

INFLUENCE OF ALCOHOL CONCENTRATION AND BRAKING PROCEDURE ON MOTORCYLIST BRAKE REACTION TIME USING A MOTORCYCLE RIDING SIMULATOR

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ABSTRACT

The statistical data published by National Police Agency, Taiwan, indicated that the motorcycle induced the highest accident rate, and drunk driving ranked first among the traffic fatality causes in 2007. The high traffic accident rate was attributed to the alcohol decaying driver reaction and the increase of frequency of using motorcycle in daily life as the car parking space and driving cost were considered. A motorcycle riding simulator, integrating a stationary real motorcycle and virtual reality system, was developed to measure motorcyclist brake reaction time under different drunken levels and braking procedures. The motorcyclist encountered an emergence that a pedestrian went across the road abruptly in a simulated driving scene. The time between an emergence and the activation of brake lever was recorded as the brake reaction time. Ten young participants, ranging from 20 to 25 years of age, were recruited in this study. Drunken levels for motorcyclist were designed to breath alcohol concentrations (BrAC) of none, 0.15 mg/l and 0.25 mg/l. In addition, two different braking procedures, subject positioned his fingers on brake level or had his fingers wrapped around the handlebar, were tested. The experimental results showed that a longer brake reaction time was induced by the motorcyclist under higher BrAC. Additionally, the brake reaction time is also significantly influenced by braking procedure. The results in this study gave really useful information for driving education and skill in the field of motorcyclist driving safety. As the motorcycle riding simulator in this study did not involve a motion platform, participants cannot experience emergency motions induced from abrupt acceleration and braking. However, by using state-of-the-art computer graphic technologies the

simulator gave a reallike scene of emergency traffic event.

INTRODUCTION

The statistics of the Department of Health, Taiwan, indicated that the unintentional injury was the fifth of top ten death factors in Taiwan in 2007 [1], and the traffic accident was the main cause of the injury. Driving is part of daily life in modern society and, of course, induces risk to some extent. However, as the car driving cost has been gradually risen, the increase of frequency of using motorcycle becomes an inevitable result. The statistical data published by National Police Agency [2], Taiwan, showing that the car type inducing the highest accident rate was the motorcycle, reflected the unsafety of motorcycle driving. Furthermore, the statistical data [2] showed that drunk driving ranked first among the traffic fatality causes in 2007. The proposing a toast in Taiwanese culture can be attributed to the drunk driving. People usually toast each other in different dinner parties, and drink excessive alcohol unwittingly. However, most people underestimate the order of severity of drunk driving in safety. The drunk driving becomes a very serious problem nowadays in Taiwan.

The speed of driver response to the changing in traffic situation has a direct influence on driving safety. When driver receives stimulus from surrounding traffic, through the sense of sight and hearing, the information is processed in brain and then decision is made. Simultaneously, command is sent to motor organ such as hands and feet to response. The time of the process from receiving stimulus to making response is the reaction time. In generally, when safety is considered the driving ability is indicated by the reaction time. Driver

concentration on driving, body condition, driving experience, drinking alcohol or using drug would all influence reaction time to different extents. It is commonly known that alcohol influences reaction. This view was supported by scientific research. Kruisselbrink et al. [3] examined how consuming low to moderate quantities of beer over an evening affected adult females. The study found that reaction time did not significantly change the next morning as a function of alcohol dose, and suggested that consuming moderate quantities of beer affects decision making but not physical and physiological performance in adult females the next morning. Fillmore and Blackburn [4] examined how an expectancy-induced adaptive response could reduce the impairing effects of alcohol on response activation, while at the same time increase its impairing effect on response inhibition. Their experimental results showed that subjects led to expect slowed reaction time displayed faster reaction time but fewer inhibitions under alcohol, compared with those who received no such expectancy. The findings demonstrated that an alcohol expectancy reduce impairment of one aspect of performance under the drug while increasing its impairing effect on another. Alcohol can further affect driving ability. Lennè et al. [5] point out that driving performance would drop if the driver is intoxicated. In their study, a driver's ability of keeping the vehicle running inside the lane is lessened, leading to an increase in lane shifts and direction deviation angle. Meanwhile, the driver's ability of maintaining his speed is weakened, which contributes to more volatile changes in speed. His response time would likewise become longer. Leung et al. [6] discover in their study that intoxicated drivers' perception of danger on curved roads would be impaired; as a result, their response would become slow. Most of the research studies exploring the effect of alcohol on driving ability focus on car drivers. In comparison, no objective data or complete research have been obtained or conducted so far on the effect of alcohol concentration on motorcyclists' response capacity. Through a drunk driving experiment participated in by motorcyclists, the real response of the motorcyclists can be determined. However, the traffic environments that the motorcyclists will face are complicated. If the drunk driving experiment with real motorcycles is carried out, then it is bound to threaten the safety of the participants and other passers-by. During the past few years, virtual reality technology has grown rapidly, and the integration of virtual reality technology into a motorcycle simulator can not only protect the participants and reduce costs, but realize the design of experimental items, guarantee the experimental significance, and simulate varied dangerous contexts as well. Therefore, considering driver safety and experiment cost, this study conducted drunk driving experiments using motorcycle riding simulator to investigate the effects

of alcohol concentration on motorcyclist brake reaction time.

EXPERIMENTAL METHODS

The study employed a motorcycle riding simulator to access the influence of alcohol concentration and braking procedure on motorcyclist brake reaction time. The participants, simulator equipment, experimental design, and data analysis are described as follows.

Participants

This research employs 20 participants, composed of 13 males and 7 females, between 20-25 years old and holding a motorcycle license. All the participants are healthy, and have no habit of excessive drinking.

Motorcycle riding simulator

The motorcycle riding simulator integrated a real motorcycle, a virtual reality-based visual and audio system, and a host computer system to create a virtual environment of motorcycle riding. The motorcycle is a real scooter, the most common motorcycle type in Taiwan. The motorcycle front wheel is mounted on a rotationable disk. The disk allows motorcyclist to change driving direction by turning steering handlebar, and the orientation and turning angle of the front wheel are detected by a rotary-type resistance equipped on the disk. Linear variable differential transformer is attached to the brake lever to detect the position of the lever as motorcyclist applies braking. The three-dimensional models of pedestrians, vehicles and buildings in the virtual environment are created using 3DS MAX 5.1 to create. The virtual environment is presented, and the interactions between the virtual models and human being are designed, using EON studio 5.2. The virtual scene is displayed on a 100-inch rear-projection rigid screen providing 85.5° horizontal × 69.4° vertical field of view. The audio system provides simulated noises from the engine and traffic environment. The control of all the input and output of software and hardware is integrated into a main program developed using Visual Basic 2005.

Experimental design

The experiment employed a 3×2 factorial within-subject design that compared motorcyclist reaction time based on different alcohol concentrations (none, 0.15 mg/l, 0.25 mg/l) and braking procedures (cover mode, uncover mode). The braking procedure of cover mode was that subject positioned his fingers on brake level. The uncover mode was that subject had his fingers wrapped around the handlebar. The different

conditions were presented in random order to participants.

Driving Scenario

A simulated driving scene was created using the VR system for motorcyclist undergoing the driving experiment in safety. When the motorcyclists are riding on the simulator, they will meet any number of pedestrians standing on the sidewalks five times during the driving process. Only in three cases will the pedestrians abruptly cross the road from the sidewalk at a quick trot, as shown as Figure 1. The pedestrians will be standing at their places 3 meters away from the middle of the lane. The pedestrians' speed when crossing the road is set at 7.2km/hr. The event of the pedestrian crossing the road will be triggered when the distance between the motorcycle and the place where the pedestrian is standing reaches 20 meters. The speed of the motorcycle is fixed at 50km/hr. If the motorcyclist does not take any action to brake after the event is triggered, the pedestrian will run into the motorcycle after 1.5 seconds. To obviate the expectations held by the participants to the events, which will then cause the collected data to lose objectivity, the times the three events of the pedestrian crossing the road are arranged randomly.



Figure 1. Pedestrian goes across the road abruptly.

Experimental procedure

The experimental procedure starts from the registration of the participants. First of all, the participants register and then fill out an experimental questionnaire. After that, the experimental process is explained by an assistant and how to use the motorcycle simulator is taught, allowing each participant to practice with the motorcycle simulator so as to ensure they are familiar with the experimental process. After the participants learn how to operate the motorcycle simulator well, the simulating experiment of conscious driving is set out

to do.

During the drunk driving experiment, participants must drink the prepared alcoholic drinks within 10 minutes and then rest for 20 minutes. The drink volume is calculated according to the information provided by the participants. Next, an alcohol detector is used to check whether the breath alcohol concentration of the participants has reached 0.15mg/l (± 0.03 mg/l). If the desired concentration is reached, the experiment is set out to conduct. After the experiment is finished, the alcohol concentration of the participants is tested and recorded again. Then, the second round of experiments will be made. The participants will be asked to drink the second cup of alcoholic drink and then rest for 20 minutes. An alcohol detector is then used to check whether the breath alcohol concentration of the participant has reached 0.25mg/l (± 0.03 mg/l). If the desired concentration is reached, the experiment is set out to conduct. After the experiment is finished, the alcohol concentration of the participants is tested and recorded once more. After all the experiments are finished, hot tea and other drinks will be provided to the participants to relieve the effects of the alcohol. The participants can take a rest for one to two hours after the experiment before leaving.

On the day before the commencement of the experiment, the participants should not eat any food containing any alcoholic ingredient to prevent alcohol from remaining within the body or the problems of alcoholic metabolism from appearing. Moreover, the participants should not stay up late, making sure to have plenty of sleep. Finally, they should keep away from food containing high oil, sugar, or caffeine content within two hours before the experiment so as not to affect the absorption of alcohol.

Data analysis

The braking response time is counted beginning from the moment the pedestrian begins to move and ends when the activation of brake lever. All experimental data are sorted out and statistically analyzed using the SPSS15.0 Statistic Application Software.

RESULTS AND DISCUSSION

Braking response times using uncover mode and cover mode for brake preparation action under different alcohol concentrations are listed in Table 1. Mean braking response time using uncover mode for brake preparation action without alcohol is 0.665 second, longer than the 0.49 second braking response time using uncover mode. This discrepancy has reached a statistically significant difference ($P < 0.001$). When the breath alcohol concentration is 0.15mg/l, the mean braking response time using uncover mode (0.680 second) for the brake preparation action is longer than mean braking

response time when using uncover mode (0.490 second). Again, this discrepancy has reached a statistically significant difference ($P < 0.001$). When the breath alcohol concentration is 0.25mg/l, the mean braking response time using uncover mode for the brake preparation action without alcohol is 0.692 second, longer than of the mean braking response time of 0.578 second when using uncover mode. This discrepancy has likewise reached a statistically significant difference ($P < 0.001$). The experimental result shows that despite the intake of alcohol, or under varied alcohol concentrations, the mean braking response time using uncover mode for the brake preparation action is longer than the mean braking response time when using cover mode, and that the discrepancy between them has reached a statistically significant difference. The results of this study indicated that the brake reaction time is significantly influenced by braking procedure. The results gave really useful information for driving education and skill in the field of motorcyclist driving safety.

Table 1.
The reaction time in different braking procedures and alcohol concentrations

alcohol concentrations	braking procedures	Average	S. D.	P value
0 mg/l	Uncover mode	0.665	0.138	0.000
	Cover mode	0.479	0.126	
0.15 mg/l	Uncover mode	0.680	0.106	0.000
	Cover mode	0.490	0.105	
0.25 mg/l	Uncover mode	0.692	0.158	0.000
	Cover mode	0.578	0.152	

The participants' braking response time under different breath alcohol concentrations when pedestrians cross the road at a quick trot is shown in Table 2. When the participants have not drunk any alcohol, the braking response time is 0.572 second; when the breath alcohol concentration is 0.15mg/l, the braking response time 0.585 second; when the breath alcohol concentration is 0.25mg/l, the braking response time is 0.610 second. The statistical analysis result indicates that the effect of different breath alcohol concentrations on the braking response time reaches a statistically significant difference ($p < 0.032$). Tukey post-hoc tests showed the difference between 0 mg/l and 25 mg/l was significant. On the other hand, there was no

difference between 0 mg/l and 15 mg/l, and between 15 mg/l and 25 mg/l. The results of this study indicated that the brake reaction time is significantly influenced by alcohol after driver drank at some level of alcohol concentration.

Table 2.
The reaction time at different alcohol concentrations

alcohol concentrations	Average	S. D.	P value
0 mg/l	0.572	0.161	0.032
0.15 mg/l	0.585	0.142	
0.25 mg/l	0.610	0.176	

CONCLUSIONS

The study investigated motorcyclist reaction time based on different alcohol concentrations (none, 0.15 mg/l, 0.25 mg/l) and braking procedures (cover mode, uncover mode). It was found from the experimental that the brake reaction time is significantly influenced by braking procedure. The brake reaction time for subject had his fingers wrapped around the handlebar was much longer than the time for subject positioned his fingers on brake level. The results gave really useful information for driving education and skill in the field of motorcyclist driving safety. The experimental results showed that a longer brake reaction time was induced by the motorcyclist under higher BrAC. The brake reaction time is significantly influenced by alcohol after driver drank at some level of alcohol concentration.

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