

## Driver's stress physiological characteristics when front vehicle cut in

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**Keywords:** driver; stress reaction; driving simulator; heart growth rate; heart rate variability ( HRV ) .

**Abstract.** Aiming at the influence of front vehicle cut in suddenly on driver's physiological load, 22 drivers were convened to carry out virtual driving test with equipment of MP150 physiology monitoring system, and driver's physiology data was recorded when the front vehicle cut in suddenly. Heart growth rate and HRV were used to analyze driver's physiological load, and result shows that: while speed was 100km/h, the average heart growth rate were 16.21%, 19.55%, 23.27% with decreasing of cut in distance, and HRV LF decreased correspondingly. While cut in distance remains unchanged, significant difference of average heart growth rate was existed with increasing of speed, the average ascensional range was 13.05%, 16.65%, 21.85%. Difference examination result shows that: driver's physiology load variation trend was similarly with the changing of cut in distance or speed, but incidence of speed factor was higher than cut in distance factor.

### Introduction

The actual driving experience shows that, Chinese drivers lane change stoppering behavior emerge in endlessly, random change, change do not turn on the lights, even malicious gasser is more common. The vehicle in front of the random variable to the behind other vehicles, the driver who is more severe challenges and improper disposal easily induced crash. In addition, if this situation occurs on the highway, the severity of the accident will not be estimated. At this time, the driver's behavior will be very urgent, sometimes no time to react to make a hedging action.

Summary of relevant literature, it is known that [1-4], research on the relationship between stress response and physiological index mainly concentrated on the influence of one's own driving factors on stress response, such as different age, driving age, gender and personality, but speed of to directly influence the severity of stress, stress factors such as distance did not carry out large-scale experiments to study. Aiming at this problem, the author through designing the scene of the driving simulator before the car suddenly cut into the front of the car, and then changed the distance between the 2 vehicles in the virtual scene. The physiological signals of the subjects were recorded by the physiological test system, and the effects of the vehicle speed and the distance between the vehicle and the driver were analyzed, and It can provide theoretical basis for how to consider the physiological and psychological load of the driver in the active safety system.

### The development of experiments

**Simulator test platform.** A driving simulator was developed to study the response of the driver's stress, and the simulator is equipped with steering wheel angle sensor (1), the pedal force and pedal travel sensor (2), and the position sensor (3), the operating behavior parameters of the driver in the

process of synchronous sampling of the analog board. In order to improve the realistic effect of the virtual scene, the simulation scene shows the triple screen technology, while using the scene matching audio player system to enhance the real sense of virtual driving simulator. Driving simulator is shown in figure 1.

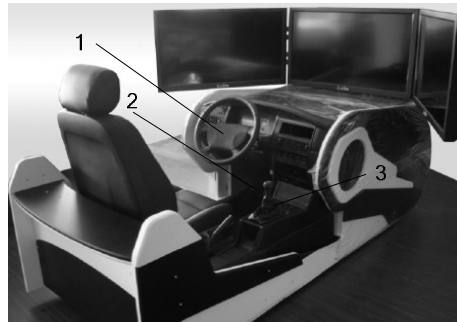


Fig.1 Driving simulator

**Test equipment and subjects.** The physiological signal of the driver was recorded by MP150 physiological test system. According to the principle of voluntary participation, open recruitment of 22 male young people who hold a driver's license test, the test age is between 22 to 24 years old, and the body is normal. After the test, the data were analyzed and processed. All 22 subjects were tested, and there were 1 people in the process of the test, which resulted in abnormal ECG data. Therefore, the effective sample size was 21.

**Test procedure.** Test to be carried out in the highway environment for 60, 80, 100, 120km/h, and other 3 kinds of speed test. By setting up the virtual scene in the simulator, we can carry out multiple stress tests. Before each experiment, the subjects were told to drive at a certain speed, and the time and place of the stress in the virtual scene were randomly distributed, so the effect of the stress was ensured.

#### **Physiological load characterization parameters**

In this paper, the heart rate, heart growth rate and heart rate variability ( HRV ) in the ECG signal are used as the physiological parameters of the stress response. The existing studies show that the HRV frequency domain analysis has a certain correlation between the 3 frequency bands and the physiological load. The LF value of the individual HRV can reflect the work load of the individual, and the LF decreases with the increase of individual workload. Therefore, LF is used to characterize the HRV in the driving stress state.

#### **Analysis of physiological characteristics of stress response of drivers**

**Physiological characteristics of stress distance.** In the environment of expressway, the driving speed of the vehicle is 100 km/h, and the physiological load characteristics of the driver under the condition of the change of the driving distance are studied. The stress tests were performed at 27.8, 41.7 and 55.6m, respectively.

By Figure 2, in the case of 100km/h, the average heart rate of the majority of the subjects was increased with the decrease of the distance of the first car. The results showed that the average heart rate increase of 21 subjects were 16.21%, 19.55% and 55.6, respectively, and the corresponding standard deviations were 23.27%, 8.33 and 7.27, respectively, when the distance was 7.37, 41.7 and 27.8m respectively. The data of the 3 groups were paired with T test, the results were  $p_1=0.06>0.05$ ,  $p_2=0<0.05$ ,  $p_3=0.01<0.05$ .

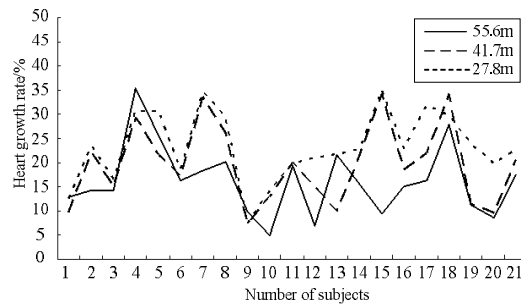


Fig.2 Heart growth rate of driver V=100km/h

This showed that the growth rate of heart rate was not significantly different between 55.6 m and 41.7 m, while the difference of heart rate increased by 41.7 m and 27.8m. When the distance change from 41.7m to 27.8m, the driver's heart rate increased by 19%, which indicates that the physiological load of the driver increases with the decrease of the driving distance.

**Physiological characteristics of speed change.** When the distance of the front car was cut into 33.3m, the stress response test was carried out in 60, 80 and 120km/h respectively. Similar to the previous analysis, the driver's heart rate increases as shown in Figure 5.

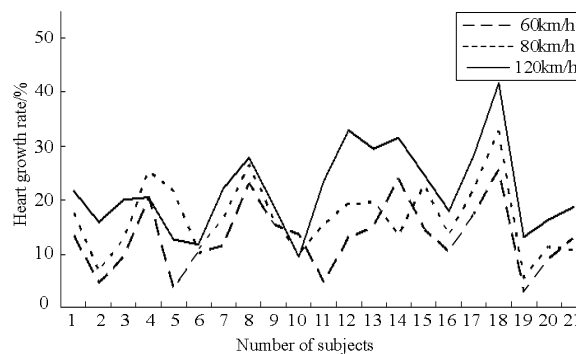


Fig.3 Heart growth rate of different speed

Analysis of the corresponding data of Figure 3, the speed of the car was 60, 80 and 120km/h, the average value of heart rate increase was 13.05%, 16.65%, 21.85%, the corresponding standard deviation was 6.49, 6.90 and 7.97 respectively. The data of the 3 groups were paired with T test, the results were  $p_1=0.008<0.05$ ,  $p_2=0<0.05$  and  $p_3=0.001<0.05$ , the results showed that there was a significant difference between the rate of heart rate increase when the car was cut in the distance of 33.3m. Compare to 60km/h, the heart rate increased by 27.6% and 67.5% in the case of 80 and 120km/h respectively. As a result, the vehicle speed is very important to the driver's workload.

**Comparative analysis of physiological effects of distance and velocity.** In the course of the statistical test, all the heart rate data of the stress response were studied. The physiological load characteristics of the 2 kinds of factors were analyzed. The results were shown in Figure 4 and figure 5.

Figure 4 shows that the current car cut in distance and driving speed alone, the driver's heart rate growth rate distribution characteristics, the difference between the average value of the 2.49%. T test,  $p=0.017<0.05$ , showed that there were significant differences between the 2 samples. This shows that when the distance factor and speed factor change alone, there is a significant difference between the driver's heart growth rate. Figure 5 shows that the current car cut in the distance and the speed of travel alone, the driver of the LF value distribution characteristics of large differences,

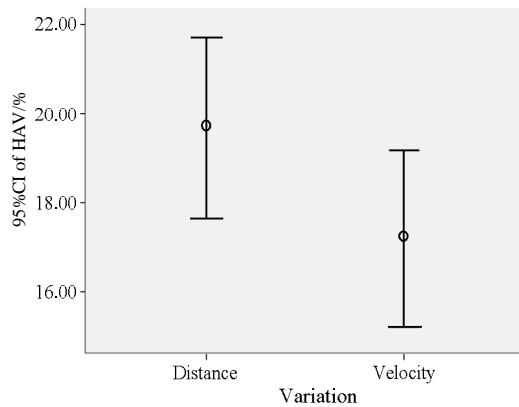


Fig.4 Heart growth rate

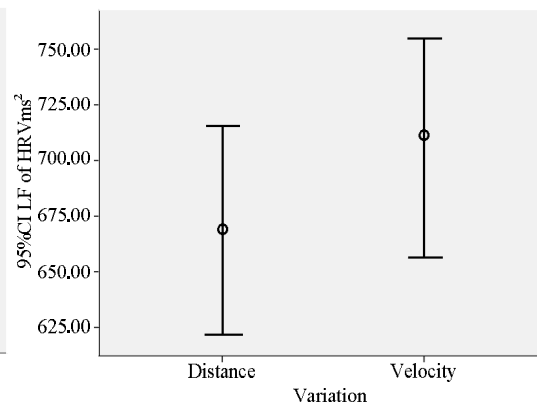


Fig.5 LF data

Figure 5 shows that the current car cut in the distance and the speed of travel alone, the driver of the LF value distribution characteristics of large differences, the difference between the average value of 37.08 ms<sup>2</sup>. Paired T test,  $p=0.001<0.05$ , showed that there were significant differences between the 2 samples. This shows that there is a significant difference between the HRV of the driver when the distance and the speed factor is changed. The LF value of the front car is changed to the distance and the speed of the vehicle is smaller than the LF value of the 5.26%. This indicates that the speed of the HRV is more than the cut distance factor.

## Conclusion

1 ) The car suddenly cut into the front of the car, since the car speed is 100km/h, the driver's heart rate increases, and the LF value of the heart rate drops. Compared with the test, the average rate of 21 subjects' heart rate increase was 16.21%, 19.55% and 23.27%, respectively. When the cut distance was 41.7, 55.6 and 27.8m, the LF value of the driver's heart rate was 615.19, 723.42 and 667.00ms<sup>2</sup>, respectively, showing a significant downward trend.

2 ) At the present time, the average rate of 21 subjects heart rate increase 13.05%, 16.65%, and 21.85%, as the speed of the vehicle increases. The average values of the LF values of the 21 subjects were 646.52, 779.57 and 690.76ms<sup>2</sup>, and the decrease trend was obvious when the vehicle speed was 60, 80 and 120km/h respectively.

3 ) The difference test results show that the change of the physiological load of the driver is the same as that of the driver's physiological load, but the influence degree of the vehicle speed is higher than that of the cut distance factor.

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