Analysis of Driver's Stress Reaction Time

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Abstract. A driving simulator was set up for analyzing driver's reaction time when driving on urban road, including reaction perception time, decision-making time and operation time. 28 participate drivers were recruited for the simulated driving test, Results show that the best fitting relationship between driver's reaction perception time and vehicle speed meets exponential distribution. Vehicle speed shows no significant effects on driver's decision-making time, and the young group's average decision-making time (236.85ms) is the shortest. The relationship between driver's operation time and vehicle speed meets logarithmic distribution, and the young group's average operation time (254.11ms) is the shortest.

Introduction

Urban road traffic environment is more complicated and the driver needs more attention when driving in an urban road environment. The sudden emergence of pedestrians, non-motorized vehicles and other vehicles from a blind area require immediate attention of the driver and provides shorter risk perception time. The processes affecting drivers' stress reaction behavior include stress reaction perception, decision making and operation. These processes directly determine the timeliness and effectiveness of the stress reaction behavior of drivers [1]. This study utilizes virtual reality techniques to develop a set of urban road environment scenes in which the stress reaction time features of several drivers were analyzed through a simulation.

Stress Reaction Experiment

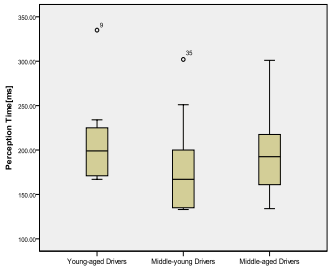
More than 10 urban road traffic scenes were designed and developed to identify the characteristics of urban traffic environment, these scenes were chosen based on the analysis of common accident data. The stress reaction time data of four scenes were selected for analysis after the experiment. Scene 1: Pedestrian crossing the road suddenly. Scene 2: Pedestrian appearing in front of a bus. Scene 3: Pedestrian crossing the road. Scene 4: At a crossroad under construction, another car suddenly appears from a hidden intersection.

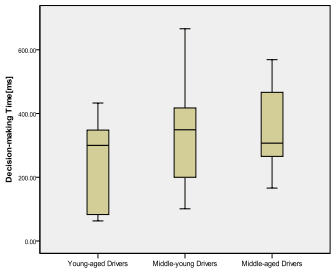
The stress reaction simulation system consists mainly of the control cabin, data collection device, data processing device, scene simulation system, display platform and sound device, and it was designed independently. An eye tracker, EyeLink II, was utilized in the experiment to track the driver's fixation behavior in real-time. The video was played frame by frame to identify the driver's fixation target. The drivers belong to different driving groups to adhere to the diversity principle. The youngest driver is 22 years old, and the oldest is 49. The drivers have no history of cardiovascular and physiological diseases, and their vision acuity is normally.

The time period from the moment danger appears until the driver identifies the danger signal is defined as perception time [2]. Decision-making time data were mainly acquired based on the eye movement data collected by the eye tracker and the accelerator pedal data collected by the stress reaction simulation system. The time from when the driver relaxes his foot on the accelerator pedal to the moment he steps on the brake pedal is defined as operation time.

Experiment Results Analysis

Age. The drivers were divided into three groups: young (20~30 years old), middle-young (30~40 years old) and middle-aged(40~50 years old), which was marked as Y, MY, MA respectively. Each group's perception, decision-making and operating time were statistically analyzed, and the results are shown below.





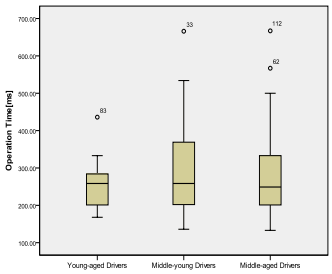


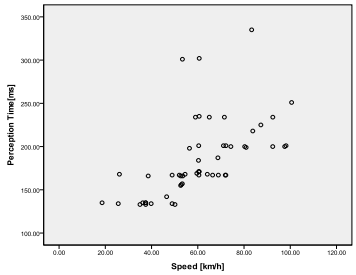
Fig 1 Perception time Fig 2 Decision-making time Fig 3 Operation time

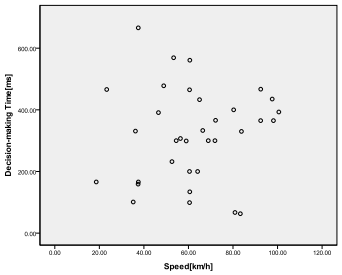
Fig. 1 shows that the mean perception time of the Y, MY and MA group is 205.77 ms, 172.07 ms and 192.83 ms, respectively. The MY's perception time is the shortest, whereas that of the Y's is the longest. The standard deviation in the perception time is 46.67 ms, 39.79 ms and 47.47 ms, respectively. The MY group has the most stable perception ability, whereas the MA group has the most volatile.

Fig. 2 shows the mean decision-making time of the Y, MY and MA is 236.85 ms, 337.15 ms and 358 ms, respectively. The decision-making time of the Y group is the shortest; the MA group is the longest. The standard deviation in the decision-making time is 155.93 ms, 147.62 ms and 145.42 ms, respectively. The MA group has the most stable decision-making ability; and the Y group has the most volatile.

Fig. 3 shows that the mean operation time of the Y, MY and MA group is 254.11 ms, 290.91 ms and 272.69 ms, respectively. The operation time of the Y group is the shortest; and the MY group has the longest. The standard deviation in the operation time is 55.71 ms, 115.5 ms and 100.88 ms, respectively. The MA group has the most stable operation speed; and the young group is the most volatile.

Vehicle Speed. A statistical analysis was performed based on speed to analyze stress reaction perception time, decision-making time and operation time in different speed conditions. The results are as follows:





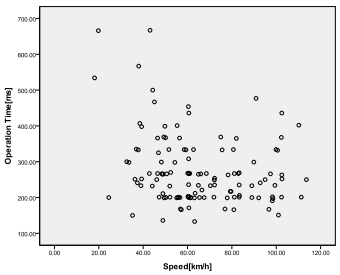


Fig 4 Perception time Fig 5 Decision-making time Fig 6 Operation time

Fig. 4 illustrates perception time at different vehicle speeds. As the vehicle speed increases, perception time also tends to increase. Pearson correlation test analysis was conducted for perception time and speed [3], and the results are shown in Table 1.

Table 1 Pearson test for vehicle speed and perception time

		Perception Time	*Speed*
Perception Time	Pearson Correlation	1	0.589**
	Sig. (2-tailed)		0.000
Speed	Pearson Correlation	0.589**	1
	Sig. (2-tailed)	0.000	

**Correlation is significant at the 0.01 level (2-tailed).

Table 1 shows the correlation coefficient between perception time and speed is 0.589, which is significant at the 0.01 level [4]. Perception time has an influence on speed. Curvilinear regression analysis was conducted for vehicle speed and perception time. The results presented in Fig. 7 shows that the exponential regression result is optimum when R^2 = 0.428 and F = 38.831, indicating the best regression model for perception time and speed is exponential regression. The formula is as follows:

$$y = 112.817 \times e^{0.008x} \tag{1}$$

where y is the perception time and x is the vehicle speed.

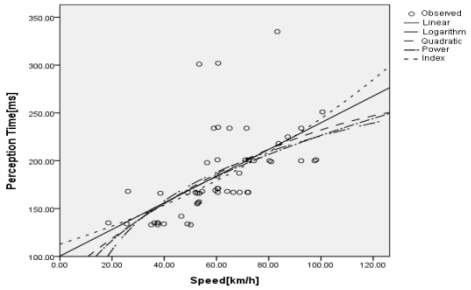


Fig 7 Curve fitting between vehicle speed and perception time

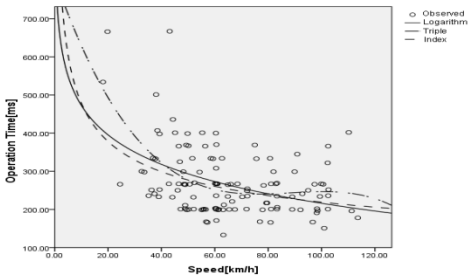


Fig 8 Curve fitting between vehicle speed and operation time.

The Fig.5 shows that no significant relationship exists between decision-making time and vehicle speed. A Pearson correlation test analysis shows no significant interaction between the two, either.

Fig. 6 reveals a relationship exists between operation time and vehicle speed. A Pearson test analysis was conducted for both, and the result is shown in Table 2. The correlation coefficient between vehicle speed and operation time is -0.042, which is significant at the 0.01 level. Curvilinear regression analysis was performed in Fig. 8.

Table 2 Pearson test for vehicle speed and operation time

		Operation Time	*Speed*
Operation Time	Pearson Correlation	1	-0.402**
	Sig. (2-tailed)		0.000
Speed	Pearson Correlation	-0.402**	1
	Sig. (2-tailed)	0.000	

** Correlation is significant at the 0.01 level (2-tailed).

The fitting result in Fig. 8 indicates that the logarithmic and cubic polynomial regression results are acceptable [5]. The best fitting model is logarithmic regression. The formula is as follows:

$$y = 758.817 - 118.99 \ln x \tag{2}$$

where y is the operation time and x is the vehicle speed.

Conclusion

This study investigated driver's stress reaction time. Analyses of the samples revealed the findings below.

(1) The perception time of the young and middle-aged is the shortest. Perception time exhibits an exponential distribution with the increase in vehicle speed.

(2) The decision-making time of the young and middle-aged group is the shortest.

(3). The operation time of the young and middle-aged group is the shortest. Operation time exhibits a logarithmic distribution.

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