Evaluation Method for Driving Suitability Level of Plateau Drivers

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Abstract: This article designs a driving suitability test method for plateau drivers in the Tibet plateau area. The method judges whether the driver is suitable for driving activities in the plateau area, through the heart rate blood sample collection and the driver's driving suitability evaluation, thereby reducing the traffic safety problems caused by altitude sickness. The evaluation method covers comprehensive indicators and is targeted. it can meet the application requirements of quantitative evaluation of driving suitability of drivers on the Tibetan Plateau to a high degree.

1 INTRODUCTION

The average altitude of the Tibetan Plateau is above 4000m. The oxygen partial pressure is only 11kPa, and the atmospheric partial pressure is the only 53kPa, which is close to the physiological limit of most people. According to medical data, drivers in plain areas will experience fear, nervousness, dizziness, depression, and other adverse reactions when they drive a motor vehicle on the plateau for the first time. These phenomena are called altitude sickness (Shu 2020, Chen, et al. 2012). According to the "2013 Statistical Annual Report on Road Traffic Accidents of the People's Republic of China", the western region has the most significant number of significant traffic accidents with more than ten deaths at a time, and the traffic safety situation is severe. At the same time, the traffic safety scholar (Zhu et al. 2013) analyzed the characteristics of 986 accidents in the plateau area and found that factors related to drivers accounted for 94.6% of the causes of traffic accidents in the plateau area. It is the leading factor in plateau road traffic accidents. The problem of plateau drivers driving suitability is serious, and driver's ability to carry out driving tasks (driving suitability) is challenging to measure. Regrettably, there is no relevant research involving equipment or methods for driving suitability assessment for plateau drivers.

In order to solve problem mentioned above, this paper designs a piece of test equipment and method for driving the adaptability level of plateau drivers. This design has made stricter evaluation standards for various complex conditions in the Tibetan Plateau, which is targeted and can meet the application requirements of quantitative evaluation of driver's driving suitability in the Tibetan Plateau to a high degree.

2 EVALUATION EQUIPMENT

The level test equipment designed as shown in Figure 1 includes a heart rate blood sample collection module, a driver's driving suitability evaluation platform, and a computer that provides basic algorithms and operating environments for the driver's driving suitability evaluation platform.

The module of heart rate blood sample collection use the MAX30102 chip to collect the pertinent data and transmit it to the computer.

The driver's driving suitability evaluation platform is shown in Figure 2, which includes a sensory ability test module, a physiological data collection module, and a suitability evaluation module.

The module of perceptual ability test collects the number and time of identification of the scary scene in the display window (Scialfa, et al. 2012, Yang, et al. 2014). As shown in Figure 3, the perception ability test module requires the tester to click on the hazard's

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location in the scene picture by playing the scene picture containing potential traffic conflicts. When the tester clicks on the image with the mouse, it will be real-time by the computer data and record. Set an effective click area at the hazard location of the scene graph. This area is used for computer discrimination and is not visible to the tester. Combined with the analysis data of related traffic safety accidents, it is concluded that the reaction time of the driver in response to an emergency during the driving process is 0.7 to 2.0 seconds, of which the average time for the driver to judge is about 1.5 seconds. Therefore, when the scene image appears in an incorrect position or is not clicked within 2 seconds, the current scene danger recognition fails; otherwise, the award succeeds. The perceptual ability test module can record the average value of the tester's successful recognition ratio and the corresponding risk recognition time of the recognized scene during the risk recognition process, and calculate the average value during the evaluation process for evaluation and analysis.

The physiological data collection module receives the heart rate and blood oxygen saturation of the test person during the hazard identification test. After the test person completes the hazard identification test, the physiological data collection module calculates the variance of the rapid heart rate time series according to the instantaneous heart rate time series. It calculates the mean value of the test person's blood oxygen saturation at the same time.

The critical parameter input module is to judge whether the tester can carry out driving activities by asking and entering the time and illness. Due to the high altitude of the Tibetan plateau, there may be different degrees of altitude sickness due to physical reasons when you first enter Tibet. The symptoms of altitude sickness will generally be relieved within 1 to 7 days after entering Tibet. Those who generally enter Tibet for less than three days do not meet the primary conditions of high altitude driving are not suitable for driving activities, especially on passenger lines. However, taking into account, the differences in the physical conditions of each age group and each individual, the progress of the test person can be recorded according to the normalization method. The state of the body is relieved after hiding. The state is to exclude patients who are not suitable for working at altitude, such as hypertension patients over 50 years old, coronary heart disease patients, severe diabetes patients, patients with moderate or above chronic lung disease, patients with bronchial asthma, and patients with pulmonary hypertension Wait, click in the selection column through the inquiry. If the test person suffers from any of the diseases mentioned above, it is consider that the test person is not suitable for driving activities and does not meet the primary conditions for plateau driving. Simultaneously, the setting of critical parameters can also refine and adjust based on further investigations.

3 EVALUATION METHOD

The specific work flow chart of plateau driver driving suitability level test method is shown in Figure 4.

Perception ability test is perform to obtain the tester's identification of the hazard in the scene picture in the plateau environment.

When the test person completes the risk identification test, the suitability evaluation module generates the sub-dimension index of perception ability and the sub-dimension index of physiological status according R_0 to the number of identification and identification time obtained by the perception ability test module, and the variance of instantaneous heart rate time series calculated by the physiological data collection module and the mean value of blood oxygen saturation, as shown in formula (1).

$$R_0 = (P_0, C_i, x_i) = \begin{bmatrix} P_0 & C_1 & x_1 \\ & C_2 & x_2 \\ & C_3 & x_3 \\ & C_4 & x_4 \end{bmatrix}, \quad (1)$$

Where, P_0 is the current level is reflected by the target element to evaluate, C_i also represents the ith index factor, and x_i is the data corresponding to the current status P_0 of the index factor C_i. After obtaining the matter element to be evaluated, the matter element analysis method is combined to further assess driver's suitability to carry out the driving task (Ai, et al. 2020). That is, input the data to assess into the suitability evaluation model.

4 ABILITY ASSESSMENT MODEL

A suitability evaluation model is establishe in the suitability evaluation model, and the tester is evaluate for the driving suitability level of plateau drivers through the suitability evaluation model. The establishment process of the suitability evaluation model includes the following steps:

Step 1) Delineate the level interval of the number identification, the identification time and the variance of the instantaneous heart rate time series and the level interval of the mean value of the blood oxygen saturation, the number of identifications, the identification time, the variance of the instantaneous heart rate time series and the mean value of blood oxygen saturation are both set to 3 levels. The three levels are respectively more suitable, suitable, and unsuitable. The three levels form a level set, $N = \{N_{01}$ (more suitable), N_{02} (suitable), N_{03} (unqualify) }, then the classical matter element R_0 is as in formula (2):

$$R_{0j} = (N_{0j}, C_i, X_{0ji}) = \begin{bmatrix} N_{0j} & C_1 & x_{0j1} \\ & C_2 & x_{0j2} \\ & C_3 & x_{0j3} \\ & C_4 & x_{0j4} \end{bmatrix} = \begin{bmatrix} N_{0j} & C_1 & < a_{0j1}, b_{0j1} > \\ & C_2 & < a_{0j2}, b_{0j2} > \\ & C_3 & < a_{0j3}, b_{0j3} > \\ & C_4 & < a_{0j4}, b_{0j4} > \end{bmatrix} \quad (2)$$

where, $N_{0j}[0,1]$ represents the jth level, $j = 1,2,3$, N_{01} represents more suitable, N_{02} represents suitable, N_{03} represents unsuitable; C_i represents the ith index factor, $i = 1,2,3,4$, C_1 represents the number identification, C_2 represents the identification time, C_3 represents

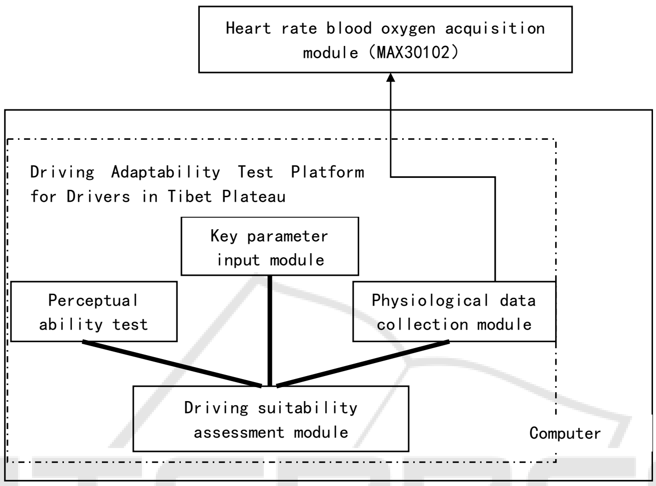

Figure 1: The structure diagram of the equipment for evaluating the driving suitability level of plateau drivers.

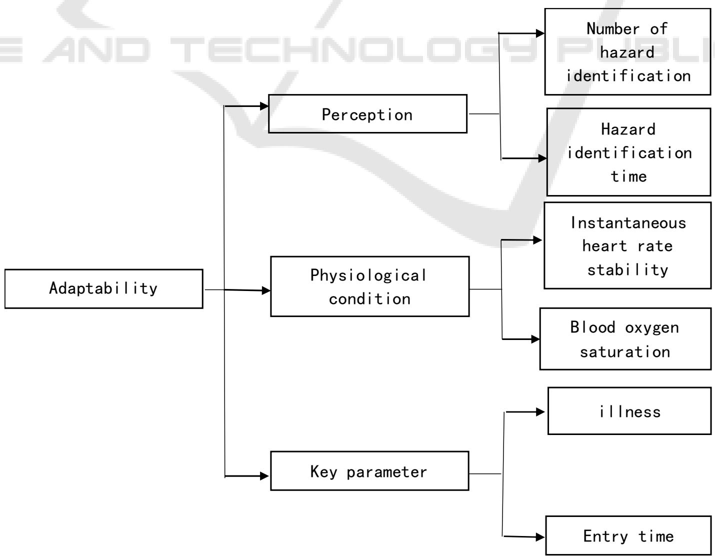

Figure 2: Schematic diagram of the evaluation index system for driving suitability level of plateau drivers.

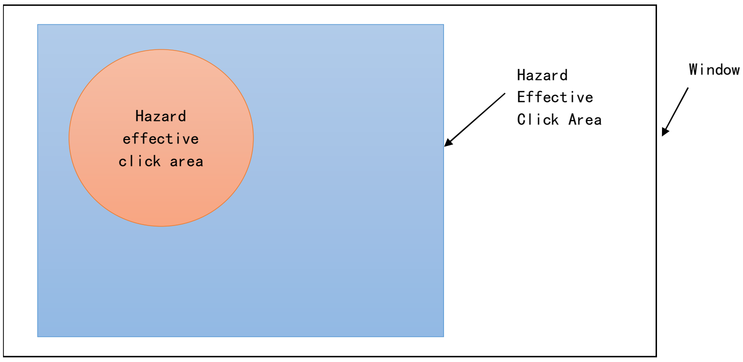

Figure 3: The schematic diagram of the perceptual ability test module in the driving suitability evaluation platform for plateau drivers displayed on the computer.

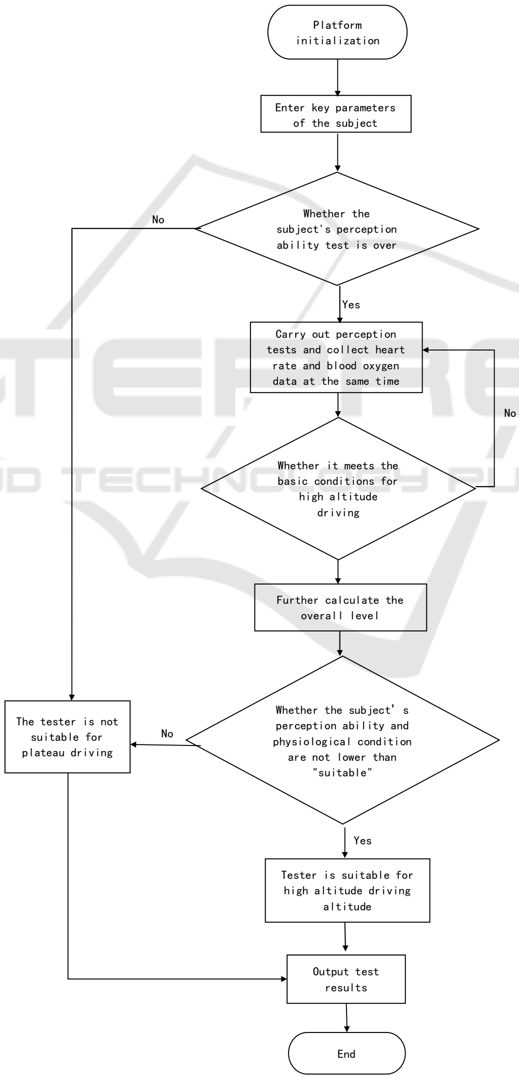

Figure 4: Schematic diagram of the process of evaluating the driving suitability level of highland drivers.

the variance of the instantaneous heart rate time series, C_4 represents the mean value of blood oxygen saturation; X_{0ji} is a number under j level, $i=1,2,3,4$, X_{0ji} is the level interval specified by N_{0j} on index factors $<a_{0ji}, b_{0ji}>$;

Step 2) Determine the number of identifications, identification time, the variance of the instantaneous heart rate time series, and the mean value of blood oxygen saturation R_P, as shown in formula (3):

$$R_P=(P,C_i,X_{Pi})=\begin{bmatrix} P & C_1 & x_{P1} \\ & C_2 & x_{P2} \\ & C_3 & x_{P3} \\ & C_4 & x_{P4} \end{bmatrix}=\begin{bmatrix} P & C_1 & <a_{P1},b_{P1}> \\ & C_2 & <a_{P2},b_{P2}> \\ & C_3 & <a_{P3},b_{P3}> \\ & C_4 & <a_{P4},b_{P4}> \end{bmatrix} \quad (3)$$

where, P is the total number of grade intervals, C_i represents the ith index factor, and x_{pi} is the whole range $<a_{Pi},b_{Pi}>$ of the grade distribution specified by the index factor C_i;

Step 3) Calculate the correlation $K_j(x_i)$ between the number of identifications, identification time, the variance of the instantaneous heart rate time series, and the mean value of blood oxygen saturation and each level, and determine the identification number, identification time, and rapid heart rate time according to the correlation. The variance of the sequence and the mean value of the blood oxygen saturation respectively correspond to the level, as in formula (4):

$$K_j(x_i)=\frac{\rho(x_i,x_{0ji})}{\rho(x_i,x_{Pi})-\rho(x_i,x_{0ji})}, \quad (4)$$

where:

$$\rho(x_i,x_{0ji})=\left|x_i-0.5(a_{0ji}+b_{0ji})\right|-0.5(a_{0ji}-b_{0ji}),$$

$$\rho(x_i,x_{Pi})=\left|x_i-0.5(a_{Pi}+b_{Pi})\right|-0.5(a_{Pi}-b_{Pi}),$$

x_i is the measured data used to calculate the degree of association with each level, that is, the measured value of the ith index factor;

Step 4) Calculate the correlation between the number identification and identification time and each level, use the most significant numerical correlation to characterize the perception ability, and use the level corresponding to the perception ability as the perceived ability level; calculate the variance and blood oxygen of the instantaneous heart rate time series The degree of association between the mean value of saturation and each class is characterized by the degree of association with the most significant weight to represent the physiological condition, and the level corresponding to the physiological state is regarded as the level of physiological condition; the perception ability and the degree of association between the physiological state and each group are calculated The level corresponding to the highest degree of relevance is regarded as the overall level, as in the formula (5):

$$K_j(P_0)=\sum_{i=m}^{n} w_i K_j(x_i), \quad (5)$$

where, m and n are the upper and lower limits of the value of i, which used for limit the calculation range; P_0 is the current level of the index factor to be evaluated by the tester, and w_i is the evaluation weight coefficient of the index factor:

When m=1 and n=2, it represents the degree of relevance of the test person's perception ability to the jth level;

When m=3 and n=4, it means the degree of significance of the test person's physiological condition to the jth level;

When m=1 and n=4, it means the degree of significance of the test person's overall grade to the jth level;

To test the evaluation weight coefficients of the four sub-dimension indicators (namely number identification, identification time, the variance of instantaneous heart rate time series, and mean value of blood oxygen saturation), in the present invention, w_1, w_2, w_3 and w_4 are respectively 0.2, 0.3, 0.2 and 0.3.

Step 5), evaluate the driving suitability level of the plateau driver on the test person, and output the evaluation result by the computer, as follows:

When the perceptual ability level and the physiological condition level are suitable or more appropriate, the overall level of the test person is further calculate. When the general story is suitable or more suitable, the test person is ideal for altitude driving; otherwise, the test person is not. Suitable for altitude driving; when the level of perceived ability or physiological condition is inappropriate, or the critical parameter input information does not meet the parameter setting standards, the test person is not suitable for altitude driving.

In summary, the output of the evaluation platform serves as a reference basis for the tester's suitability for plateau driving.

5 CONCLUSIONS

The design coverage index of this article is more comprehensive and pertinent. First, the indicators involve the primary indicators of the driver's perception of danger and the physiological indicators and critical indicators of the driver in the plateau environment; secondly, the matter-element analysis method used to evaluate the driving suitability level of plateau drivers can meet the application requirements of quantitative evaluation of driving suitability of plateau drivers in Tibet to a great extent; at the same time, this paper sets up key parameter input modules to perform preliminary evaluations on the testers' driving suitability level for plateau drivers, which can improve the efficiency of the assessment; and the sensory ability test module passes the visual evaluation, which is more intuitive to the tester's test effect, and can reflect the tester's perceptual ability more realistically. This article is to reduce the safety risk of plateau drivers through various physical tests on drivers. However, there are still many unpredictable factors in plateau areas. The driving ability test of drivers can be further improved and strengthen.

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