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Analysis of Driver's Visual Characteristics in Different Road Space

Honghao Wang

School of Traffic & Transportation, Chongqing Jiaotong University, Chongqing, 400074, China

Abstract

Two-lane highways in mountainous areas have complex alignments and changeable road space. In order to study the differences in the visual characteristics of drivers in different road spaces, this paper conducts a real vehicle experiment, and obtains the driver's visual psychological parameters through the experiment. characteristics and visual load were studied. The research conclusion shows that the visual load of driving in the closed canopy space and the semi-closed canopy space is higher than that in the open space, and the specific numerical relationship can be expressed as canopy closed space>semi-closed space>open space.

Keywords

Two-lane highway; Canopy closed space; Visual characteristics.

1. INTRODUCTION

My country is a terrain with a stepped distribution from west to east, from high to low. Plateau landforms and mountainous and hilly landforms account for about 70% of my country's total land area. Due to the complex topography and geological conditions in mountainous areas, the alignment of two-lane highways in mountainous areas is poor, the road space is complex and changeable, and the driver's driving comfort is poor. Therefore, the incidence of road traffic accidents in mountainous areas is significantly higher than that in other areas. The consequences are also more severe than in other regions.

When a driver drives in a bad traffic environment, the received road information changes with time, and the dynamically changing road information often increases the driver's driving load. A large amount of traffic information is transmitted to the brain through the human eye, processed by the brain and then transformed into the driver's driving operation. Therefore, the complex driving environment directly affects the driver's visual load, and the size of the visual load is closely related to the driving safety of the vehicle. Therefore, it is of great significance to study the visual characteristics of drivers in different road space spaces for improving driving safety.

2. A REVIEW OF RELATED RESEARCH

In recent years, relevant scholars at home and abroad have carried out research on road traffic safety issues. The main research process and conclusions are as follows: Berlyne D.E [1] studied the laws of human visual and psychological changes under different levels of information complexity. It is found that when people acquire more complex visual information, the psychological fluctuation is larger, and based on this, the theory of visual stimulation motivation is proposed. Based on the driving simulation method, Pierre Thiffault et al. [2] evaluated the visual stimuli experienced by the driver with the movement of the steering wheel in the monotonous landscape environment and complex landscape environment of the same road alignment. The results showed that the driver in the monotonous landscape environment Due to less visual load, it is prone to driving fatigue. Based on simulation experiments,

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ENGSTROM J[3] takes the driver's driving visual cognition as the research object, and explores its influence on various driving states. Indicators and other data, it is concluded that the driver's visual cognition has a certain degree of influence on the driving behavior.

Xie Songfang, Zhu Shoulin, etc. [4] took the grassland highway landscape as the research object, and explored the impact of its changes on the driver's vision. They used an eye tracker to conduct a real vehicle experiment, and collected the eye movement data indicators of drivers in two different landscapes. After data analysis, the results show that the relatively monotonous landscape of grassland highways has less visual stimulation for drivers, which is easy to cause visual fatigue of drivers. Yang Yunxing and Chen Fang [5] studied the impact of canopy closure on the driver's vision on the mountain expressway, and collected indicators such as the driver's skin electricity, heart rate, electrocardiogram, gaze time, and saccade amplitude. The results of the study show that the road space with different canopy closures has an impact on the driver's psychological load and cognitive load. Qin Yaqin, Yang Ni, etc. [6] used VS-Design 3D scene to build a 12km long four-level two-way single-lane highway in mountainous area, and tested it based on the driving simulator. The test results show that there are visual differences in the typical sections of the low-grade highway in the mountainous area, and the apparent load is larger than that of the longitudinal slope section and the dangerous road near the mountain.

The above research results show that: in the research on the driver's visual characteristics, most of them focus on the selection and comparison of the parameters representing the visual characteristics, and less research has been done on the changes of the driver's visual characteristics caused by different road spaces in the mountain highway. This paper intends to conduct real vehicle experiments in different road spaces in mountainous areas to explore the differences in drivers' visual characteristics in different road spaces.

3. REAL CAR TEST

Combined with the characteristics of mountain highway environment, according to the degree of canopy closure, the expressway space environment is divided into three typical spaces, namely open space, semi-canopy closed space and canopy closed space [7]. The experimental section is a secondary highway in a mountainous area in Chongqing. The total length of the section is 10 kilometers. The traffic safety facilities along the road are complete, the road environment is rich in changes, and the road alignment is complex and changeable. It has the basic characteristics of a typical two-lane highway in the mountainous area.

3.1. Laboratory Apparatus

According to the requirements of the experiment, this paper needs to obtain the driver's eye movement data and main psychological parameters. The eye movement data was collected with the Dikablis glasses eye tracker from Germany, and the Varioport physiological recorder was used to collect the main parameters of the driver's psychology. Both instruments can accurately capture the data required for the experiment. In addition, the driving recorder is used to record the road driving environment.

3.2. Experimenter

According to the requirements of the experiment, 15 male drivers aged 25-35 years old who were unfamiliar with the experimental road section were randomly selected to conduct the experiment. Before the experiment, all drivers and recorders rested normally, had normal mental states, and had normal driving conditions and work conditions. condition.

3.3. Experimental Program

All the people participating in the driving experiment drive on the road section in sequence. The recorder pays attention to the changes of the instruments in the car and records the

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experimental data in real time. At the same time, the changes of the road environment are photographed and recorded.

4. ANALYSIS OF DRIVER'S VISUAL CHARACTERISTICS

In this paper, based on the existing research results, the pupil area change rate and the heart rate change rate are used as the main parameters to evaluate the driver's visual characteristics. In this experiment, the driver's visual load changes were evaluated by collecting the driver's gaze characteristics, pupil area and heart rate values under different road conditions.

4.1. Gaze Behavior

The gaze coordinates in the recorded data are divided into visual fields, and the gaze time collected by the instrument is counted, and the driver's gaze characteristics are studied through the driver's visual heat map under different road conditions.

Figure 1. Distribution of visual hot spots in semi-canopy closed space

Figure 2. Distribution of visual hot spots in open space

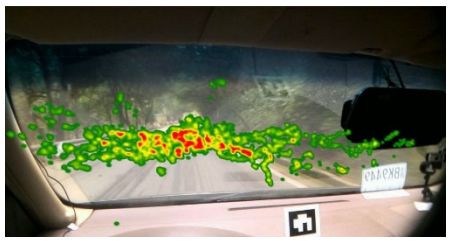

Figure 3. Distribution of visual hot spots in canopy closed space

Table 1. Comparison of fixation time in different spaces

View zone	Semi-closed space	Open space	Canopy space
Left	2.659	0.153	8.015
Superior	0.267	0.105	0.13
Middle	51.356	20.168	29.351
Down	32.153	22.35	64.29
Right	0.136	0.03	3.354
Inside the car	0.142	0	0
Total	86.713	42.806	105.14

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Statistical analysis of the experimental data shows that in the three different road spaces, the open space fixation points are more concentrated, concentrated in the middle and lower parts of the visual field, accounting for 99.33% of the total fixation time, and the total fixation time is less. The amount of information processed in this space is less. When driving in a semi-closed space, the total fixation time of the fixation point is 86.713 seconds, which indicates that the driver processes a large amount of information when driving in this space. When driving in a closed space, the driver's total gaze time is 105.14 seconds, which is the largest in the three spaces, indicating that the driver's attention is the most concentrated and the driving task is the heaviest.

4.2. Pupil Area Change Rate Analysis

The formula for calculating the rate of change in pupil area is:

$$\varphi_e = \left| \frac{A_i - A_0}{A_0} \right|$$

where: φ_e — rate of change of pupil area; A_i — pupil area; A_O — initial pupil area.

Now, the abnormal values of the three groups of pupil area data in different road areas are eliminated, and the statistics are as shown in the following figure. The statistical results are shown in the figure:

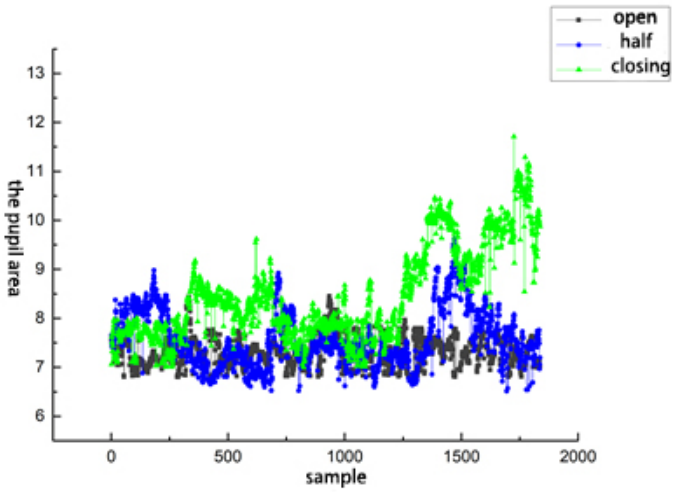

Figure 4. Statistics of pupil area in different road areas

The statistical data shows that the pupil area of the driver varies significantly in different road spaces, and its size law is close to canopy closed>semi-closed>open.

For the three groups of pupil area change rates in different road areas, the abnormal values were eliminated, and the statistics were made as shown in the following figure. The statistical results are shown in the figure:

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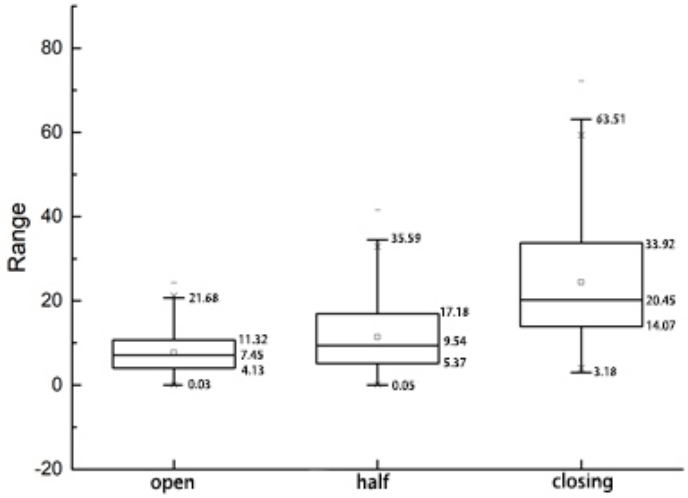

Figure 5. Pupil Area Change Rate

The statistical data shows that the pupil area change rate varies significantly when drivers drive in different road spaces. From the boxplot data, it can be seen that the change rate of the pupil area of the driver in the semi-closed space and the closed space is larger than that in the open space, indicating that the driver bears a greater driving load when driving in this environment.

4.3. Heart Rate Characteristic Analysis

In order to accurately study the change of the driver's heart rate at a certain moment (time period), it is decided to use the heart rate change rate as the driving load characterization index. The heart rate change rate is calculated as shown in the formula:

$$\varphi_h = \left| \frac{H_i - H_0}{H_0} \right|$$

where: φ_h — heart rate variability; H_i — heart rate value; H_O — normal heart rate.

Due to the high acquisition frequency of the physiological recorder, there is no change in the driver's heart rate in a short period of time. After excluding the value that has not changed in a long time, boxplot statistics are made on the rate of change in the driver's heart rate. The results are shown in the figure:

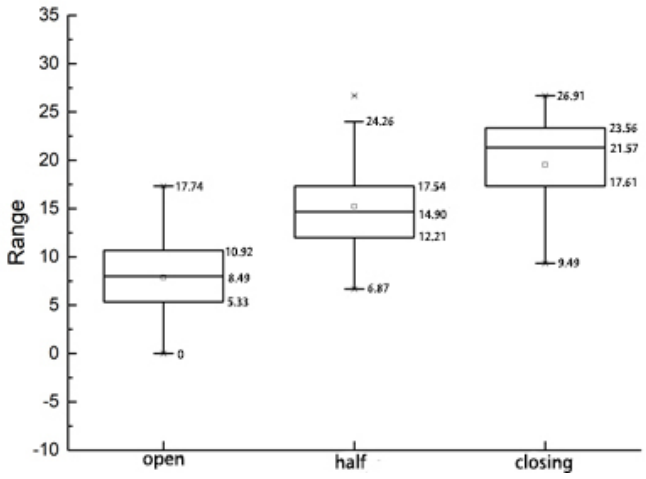

Figure 6. Heart Rate Change Rate

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The boxplot data shows that there are obvious differences in the rate of change of the driver's heart rate under three different road space spaces. The change rate of the driver's heart rate in the semi-closed space and the closed space is larger than that in the open space.

5. ANALYSIS CONCLUSION

In this paper, through real vehicle experiments, the visual characteristics and heart rate of drivers under three road space conditions are analyzed in detail. From the statistical data, the specific values of the driver's gaze characteristics, pupil area change rate and heart rate change rate in three different spaces are obtained. The following conclusions are drawn: when driving in a mountainous area with two lanes, different road spaces have significantly different effects on the driver's driving load, that is, the driving visual load is high when the vehicle drives in the canopy-closed road space and the semi-canopy-closed road space. Driving in an open space, the specific numerical relationship can be expressed as canopy closed space>semi-canopy closed space>open space.

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