device (Figure 1).

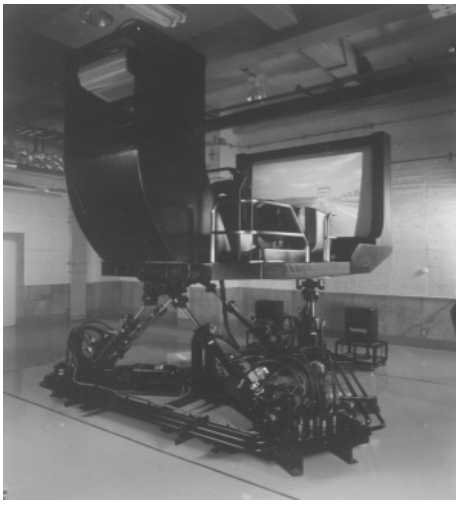

Fig. 1. Driving simulator in the National Research Institute of Police Science

In the present study, portable driving simulator (Figure 2) is used, which is constructed by a workstation (Asterism 2CPU/4GB Memory system), a liquid crystal television (Sharp Aquos LC-37GS20), and a controller that is originally developed for electronic games (Logicool GT Force Pro). The NRIPS software is improved for portable driving simulator.

Fig. 2. Portable driving simulator develoed in this study

2.3. Procedure

Preceding to the experiment, participants were requested to answer the questionnaire about their driving history. After the questionnaire, they were instructed and requested to drive.

The experimental situation is a three-lane highway. Approximately 5 minutes habituations session allowed participants to become familiar with the simulator. In the habituation session, two forward cars and one backward car were allocated. These cars travelled approximately 90km/h. During the habituation session, participants could make lane change freely. Figure 3A shows the overview of habituation session.

a) Habituation session

b) Experimental session

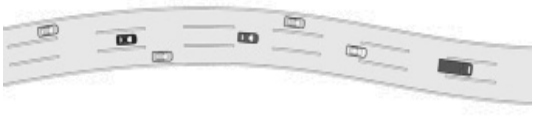

Fig. 3. Overview of habituation and experimental session. (Red: a car participant driving, Green and White: forward cars, Black: backward cars, Yellow: high-speed car)

Immediately after the habituation, three experimental trials (approximately 12 minutes) were conducted. Intertrial interval was approximately 3 minutes. Since high-speed cars, which travelled both right and left lane, appeared and passed participants' car in the experimental situation, participants were instructed to keep the center lane. Figure 3B shows the overview of experimental session. Actual view of experimental session is also shown in Figure 4.

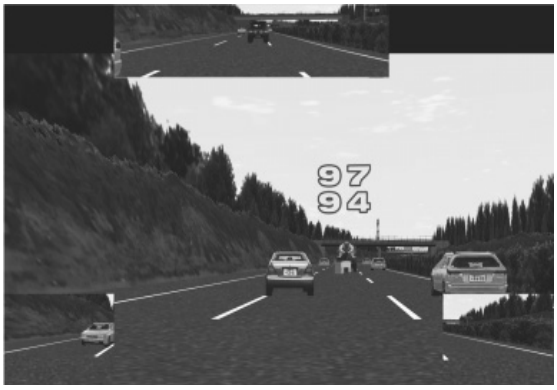

Fig. 4. An example of experimental session

Upon occasion, a dangerous situation is presented during experimental session, which is called the obstacle event. Figure 5 shows the overview of the obstacle event. In the obstacle event, an obstacle appears between the first and the second forward cars (Figure 5A). When the second forward car (immediately before the participant's car) made lane change, an obstacle was presented in front of participant's car. Since travelling the center lane results in crash, they were instructed to avoid the possible crash by changing the lane to which is assumed to be safe. During the obstacle event, participants were required to pay attention around their periphery and judge the lane without following cars (Figure 5B). Changing lane to the lane without following cars is operationally considered as correct response (Figure 5C). For example in Figure 4, a following car travels in the left lane. Therefore, to change lane toward right is correct response.

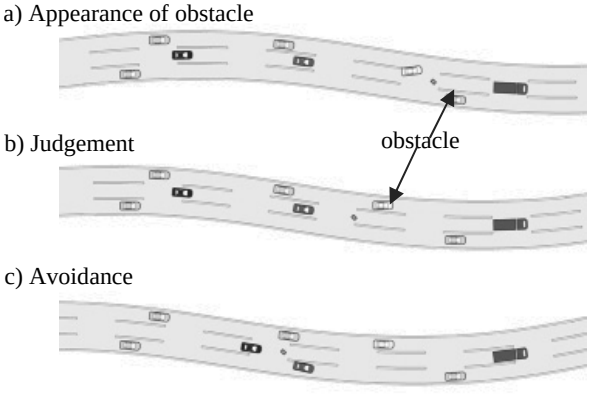

Fig. 5. An illustration of obstacle event

In the experimental situation, participants were requested to read out the figure to fix their eyes frontward. As shown in Figure 4, four figures were displayed on the upside of the forward car. Three kinds of figures were randomly selected from zero to nine. Among four figures, one kind of figure is overlapped. Participants were requested to search the overlapped figure and read it out. Since the figure changes every 3 seconds, they had to read out the figures throughout the trials. However when they found difficulty in reading out figures, they could cease reading out.

3. Results

Mean percentage of correct responses for male and female is shown in Fig.6. Mean percentage of correct responses were 75.2% and 56.6% in 1st trial and 95.7% and 72.6% in 3rd trial, respectively. Throughout three trials, correct response of male is higher than that of female. Regardless of sexes, correct response increases as training progressed.

Two-way analysis of variance revealed that the main effect of sex (F (1, 14) = 7.84, p < .05) and trials (F (2, 34) = 10.19, p < .001). There were no significant interaction between sexes and trials. These results indicate that numbers of car accidents are dramatically decreased and the driving skills of male are superior to that of female.

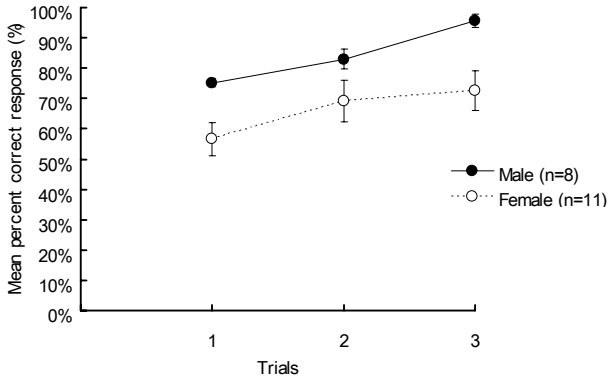

Fig. 6. Mean percentage of correct responses in experimental situation (±S.E.M.)

4. Conclusions

The present study developed the portable driving simulator system, which is constructed by a workstation, a liquid crystal television, and a controller for electronic games. Using the developed simulator, we examined the effect of training on driving skills. Our results indicated that that numbers of car accidents are dramatically decreased and the driving skills of male are superior to that of female. Since the improvement of driving skills is revealed, our experimental design is expected as the tool for the preservation of driving skills in the MCI drivers.

Although the present study revealed the differences in driving skills between the sexes, their driving history was not considered.

Driving history of each participant should be examined in future study. In addition, our results should be compared with that of conventional simulator under the same experimental situation.

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