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Analysis of Traffic Signs on Driving Behavior Safety

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ABSTRACT: In response to the issue of the impact of traffic signs on driver driving behavior, this article analyzes their impact on driving behavior from the perspectives of the location and height of traffic sign settings, the amount of information contained in traffic signs, and the type of traffic sign settings. This article summarizes and analyzes the research background, methods, and achievements of 8 literature on the impact of traffic signs on driving behavior. This study selects appropriate indicators and summarizes the analysis of driving behavior characteristics, studying the safety analysis of traffic signs on driving behavior. The research results of this article can effectively improve road safety and reduce accidents.

Keywords： traffic sign; driving behavior;driving simulation experiment;safety analysis

I. INTRODUCTION

With the acceleration of urbanization and the improvement of road infrastructure, a large number of traffic signs have been installed in the urban road network. Traffic signs play a role in transmitting road information, conveying traffic managers' intentions to drivers to help them quickly and safely reach their destinations. With the increase of traffic signs, the process of identifying traffic signs by drivers has become more complex, that is, the degree to which drivers' operational behavior, psychological changes, etc. are affected by traffic signs has also become more complex.

At present, domestic and foreign scholars have achieved fruitful results in the study of the intrinsic relationship between traffic signs and drivers. Xu Huizhi et al. [1] analyzed the impact of traffic signs on the driving behavior of bus drivers from the perspective of prohibition signs, and used correlation analysis to obtain the inherent characteristics of the survey data. They found that the distribution of prohibition signs per kilometer is significantly correlated with the number of lane changes, acceleration and deceleration times, And an exponential model and a cubic model were constructed for fitting. Zhao Xiaohua et al. [2] studied the impact characteristics of traffic signs (speed limit signs, exit warning signs) inside highway tunnels on driving behavior. They selected an extra long tunnel as the experimental section, obtained fine-grained micro behavioral data of drivers through driving simulation experiments, and then constructed a linear mixed effect model considering the influence of random effects, Revealed the impact characteristics and mechanism of traffic signs inside the tunnel on driving behavior. Jing Difei et al. [3] studied the impact of variable information sign lead distance on driving behavior on an eight lane highway. Li Na et al. [4] explored the effects of traffic sign installation height, angle, and their interaction on driver gaze characteristics within the recommended range of national standards. LvNengchao et al. [5] analyzed the impact of traffic signs with different amounts of information on driver cognitive load through experiments, and verified the effectiveness of traffic sign information on load loading. Lv Zhen et al. [6] explored and analyzed the impact of the type of traffic sign setting on the flat curve of grassland roads on the visual characteristics of drivers. Huang Lihua et al. [7] investigated the impact of warning signs in the overpass area of expressways on drivers. Zhao Xiaohua et al. [8] explored the impact mechanism of different warning sign positions on driving behavior at sharp turns. Using driving simulation experiments, five different warning signs were set up before sharp turns to observe the operating status of vehicles in straight and curved sections before the turn.

In view of this, existing research has achieved certain theoretical research results in driver visibility, distance before prohibition signs, roadside traffic sign occlusion, and traffic sign information content. This article mainly summarizes and analyzes the above research to study the safety analysis of traffic signs on driving behavior.

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II. EXPERIMENTAL METHOD

Most researchers use driving simulation experiments to explore the impact of traffic signs on driving behavior, while a few researchers use video recording observation, natural driving surveys, and table recording methods. Xu Huizhi explores the impact of driving behavior through a survey plan. Other researchers conducted driving simulation experiments.

2.1 Experimental object

Research generally recruits 30-50 participants with comparable driving abilities, ranging in age from 20 to 50 years old (average age=26-30, SD=2.13), all of whom have been driving for more than 2 years and are in good physical condition without color weakness or color blindness. To ensure that the subjects have a good mental state on the day of the experiment, they are required to ensure 8 hours of normal sleep and alcohol consumption the night before the experiment. In addition, participants are prohibited from consuming stimulating beverages such as tea or coffee before the start of the experiment to reduce the impact of other factors on the participants.

2.2 Experimental instrument

Research generally uses a simulated driving experimental platform (system) to select other suitable experimental instruments based on specific experimental requirements, such as eye trackers, computers,large capacity batteries, LED screens, etc.

Figure 1 Driving Simulation Platform

2.3 Experimental section and plan

Design experimental designs based on the surveyed road sections. The infrastructure for other traffic signs and markings shall be designed in accordance with the specifications of GB5768.2-2009 "Road Traffic Signs and Markings - Part 2: Road Traffic Signs". According to the requirements of road design parameters in the design specifications, apply 3D Max software to build a virtual simulation scene for the road.

In order to minimize the impact of external environmental conditions on the equipment and driver's condition during the experiment, the experiment was conducted on a morning with good weather conditions. The illumination and noise inside the vehicle were measured using a digital handheld illuminometer and a noise meter to ensure that the light intensity level was basically consistent during the experiment, and the noise was controlled below 70 decibels. The experiment is divided into two stages. Firstly, a 5km long driving adaptation training is conducted to enable the participants to adapt to the driving environment and equipment, and enter a normal driving state. Then, the formal experiment in the second stage is carried out. In the formal test, participants are required to turn off electronic devices unrelated to the test inside the vehicle, complete driving tasks according to daily driving habits, control the driving speed within the maximum speed limit (80km/h), and do not allow drivers to overtake on flat curve sections. During the entire test, conversations with vehicle staff are avoided, and the total test time is about 2 hours. The research design of the experimental section is shown in Figures 4:

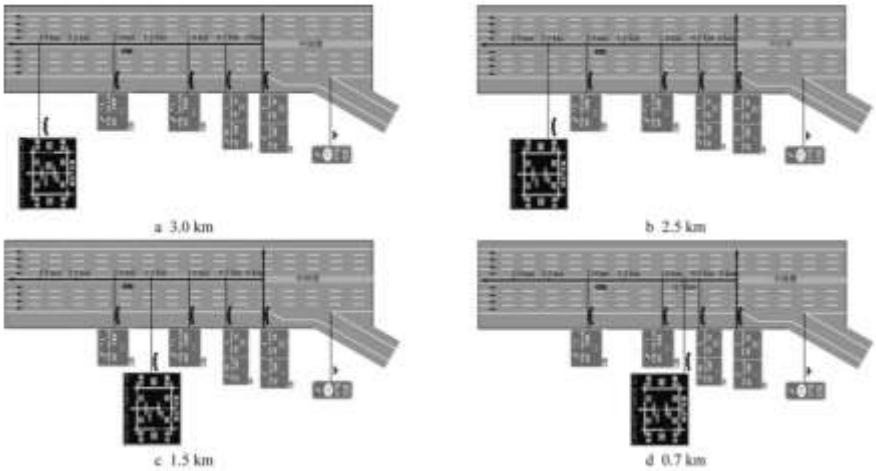

Figure 3 Layout of Signs with Different Leading Distances

2.4 Experimental process

The experiment consists of a pre-experiment and a formal experiment. The pre-experiment selects informal experimental scenarios to test whether the subjects adapt to the driving simulation environment and are familiar with driving simulation controls. During the formal experiment, participants were required to drive through three randomly arranged tunnels. The driving time for each scenario is approximately 10 minutes. To avoid fatigue effects caused by prolonged driving, the participants only drove one scene at a time and tested three times, with a minimum interval of 20 minutes between each driving task. The experimental steps are as follows:

(1) Subjects fill in relevant information, including personal information and pre-experimental physiological and psychological tables;

(2) Practice driving for 5 minutes and read out experimental instructions to the participants, including precautions, emergency response, and use of equipment and instruments;

(3) Wear equipment, inform the subject of their destination, and complete the driving test;

(4) The experimenter records the driving situation and saves data;

(5) After the experiment, the subjects filled out a subjective questionnaire to evaluate the authenticity of the simulated scene and the subjective psychological feelings during the driving process.

III. ANALYSIS OF DRIVING BEHAVIOR CHARACTERISTICS

3.1 indicator selection

Different studies select different indicators. For example, Zhao Xiaohua and others selected the following indicators when studying the impact of tunnel traffic signs:

(1) Safety indicators

Select average speed, standard deviation of speed, and vehicle lateral deviation as safety indicators.

The average speed (km/h) represents the average speed at which a vehicle operates. Research has shown that within the range of road speed limits, there is a positive correlation between average speed and accident incidence; The lower the average speed, the better the driver's control ability under the influence of tunnel traffic signs, and the higher the driving safety.

The standard deviation of speed represents the fluctuation of vehicle operating speed. The higher the value, the less drivers adjust their driving speed, the smoother the vehicle travels in the tunnel, and the higher the driving safety.

The lateral displacement (m) of a vehicle represents the displacement of the vehicle center relative to the centerline of the lane, reflecting the driver's perception and handling level of the vehicle's lateral position. The smaller the value, the better the driver's ability to control the vehicle and space under the influence of tunnel traffic signs, and the higher the driving safety.

(2) Comfort indicators

Select acceleration (m/s^2) as the comfort index. There is a direct relationship between the acceleration value and people's subjective feelings, that is, the greater the acceleration, the worse the driving comfort. Therefore, the smaller the acceleration, the lower the psychological tension of the driver under the influence of tunnel traffic signs, and the better the driving comfort.

The indicators selected for the study of driver visual characteristics are:

(1) Average fixation duration and fixation frequency

The average fixation duration refers to the average duration of all fixations of a driver in a fixed area. It can reflect the time spent by the driver in the area, the difficulty of extracting information from the area, and measure the state of cognitive load. Video annotation rate refers to the number of fixations per unit of time that a driver takes, and the more fixations they take, the lower their search efficiency.

(2) Fixation intensity

When a vehicle passes through a flat curve segment at a certain speed, the intensity of road information will affect the driver's gaze duration and gaze frequency. The product of gaze duration and gaze frequency is defined as gaze intensity, also known as a single point of view indicator, used to characterize the driver's information processing ability under a certain speed and road information.

3.2 Result analysis

Generally, SPSS 25.0 is used to analyze the data results. For the sections affected by traffic signs, a single factor repeated measurement analysis of variance method is used, and a box chart is drawn to judge the indicator results. If there is any abnormality in the data, it may be due to nervousness during the experiment, which caused the focus to be on the road ahead and did not pay attention to traffic signs. This is not closely related to this study, so the data of the subject was excluded and the final data sample was obtained.

3.3 Residual normality and variance homogeneity test

Conducting variance analysis requires sample data to meet certain conditions, and organizing scholars' research results mainly includes the following 6 items:

(1) The dependent variable is a continuous variable.
(2) There are 2 categorical independent variables.
(3) Having independent observations.
(4) There are no significant outliers in any classification.
(5) The residual in any classification approximates a normal distribution.
(6) Any classification has equal variance

IV. DRIVING BEHAVIOR ANALYSIS

This article analyzes the impact of the types of flat curve traffic signs on the visual characteristics of drivers on grassland highways.

4.1Analysis of average fixation duration and fixation frequency indicators

Statistical analysis was conducted on the average gaze duration and video frequency data of drivers passing through flat curves with different traffic signs.

After testing, it was found that under different traffic sign setting conditions, the driver's eye skip frequency met the requirements of normality and homogeneity of variance ($F=0.0897$, $P=0.9144$), meeting the requirements of one-way repeated measurement analysis of variance.

According to the TURKEY test results, there are significant differences in the average fixation duration and video recording rate between linear guidance signs and traffic facilities without signs or warning posts. This is because in flat curve sections without traffic signs, drivers cannot obtain any guidance or warning, and can only sense changes in the route shape and traffic environment by themselves. Therefore, they need to gaze multiple times and spend a long time collecting road traffic related information. In the flat curve section where traffic facilities are equipped with warning posts, due to the symmetrical setting of red and white warning posts on both sides of the road, the amount of information that drivers need to perceive in a short period of time increases (in addition to changes in road alignment, including the warning posts themselves). Therefore, drivers must constantly pay attention to changes in traffic information on the road ahead, resulting in a significant increase in the length and frequency of their gaze on the flat curve section. In the flat curve segment with linear guidance signs and linear guidance signsspeed bumps, the driver's gaze duration and gaze frequency are both lower, and the driver's gaze duration in the flat curve segment with linear guidance signsspeed bumps is greater than that in the flat curve segment with simple linear guidance signs, but the difference between the two is not significant. This is consistent with Han Lei's research results on the average gaze duration of drivers under different levels of information on grassland roads. The research results show that in sections with information content of Q0 (no signs) and Q5 (linear guidance signswarning posts), drivers have longer gaze durations. The setting of linear guidance signs can effectively and reasonably guide the driver's line of sight, and drivers do not need to gaze multiple times and for a long time to obtain road traffic information. The setting of speed bumps has little effect on the average gaze duration and frequency of drivers.

V. SUMMARY OF RESULTS

Xu Huizhi et al. found in their study on the impact of urban roadside ban signs on bus drivers' driving behavior that the distribution of urban roadside ban signs significantly affected bus drivers' operating behavior on survey road sections and

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survey periods; 1.6 can be used as the judgment threshold for the change in the distribution of prohibition signs. When the average change in lane changes is less than 0.8 and the average change in acceleration and deceleration is less than 1.1, the driving behavior of bus drivers is relatively stable; When the change in the distribution of prohibition signs exceeds 1.6, the complexity of driver operations increases, manifested by frequent lane changes and acceleration/deceleration of vehicles.

Zhao Xiaohua et al. found in their research on the impact characteristics and mechanism of tunnel traffic signs based on driving behavior that there are differences in the effects of traffic signs on driving behavior within different influencing sections; Setting speed limit signs inside the tunnel can reduce the probability of accidents to a certain extent, and the repeated setting of speed limit signs can improve the driver's handling ability to a certain extent; Setting speed limit signs and exit distance warning signs inside the tunnel can help improve the driver's spatial control ability and driving comfort. Among them, setting tunnel exit distance warning signs in the affected area less than 1 km away from the tunnel exit can help improve the driver's driving comfort. At distances of 2 km and 1 Setting warning signs within a 5 km affected section can improve vehicle control capabilities while allowing drivers to drive at higher speeds; In addition, driving behavior under the influence of tunnel traffic signs is influenced by characteristic attributes such as driver gender, age, and driving experience, with male drivers having lower driving risks.

Jing Difei et al. found in their study on the impact of the front distance of variable information signs on driving behavior on eight lane highways that the process of variable information sign (VMS) recognition belongs to multi task driving behavior, and drivers need to complete VMS recognition, path decision-making, vehicle deceleration, and lane changing in a short period of time; When the front distance of the VMS is insufficient, the driver needs to quickly and significantly turn the steering wheel for continuous lane changing and emergency lane changing; In order to smoothly enter the deceleration lane, some drivers have taken measures to slow down and change lanes, increasing the risk of accidents; When the front distance of the VMS is too long, the short-term memory effect of the driver on the VMS increases the driving load.

Li Na et al. found in their study on the influence of the installation height and angle of a single column stop sign on the driver's fixation characteristics that: in univariate analysis, different installation angles only have a significant impact on fixation time, and the fixation time caused by forward installation is higher than that caused by a larger inclination angle; There was no significant difference in the effects of different installation heights on the driver's gaze time, gaze frequency, and first entry time; The interaction between installation height and angle has a significant impact on the driver's fixation time and fixation frequency, and among the four combinations of height (high and low) and angle (positive and oblique), "high × The fixation time and number of fixations caused by "positive" are much higher than other combinations, indicating that the installation of no stop signs using this combination can attract the most interest and attention of drivers. It is recommended to use this combination to install no stop signs on two-way four lane urban roads.

LvNengchao et al. found in their study on the effectiveness of driving load loading based on traffic sign information that there is a high correlation between subjective driving load and traffic sign information, and the reaction time increases with the increase of information level; However, the gender and driving experience of drivers have no significant impact on the reaction time of traffic sign recognition and subjective driving load quantification. This indicates that in driving tests, the amount of traffic sign information can be used to load cognitive load in driving tests, and this load has no difference in the gender and driving experience of drivers.

Lv Zhen et al. investigated the impact of different types of traffic signs on the visual characteristics of drivers on flat curves of grassland roads. They found that drivers had shorter fixation duration, lower video frequency, smaller fixation intensity, and a wider and more uniform distribution of fixation transfer when setting linear guidance signs and linear guidance signs+speed bumps in curve segments. In the curve section where warning posts are set, the driver's gaze duration and gaze frequency are both larger, which significantly increases their gaze intensity and increases the probability of the driver shifting between different areas. In the unmarked flat curve section, the driver's gaze range is relatively narrow, but due to the lack of guidance and warning from traffic signs, the driver's gaze intensity is greater than the setting of linear guidance sections.

Huang Lihua et al. found in their study on the impact of warning signs in the overpass area of expressways on drivers that only the number of lane changes showed a significant difference among the seven indicators. Through in-depth analysis of the characteristics of lane changing behavior, the results indicate that the impact of warning signs on lane changing behavior is independent of whether the overpass type guide signs are set up; Under directional, semi directional, and circular ramp conditions, setting warning signs will increase the number of lane changes within the scope of action, and the key increase area will be located within the range of 100 meters in front of and 300 meters behind the third level warning signs; Setting warning signs will increase the proportion of people changing lanes for the second and third times, by 14.61% and 2.37%, respectively, effectively improving drivers' lane changing behavior.

Zhao Xiaohua et al. found in their study that the location of warning signs at sharp turns has a significant impact on driving behavior, including the average speed on straight sections, the average acceleration on straight and curved sections, and the standard deviation of speed; The interaction effect between the position of the sign and the radius of sharp turns has a significant impact on the average speed of straight sections and the average acceleration of curved sections. The position of warning signs can affect the driving speed of vehicles on straight sections before turning, the longitudinal control of speed by drivers on curved sections, and the fluctuation of speed before and after turning; At the same time, the impact on speed control is also affected by the interference of sharp turning radius.

VI. CONCLUSION

This article studies the safety analysis of traffic signs on driving behavior. Eight references were selected, including the impact of urban roadside ban signs on bus drivers' driving behavior, the characteristics and mechanisms of tunnel traffic signs based on driving behavior, the impact of variable information sign lead distance on driving behavior on eight lane highways, the impact of single column stop sign installation height and angle on driver gaze characteristics, and the effectiveness of driving load loading based on traffic sign information content A safety analysis was conducted on the impact of different types of traffic signs on the visual characteristics of drivers on grassland roads, the impact of warning signs on drivers in the overpass area of expressways, and the impact of warning signs on driving behavior at sharp turns.

Most of the research is conducted through driving simulation experiments. By selecting indicators, conducting driving simulation experiments, conducting statistical analysis of experimental data, and analyzing driving behavior characteristics, relevant models are established to draw conclusions.

The location and height of traffic signs, as well as the amount of traffic sign information and traffic sign information, all have an impact on the driving behavior of drivers. Appropriate traffic signs should be set up at appropriate locations on the road to improve road safety.

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