Experiment Research on Influence of Anxiety Emotion for Driving Behaviors

Liping Liu, Chang Sun, Dong Kong, Yingcui Du, Yunyun Wang, Xiaoyuan Wang

***Abstract*— Anxiety is a common negative emotion during driving, which has an important influence on driving behaviors. In order to explore the influence mechanism of anxiety on driving behavior, an anxiety emotion induced method is designed and virtual driving experiment is carried out by using the high simulation virtual driving platform in this paper. And the changing regularities of driving behaviors of driving speed, acceleration frequency, lane changing frequency and acceleration interference in anxiety emotion are studied. One-way analysis of variance (ANOVA) shows that driving behaviors in anxiety emotion are significantly different compared with the normal emotion. This study provides a basis for further analysis of the relationship between driving behavior and traffic safety in anxiety emotion, which is of great significance to future research of auxiliary driving and unmanned driving.**

***Index Terms*— Traffic safety, Anxiety emotion, Driving behavior, One-way analysis of variance**

I. INTRODUCTION

Anxiety is an emotional reaction to the reality of the potential challenges or threats, a common reaction when a person is facing an event or scene that he cannot control. Bekker et al. [1] believes that anxiety is the subjective feeling of worry, nervousness and irritability, which can make the autonomic nervous system excited. It is a kind of negative emotions we are familiar with, and mainly occurs when a person is confronted with uncertain situations in order to deal with potential threats. Research shows that driver's anxiety emotion is related to many dangerous driving behaviors [2]. Therefore, it is of great guiding significance for traffic safety to study drivers' behavior characteristics in anxiety emotion.

However, the relationship between anxiety emotion and traffic accidents in academia is inconclusive. Studies have shown that anxiety-related dangerous driving reaction can lead to aggressive driving behavior [3]. The frequent and unpredictable events such as traffic congestion, overtaking and overtaken in the journey constantly consume personal coping abilities. As a result, driver's anxiety emotion will be triggered out and a series of anxiety-related behaviors like emotional irritability, hostile confrontation and retaliation will rise to the surface when driver's coping ability cannot meet the objective needs. Taylor et al. [4] investigated the drivers who had had traffic accidents with questionnaires. And the result showed that drivers with high anxiety were likely to suffer more driving errors. Shahar [5] found that anxiety could distract the driver and create a flaw in attention, which would lead to operation errors, and have a negative impact on traffic violation. Wong, Ides Y. et al. [6] used self-report questionnaires to examine the effects of trait anxiety on driving behavior. And the result suggested that anxiety could affect driving behavior, especially driving errors. However, many studies have found that anxiety can improve driving vigilance. Although drivers may be distracted by anxiety, their accident rates are below average due to focus on threat assessment in anxiety emotion. Actually, Taylor et al. [7] have found that drivers in anxiety emotion made more errors than control group, while there was no difference in accident rates in a road driving task. Therefore, it can be concluded that all driving behaviors in anxiety emotion are not conducive to traffic safety, and their role is still unclear.

On this basis, effective scheme is designed to induce drivers' anxiety emotion and virtual driving experiment is carried out after the driver's anxiety emotion is induced. The influence of anxiety emotion on driving behaviors of driving speed, acceleration frequency, lane changing frequency and acceleration interference is explored, which lays a foundation for further analysis of the relationship between anxiety and traffic safety.

II. EXPERIMENTAL DESIGN AND DATA ACQUISITION

A. Subjects

30 drivers including 19 males and 11 females were recruited randomly, ranging in age from 20 to 50, with an average age of 28.7 years, and were healthy, belonging to individuals selected from the normal population.

B. Experimental conditions

Virtual driving is used to instead of actual driving in this experiment in order to ensure the safety of the experiment and the repeatability of the road traffic environment. The experimental equipment mainly includes: the high simulation virtual driving platform (including simulated driving experimental vehicle, simulation workstation cluster, visual display system, sound system, mobile control terminal, and data collector for vehicle simulation driving test platform, as shown in Fig. 1), notebook computer, high-definition camera, emotional experience self-report questionnaire. Emotional materials used in this experiment include International Affective Picture System (IAPS) and Chinese Affective Picture System library of Beijing Normal University (CAPS). IAPS is an international authoritative emotional material and CAPS is the emotional material that adapt to Chinese social and cultural background. According to the different sensory channels presented by the material, the experimental emotional materials include visual (text, pictures), auditory (emotional music) and multi-channel stimuli (video).

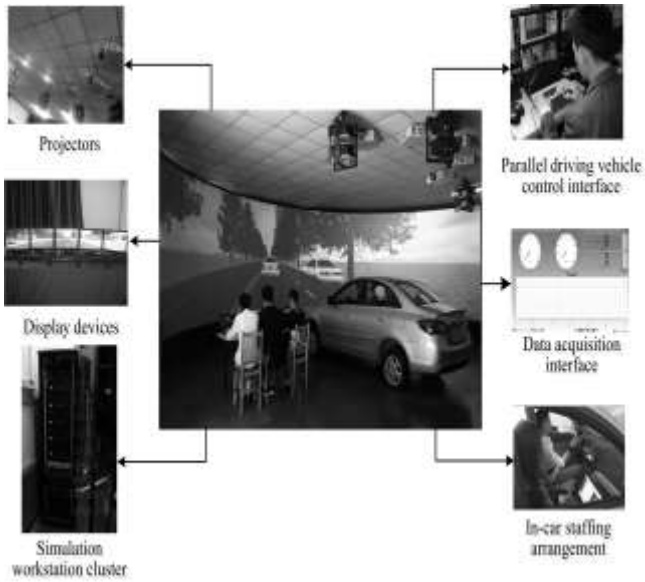

Fig. 1 High simulation virtual driving platform

According to the standard of "Road traffic signs and markings" (GB5768-2009), experimental route was structured with road editor (as shown in Fig. 2). Import the generated road network into the vehicle driving simulator, and the basic traffic scene is shown in Fig. 3. Set the driving environment to sunny, good air visibility, breeze, medium traffic density, no traffic jam.

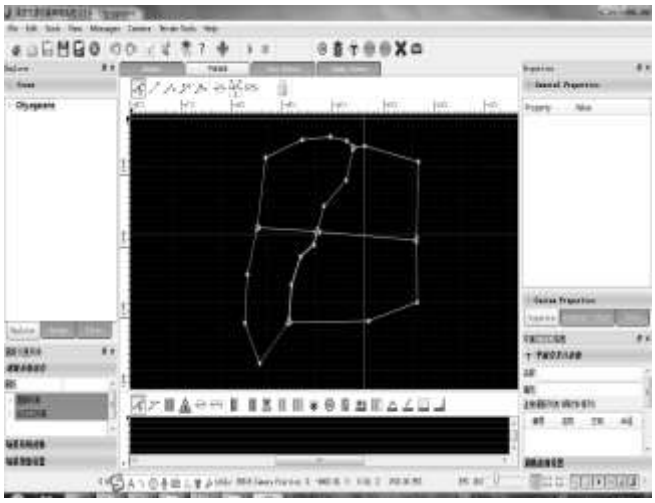

Fig. 2 Virtual driving experimental road map

Fig. 3 Rendering of basic traffic scene

C. Experimental process

The experimental procedure is shown in Fig. 4:

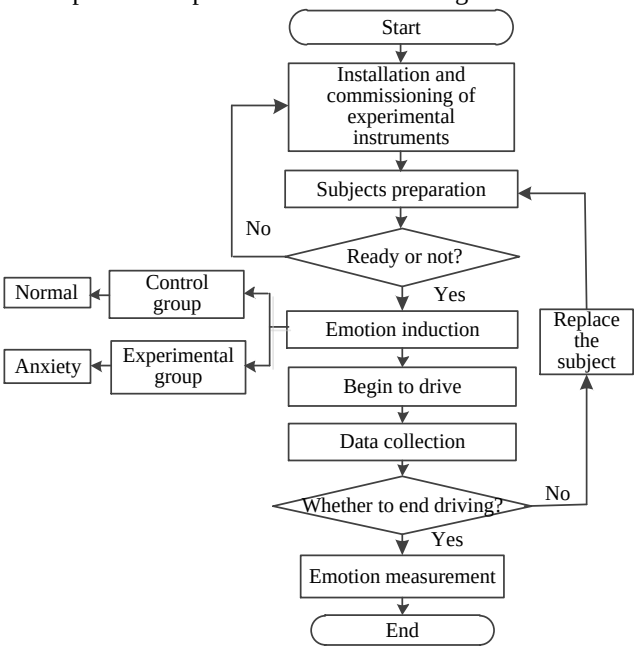

Fig. 4 Flow chart of virtual driving experiment

(1) Install and connect the experimental equipment, debug them to ensure that the experimental equipment work properly and the experiment go smoothly.

(2) Matters needing attention and system of rewards and penalties in the process of experiment were conveyed to subjects. Matters needing attention were as follows: try to keep the natural driving state, don't be too nervous, and don't suppress their own emotions. System of rewards and penalties was as follows: a certain reward they would get if the experiment completed successfully and part of the reward would be deducted if the experiment cannot be carried out normally due to their own fault. Next, the subjects were trained to learn driving simulator to familiarize with various driving operations.

(3) Play soothing music for the subject to create a quiet atmosphere, so that the emotion keeps in a normal state. Start the experimental equipment and guide him to drive experimental vehicle. Collect the experimental data when the subject in the normal emotion.

(4) Then the anxiety-provoking experiment was carried out. Before driving, the experimental organizers showed picture materials that could induce anxiety emotion in IAPS and CAPS to the subject，so that the subject could produce association and imagination. And then recall his memory about anxious events to remind his feelings when events occurred, such as difficulties encountered at home, violation of traffic regulations, and the driving license was confiscated etc. As the memory went on, the emotion was gradually aroused. Driving experiment was carried out immediately afterwards. During driving, voice induction was conducted to continue subject's memories about the picture materials that displayed before driving and his own experience. Then sound materials that could induce anxiety emotion in CAPS were played to the subject. In addition, the time of red light in crossing was extended by controlling the background operating system to induce anxiety emotion by waiting for a long time. And the subject's emotional activation degree, which was divided into 3 grades of low-medium-high, was

asked and recorded every one minute. The driving data was synchronously collected and recorded by the experimental equipment. And the subject's facial expression and behavior were recorded in real time with video detection system.

After driving, the subject would watch the video playback during driving, and fill out the self-report questionnaire of emotional experience. Effectiveness of emotion induction of the subject was determined finally according to natural inquiring, emotional self-report questionnaire and statistical analysis results of facial expression and behavior.

According to the above experimental steps, 30 subjects were organized to participate in the experiment. each subject in the calm and anxiety state were two virtual driving experiments, received a total of 120 experimental data.

III. RESULTS

In order to explore the difference of driving behavior in anxiety and normal emotion, one-way ANOVA is used in this research to check whether there are significant differences in behavioral parameters when the significance level α is 0.05. The results show that the driving speed, acceleration frequency, lane changing frequency and acceleration interference are different obviously in anxiety and normal emotion. And the distribution diagrams of 30 subjects' behavioral parameters in anxiety and normal emotion are plotted to display the influence of anxiety on driving behavior more intuitively.

A. Driving speed

The driving speeds in anxiety and normal emotion are analyzed by one-way ANOVA, and the results are shown in Tab.1.

Tab.1 One-way ANOVA of driving speeds

Source of variance	Sum of squares	Degrees of freedom	Mean square	F-ratio	Value of *p*
Between-group	3502.176	1	3502.176	86.106	0.000
Within-group	2359.028	58	40.673		
Total	5861.204	59			

As can be seen from the Tab.1, value of p <0.05. So the null hypothesis is rejected when the significance level is 0.05. Therefore, it can be inferred that the driving speeds are significantly different in the emotion of anxiety and normal. The average driving speeds of 30 subjects are shown in Fig.5.

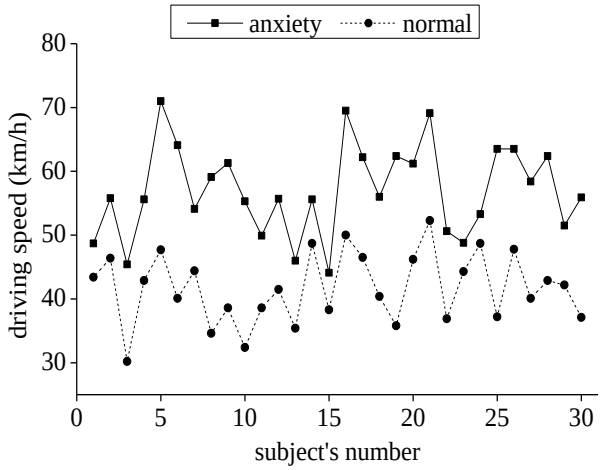

Fig.5 Average driving speeds of 30 subjects

It can be seen from Fig.5, the average driving speeds of the subjects in anxiety emotion are significantly increased compared with the normal emotion. The maximum difference value is 26.6 km/h and the minimum difference value is 4.5 km/h. Thus, drivers in anxiety emotion tend to pursue higher speed, which shorten the time of vehicle control in emergency situations. As a result, probability of traffic accidents will increase. Therefore, the influence of anxiety on driving speed is one of the unfavorable factors of traffic safety.

B. Acceleration frequency

The acceleration frequencies in anxiety and normal emotion are analyzed by one-way ANOVA, and the results are shown in Tab.2.

Tab.2 One-way ANOVA of acceleration frequencies

Source of variance	Sum of squares	Degrees of freedom	Mean square	F-ratio	Value of *p*
Between-group	1161.600	1	1161.600	199.198	0.000
Within-group	338.220	58	5.831		
Total	1499.820	59			

As can be seen from the Tab.2, value of p <0.05. So the null hypothesis is rejected when the significance level is 0.05. Therefore, it can be inferred that the acceleration frequencies are significantly different in the emotion of anxiety and normal. The average acceleration frequencies of 30 subjects are shown in Fig.6.

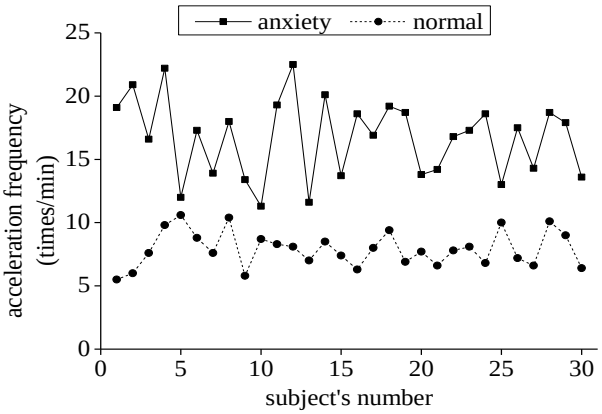

Fig.6 Average acceleration frequencies of 30 subjects

It can be seen from Fig.6, the average acceleration frequencies of the subjects in anxiety emotion are significantly increased compared with the normal emotion. The maximum difference value is 14.9 times/min and the minimum difference value is 1.4 times/min. Thus, drivers behave more aggressively in anxiety emotion, which increases the security risk to some extent.

C. Lane changing frequency

The lane changing frequencies in anxiety and normal emotion are analyzed by one-way ANOVA, and the results are shown in Tab.3.

Tab.3 One-way ANOVA of lane changing frequencies

Source of variance	Sum of squares	Degrees of freedom	Mean square	F-ratio	Value of *p*
Between-group	1.442	1	1.442	214.818	0.000
Within-group	0.389	58	0.007		
Total	1.831	59			

As can be seen from the Tab.3, value of p <0.05. So the null hypothesis is rejected when the significance level is 0.05. Therefore, it can be inferred that the lane changing frequencies are significantly different in the emotion of anxiety and normal. The average lane changing frequencies of 30 subjects are shown in Fig.7.

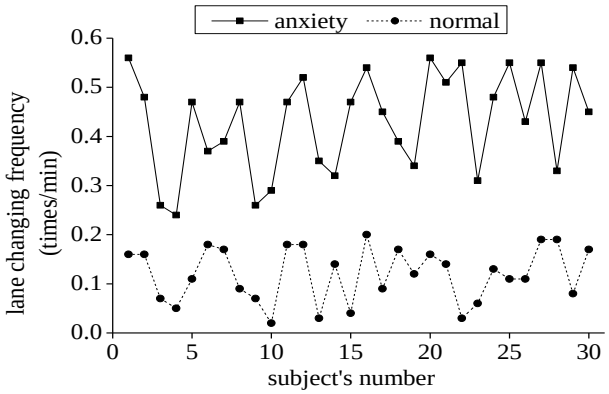

Fig.7 Average lane changing frequencies of 30 subjects

It can be seen from Fig.7, the average lane changing frequencies of the subjects in anxiety emotion are significantly increased compared with the normal emotion. The maximum difference value is 0.52 times/min and the minimum difference value is 0.14 times/min. Thus, drivers in the anxiety emotion tend to change the current traffic situation and choose the traffic environment which can better meet their own needs.

D. Acceleration interference

The acceleration interferences in anxiety and normal emotion are analyzed by one-way ANOVA, and the results are shown in Tab.4.

Tab.4 One-way ANOVA of acceleration interferences

Source of variance	Sum of squares	Degrees of freedom	Mean square	F-ratio	Value of p
Between-group	5.046	1	5.046	184.555	0.000
Within-group	1.586	58	0.027		
Total	6.632	59			

As can be seen from the Tab.4, value of p <0.05. So the null hypothesis is rejected when the significance level is 0.05. Therefore, it can be inferred that the acceleration interferences are significantly different in the emotion of anxiety and normal. The average acceleration interferences of 30 subjects are shown in Fig.8.

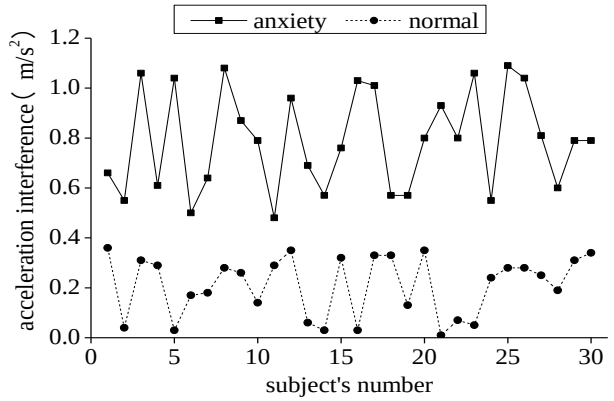

Fig.8 Average target vehicles' acceleration interferences of 30 subjects

It can be seen from Fig.8, the average acceleration interferences of the subjects in anxiety emotion are significantly increased compared with the normal emotion. The maximum difference value is 1.01 m/s^2 and the minimum difference value is 0.19 m/s^2. Thus, target vehicle disturbance is larger and driving comfort is poor when drivers in the anxiety emotion.

IV. DISCUSSION

In this paper, virtual driving experiment is carried out, and the changing regularities of driving behaviors of driving speed, acceleration frequency, lane changing frequency and acceleration interference in anxiety emotion are studied. Analysis found that anxiety makes the driver is not satisfied with the current traffic environment, and thus eager to seek strategy to change. As a result, driving behavior is more radical. Furthermore, the average driving speed, acceleration frequency, lane changing frequency and acceleration interference are increased in anxiety emotion. Therefore, anxiety has a certain impact on the occurrence of traffic accidents, which is one of the adverse factors of transport safety. However, there are still the following problems in this study: ① the number of driver samples is relatively small, the universality of the conclusions to be further clarified; ② research conclusions are from the virtual driving experiment, and actual driving experiment is needed to further verify the conclusions. These issues need to be studied and refined in subsequent studies.

V. CONCLUSION

Emotion is the main factor that affects the driving behavior. As a common negative emotion in the process of driving, anxiety has an important influence on the driving behavior. In this paper, virtual driving experiment is carried out based on the high simulation virtual driving platform to explore the changing regularities of driving behaviors of driving speed, acceleration frequency, lane changing frequency and acceleration interference in anxiety emotion. One-way ANOVA is used to check the differences of behavioral parameters. Every behavioral parameter in anxiety and normal emotion are compared finally. The results show that anxiety emotion has a significant effect on driving behaviors such as driving speed, acceleration frequency, lane changing frequency and acceleration interference. This study provides a basis for further analysis of the relationship between driving emotion and behavior, which is of great significance to the study of vehicle active safety warning and future unmanned research.

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