Research for the Novice driver's Capacity of Hazard Perception and Response

Li Gao[a], Xiaoting Yu[b] *and Liting Hou[c]

School of Mechanical Engineering, Beijing Institute of Technology; Beijing 100081, China

[a] ligaobit@bit.edu.cn, [b] 13651036212@163.com, [c] leetinghou@163.com

Keywords: Novice driver; Experience; Hazard perception; Mental workload

Abstract. In order to research the hazard perception and response of the novice driver, Creator was used to build a series of dangerous traffic scenes, and then the data was tested while driving. Three groups of test subjects was set: novice driver group, experience driver group and trained driver group. Response sensitivity, response time and mental workload were recorded and analyzed. It turned out that with the increase of driving experience, driver's capacity of hazard perception and response sensitivity greatly improved, and the response time and mental workload greatly reduced.

Introduction

Ministry of Public Security Traffic Management Bureau statistics show that traffic accident of novice drivers within three driving years accounted for more than 40% of the total number of accident, and fatalities occupied nearly half[1]. This article based on statistics, driver experience and driving mileage, defines novice driver as one drives less than three years or 10000km with a poor psychological quality and adaptation and coordination among automobiles, roads and environment.

It was found that levels of feelings of Danger and rate of accident are negatively correlated[2]. That is to say, the lower the risk of feeling level, the more easily it leads to accidents, and vice versa. Compared with the experienced drivers, the novice driver's perception of hazard is much poorer. This article defines hazard perception as capability of hazard of perception, evaluation and prediction[3]. This capability can make drivers aware of potential traffic risks, and take the necessary measures to avoid the risk. Hazard perception can be developed by long driving experience or driving hazard perception training.

This article based on simulated driving system and physiological measurement feedback system analyzes differences between the experienced and novice driver awareness of the dangers, and thus targeted to increase novice driver's perception of hazard responsiveness to reduce the risk of accidents.

Research Method.

This paper is based on real dangerous traffic scenes, and uses Creator to build three-dimensional model under the typical dangerous traffic scenes. Based on established vehicle dynamic model, the VC and Vega Prime are applied to build real-time traffic scenes, and simulate unexpected dangerous traffic scenes; thereafter, it establishes an interactive simulation. Data about driving behavior (The pressure of accelerator and brake and steering angle of steering wheel), vehicle situation (speed and acceleration), vehicle position (relative lane location and deviating lane angle) are collected by the operation of sensor from haptic simulation system, and the operating signal is transferred to a real-time controlled computer by transmission equipment. Under data collection, this paper tends to have a comprehensive analysis of data collected simulated driving situation; and then this paper conduct tracking tests for drivers' brain load. By showing the virtual scenes, this paper identifies the influence of driving experience on drivers' feeling for dangerous driving situation. And further analyze and assess perceptions for dangerous driving scenes between experienced drivers and novice drivers.

This experience has three groups participated. The three groups are novice drivers group, which are drivers with less than 3 years' driving experience or driving less than 10,000 km mileage; experienced drivers group, which are drivers with more than 3 years driving experience and drive more than 10000

km mileage; and control group, which consists of drivers have been participated a training for strengthen perception for danger before experiment. Subjects in 3 groups take experiment in virtual driving platform respectively. This experiment collects data for reaction time and brain wave, by means of SPSS to analyze data and finally obtain the result for the difference between experienced drivers' perceptions for danger and novice drivers' perception for danger.

Experiment Design.

Experimental scene design. As illustrated in Fig.1, this paper divides driving behaviors into 12 categories. And each driving behavior completes by the process of stimuli perception, judgment and decision-making, and stimuli release.

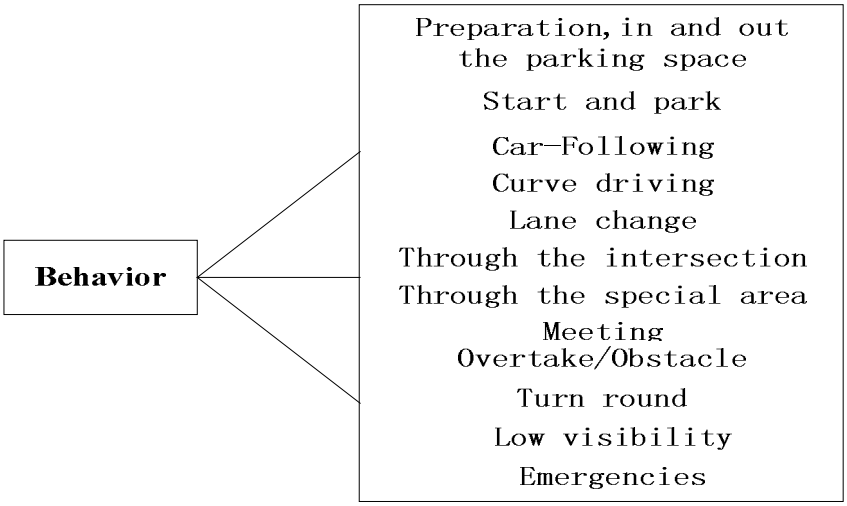

Fig.1: Classification of Driving Behavior

In this paper, we process research for which three kinds of high risk basic driving behaviors: passing intersections, overtaking or avoidance, and emergency contingencies.

Scene 1: It may lead to traffic collisions when the driver straight through the intersection, interfering vehicle on right lane turns left into the path of the test vehicle.

Scene 2: The vehicle followed by a truck, they are both waiting for the green light turn left. Be limited by the front truck, driver's sight blocked, and he unable to promptly observe to the opposite lane straight vehicles.

Scene 3: The driver is traveling straight on urban roads, when approaching an intersection, the lights suddenly turns red from green, and the subjects had to suddenly stop the vehicle.

Scene 4: The vehicle is driving on urban road normally, suddenly found a soccer ball rolled in front of the vehicle, it is likely that there will be a child appears to pick, this scene to determines whether the driver has enough driving experience to judge in advance, slow down and view street if someone jump out, in order to avoid accidents.

Scene 5: The vehicle is driving normally to the sidewalk, there is a stationary pedestrian by the road, the pedestrian maybe through a red light in the sidewalk.

Scene 6: On a long straight line, since the driver relaxed vigilance and drives faster and faster. In the absence of obvious prompt, suddenly if there was a sharp curve, the driver can make the right judgments.

Scene 7: In the car-following state, there is a pedestrian by the road, when the front vehicle suddenly stops, the driver needs to anticipate hazards and avoid danger.

Scene 8: The vehicle will meet with oncoming vehicle in the case of a faulty vehicle in the opposite lane, the driver needs to anticipate that it's possible the vehicle crosses the centerline, to regulate the speed, try to avoid obstructions meet and give way to vehicle.

Scene 9: Driver on urban roads drive normally, then finds there is a fault in the front, cannot pass, so the vehicle wants to go on the left lane, but there is a vehicle in the left lane.

Scene 10: In the foggy days, the vehicle drives through the intersection. Since the driver is difficult to see the surrounding circumstances.

Experiment program. Use Creator software to build three-dimensional simulation model of 10 typical dangerous scenes and build virtual driving scene. Selecting 3 types of experiment drivers: novice drivers, experience drivers, novice drivers in the control group, each group should have 15 people, which include 10 men and 5 women. To exclude the impact of age, the novice drivers and the control group in the age range of 18-25 years old. The experienced drivers in the age range of 26-49 years old. Drivers connect biofeedback measurement system, simulated driving, record the brake voltage of the vehicle, vehicle speed, steering wheel angle and the driver's mental workload data.

Experiment procedure. The driver in each group connects biofeedback measurement system, they should follow by 10 typical dangerous scenes in the virtual drive platform.

When each driver drives, record the physiological data of each driver's braking voltage, time, vehicle traveling data offset and brain and other loads.

Experimental Results Analysis

Sensitivity: sensitive degree of the driver for each sets in response to certain event, namely, how many drivers had reaction to the event.

Reactions time: In accordance with the unit for seconds. Recording the time the driver takes to make corresponding measures from driving appearance of danger to the driver to perceive the danger. In the test, when the driver perceived danger and stepped on the brake pedal, the observed voltage will change. Based on the time difference of braking voltage change to research the driver's hazardous reaction, we can not only reflect the driver's risk perception, also can reflect the driver's reaction time.

Mental workload: when the driver perceived danger, the mental workload will change significantly. The feeling, perception, reaction capability and operational capacity will be seriously affected while the driver with high mental workload on driving.

Studies have shown that, for a dominant dangerous, there is no difference on hazard perception between the novice drivers and experienced drivers[4]. By preliminary analysis of the scene 2,4,6,8 and 10, the differences in the performance by novice drivers and experienced drivers are insignificant, so our analysis focused on the rest of the scene.

Analysis of respond sensitivity. For a particular dangerous scene, the response sensitivity of a particular group to represent the percentage of the number of members of the group reacts to this event of the total number of this group use. As some scenes may be the driver does not react, so it is valuable and reliable to research the response sensitivity of the driver in dangerous scenes.

Tab.1: Respond sensitivity of three groups in 5 dangerous scenes

	Respond sensitivity		
Scene	Novice drivers	experienced driver	The control group
1	87%	100%	93%
3	87%	93%	93%
5	73%	80%	80%
7	67%	80%	73%
9	73%	93%	87%

From the 3 groups the driver's response sensitivity in the five dangerous scenarios in Tab.1 we can see that:

Compared with the experienced drivers, novice drivers respond to the hidden dangers of scenes with significantly lower sensitivity.

The driver in control group response sensitivity is higher than novice drivers, and close to the experienced driver group. That shows a certain amount of training will help the driver timely reaction to a dangerous situation.

Analysis of hazardous reactions. By analyzing the driver's braking voltage changes with time data, the obtained the driver reactions in dangerous situations. Based on the data samples that reaction by driver's on the dangerous situation, and grouping of the driver (different driving experience) as a factor level to analysis the influence significantly changed by the time on driving experience for brake voltage situation using single factor analysis of variance.

		N	Subset for alpha = .05	
			1	2
Student-Newman-Keuls [a]	1.00	13	90.206	
	2.00	15		87.331
	3.00	14		88.174
	Sig.		1.000	0.473

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 13.952

Fig.2 scene 1 Comparative analysis of reactions by novice and experienced drivers and control group

Novices driver group (group 1), experienced driver group (group 2) and the control group (group 3) were significantly different about with respect to dangerous scenarios perception and reaction time, while group 2 and group 3 the difference was not significant.

Tab.2 Reaction contrast to the situation under five kinds Scene of 3 driver groups

	Scene 1		Scene 2		Scene 3		Scene 4		Scene 5	
	Subset for alpha =.05		Subset for alpha =.05		Subset for alpha =.05		Subset for alpha =.05		Subset for alpha =.05	
Group	1	2	1	2	1	2	1	2	1	2
novices driver	90.206		198.155		365.326		518.652		662.927	
experienced driver		87.331		195.413		364.360		517.006		658.974
control group		88.174		196.173		364.985		517.847		660.346
Sig.	1.000	0.473	1.000	0.952	1.000	0.716	1.000	0.748	1.000	0.533

Novice driver's dangerous scenes perception reaction time was significantly longer than the experienced driver, and the difference with the control group of novices driver are more significant, indicating that this ability can be trained to gradually improves through the dangerous perception.

Analysis of mental workload. Compared to the skilled driver, the novice driver looking for a single target takes longer duration, which takes a long time to interpret the gaze object, when the transportation are complex, the driver is easy to lose the other needs to receive and process traffic safety related information, but also the highlight information processing is not timely, and causes big mental workload and fatigue. Studies have shown that when the driver is in the larger mental workload, driving perception, reaction capability and operational capacity will be seriously affected[5]. Therefore, study the novice and experienced drivers' perception and ability to respond in dangerous situations by studying the driver mental workload.

Fill the driver mental workload subjective rating scale, evaluate items which includes mental demand, physical demand, time requirements, performance demands, effort level and frustration level, each entry score ranges from 1-21.

Tab.3 Scene 1 items Comparison table

Scene 1						
item1 / item 2	mental demand	physical demand	time requirements	performance demands	effort level	frustration level
mental demand	-	physical demand	mental demand	mental demand	effort level	mental demand
physical demand		-	physical demand	performance demands	effort level	physical demand
time requirements			-	time requirements	time requirements	time requirements
performance demands				-	effort level	frustration level
effort level					-	frustration level
frustration level						-

Tab.4 Weight Value of different items in NASA

Scenes / items	Scene 1	Scene 3	Scene 5	Scene 7	Scene 9
mental demand	4/21	4/21	4/21	3/21	4/21
physical demand	6/21	4/21	3/21	5/21	3/21
time requirements	3/21	2/21	4/21	5/21	5/21
performance demands	2/21	3/21	3/21	2/21	3/21
effort level	2/21	4/21	4/21	3/21	3/21
frustration level	4/21	4/21	3/21	3/21	3/21

Tab.5 Novice driver's Score of different items and scenes in NASA

Scenes / items	Scene 1	Scene 3	Scene 5	Scene 7	Scene 9
mental demand	35	50	60	20	30
physical demand	60	60	80	50	70
time requirements	80	25	30	40	40
performance demands	50	40	15	50	70
effort level	70	25	40	75	60
frustration level	75	70	70	40	30

So we can get the data of experienced group and control group.

The formula of calculating mental workload is :

$$A=\frac{1}{6}\sum_{1}^{6} V_i \times W_i \quad (1)$$

we can calculate the mental workload of three group, five situation successively.

Tab.6 Mental Workload for different drivers in different Scenes

	Mental Workload		
Group / Scenes	Novice drivers	Experienced drivers	Control group
1	10.6	8.25	9.37
3	7.86	6.23	7.22
5	8.06	5.52	6.35
7	7.58	5.79	6.75
9	8.02	6.11	7.1

The novice drivers have larger mental workload than experienced drivers under dangerous situations obviously, that is, the experience of driving can influence mental workload, and then influence the hazard perception and response sensitivity of the drivers. Training on novice drivers can mitigate mental workload of drivers and improve the hazard perception and response sensitivity.

Summary

Comparing novice drivers with experience drivers, the response sensitivity towards recessive dangerous situations of novice drivers is obviously lower than experienced drivers. As well as training is good for quicker response in dangerous situations.

The time needed for hazard perception and response of the novice driver in dangerous situations is longer than experience drivers. And also have large difference when comparing with control group. But this ability can be improved by hazard perception training.

The experience of driving can influence the mental workload, further, influence the hazard perception and response sensitivity. Novice drivers have heavier mental workload than experienced drivers under dangerous situations obviously. Training on novice drivers can mitigate mental workload of drivers and improve the hazard perception and response sensitivity.

Research shows that there is a huge difference of hazard perception and response sensitivity between novice drivers and experience drivers. Strengthening of training of hazard perception ability on novice drivers can mitigate mental workload of drivers, improve the response sensitivity, reduces the response time and the risk of traffic accidents of novice drivers. This research also provides scientific foundation for further study of training of hazard perception ability and mental workload of novice drivers.

References

[1] Longhua Ma, Huizhi Tang, Lin Cheng, Analyze for the Hazard Perception of the novice and experienced drivers, J. Chinese scientific papers online. 6(2011)11-12.

[2] Klauer, Sheila G,Guo, Feng, Simons-Morton, Bruce G, Ouimet, Marie Claude, Lee, Suzanne E, Dingus, Thomas A. Distracted Driving and Risk of Road Crashes among Novice and Experienced Driver, J. New England journal of medicine. 370(2014)54-59.

[3] Meng Du, Driver Ability hazard prediction and predictive ability training system based visual simulation technology, D. Xi'an: Chang'an University Automotive Institute. (2008)

[4] Zhihui Tang, Differences between the hazard perception of novice and experienced driver, D. PhD thesis in Southwest Jiaotong University. (2012)

[5] Hongji Du, Research the impact and method of determination of fatigue driving, D. Master's degree thesis in Beijing University of Technology. (2014)

