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Research Article

A Pilot Study on Impact of Mood State on Emergency Response Capacity for Young Novice Drivers

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As young novice drivers are inclined to getting involved in traffic accidents due to their improper emergency response under sorts of gender affective state, namely, mood, widely generated in fast-paced urban life, it is of great necessary to study the impact of mood state on responsive capacity for young novice drivers. Fourteen college students were recruited to take part in complex reaction experiments for this pilot study. Each subject's mood was collected through a simplified POMS scale, while their complex reaction time (CRT) and response error rate (RER) were acquired during the experiments. The study results showed that young novice drivers' RER was significantly positively correlated (pc=0.323**, "pc" omitted next) with their score of total mood disturbance (TMD), and a logarithmic regression model was feasible to describe the correlations with a good fitting effect. Further, their RER was also significantly positively correlated with score of negative mood state components such as nervousness (0.290**), anger (0.300**), fatigue (0.278**), depression (0.287**), and fluster (0.261*), and a quadratic or cubic regression model was suitable to describe the correlations. Additionally, the young novice drivers' CRT was significantly positively correlated with score of nervousness (0.222**), vigorousness (0.227*), and fluster (0.273*), and a quadratic or exponential regression model was suitable to describe the correlations. The results can provide theoretical support for developing targeted intervention to improve young novice drivers' emergency response capacity for driving training or traffic management authorities.

1. Introduction

A traffic accident usually happens due to different types of factors including human, vehicle, road, and environment, among which, human factor accounts for 90% of all traffic accidents [1, 2]. For current complex traffic environments, especially in urban roads with mixed traffic flow including motor and non-motor vehicles in China, a driver would often encounter emergent events like front vehicle's sudden braking or surrounding vehicle's unexpected cutting in line or pedestrian's abrupt jaywalking. Then, whether a traffic conflict or accident happens or not will depend on the driver's emergency response ability. A static report indicated that 4.19% of road traffic accidents in China occurred because of drivers' improper emergency response [3]. Additionally, with rapid development of social economy, lots of young drivers can afford a car for commuting or entertainment or travelling, leading to more and more novice drivers emerging on urban roads. However, due to the lack of driving experience and poor self-adjusting, young novice drivers are apt to become more emotional or aggressive, contributing to more involvements in traffic conflicts even accidents [4]. A global status report on road safety from World Health Organization (WHO) in 2015 indicated that the leading cause of death for teenagers and young adults aged 15 to 29 today was road traffic injuries [5]. In China, a report showed that traffic accidents caused by novice drivers with less than 5 years' driving experience accounted for 36% of the total accidents [6]. Therefore, it is strongly necessary to study young novice drivers' emergency response capacity for improving traffic safety levels in auto era nowadays.

1.1. Driver's Emergency Response. Currently, observational indicators of a driver's emergency response mainly focus on physiological features [7, 8], visual character [9–11], operational behavior [12, 13], and reaction time [14–17]. For instance, Wang et al. found that when encountering a pedestrian's abrupt jaywalking, a driver's growth rate of heart rate and low frequency value of heart rate variability increased with the decrease of emergency response distance when the vehicle speed remained unchanged [7]. Niu et al. found that when distraction degree or the hazard level of traffic scenes increased, the drivers' pupil diameter would increase and the fixation duration would become longer after the take-over reminder in automated driving [9]. Jia discovered that the average value of maximal brake pedal force would become bigger and the time to reach the maximal force would become smaller if traffic situation was more urgent, and the steering behavior would become fiercer when the driver's vision was limited [13]. Compared with the aforementioned physiological features, visual characters, and operational behaviors, the indicator of reaction time is more widely used to evaluate a driver's emergency response capacity. Fujita et al. explored that elderly drivers (aged>75-years) took the same time from viewing visual stimulus to releasing the accelerator pedal as younger drivers (aged 22-39 years), but took longer time to switch to the brake pedal during emergency braking [14]. Medic-Pericevic found that there existed a positive correlation between reaction time and aging for professional drivers and their response time was more dependent on age than that on driving experience [15]. Sagberg et al. investigated the hazard perception time for novice drivers with an average driving year of 1 and experienced drivers with an average driving year of 27 through watching hazard-related videos, and found that the average hazard perception time for experienced drivers was less than novice drivers', but with no significance [16]. Yadav et al. explored that a year increase in driving experience led to 2% reduction in reaction time, and mature drivers (aged≥25years) responded 15% faster than young drivers (aged<25 years) [17]. However, most of the observational indicators including physiology, vision, and operation behavior was not suitable to be used to directly evaluate one driver's emergency response capacity, as those indicators were not closely related with traffic accidents. With regard to the indicator of reaction time, it is not enough to be used to comprehensively evaluate a driver's emergency response capacity as the response accuracy is not taken into consideration.

1.2. Effect of Psychological Factors on Emergency Response. Except for those stable personal characteristics like age and driving years, some psychological factors like distraction

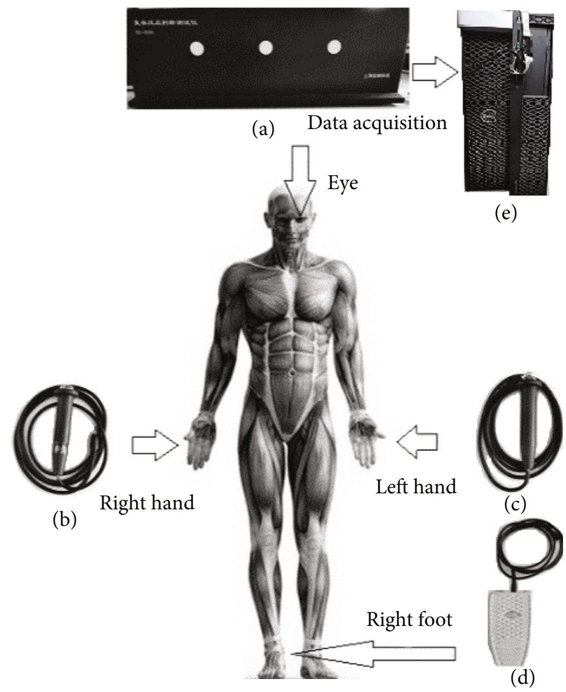


Figure 1: Schematic diagram of complex reaction test.

Figure 2: A subject's experimental operation diagram.

and emotion also influence a driver's emergency response capacity. D'Addario et al. discovered that cognitive distraction significantly increased brake reaction time for the right-incursion vehicle hazard and left-turn across path hazard [18]. Lyu et al. discovered that compared with normal driving, distractions through complex calculations during driving could result in a narrower visual search range, a weaker ability to control accelerator pedal, and a significantly increased response time in emergency situations [19]. Besides distraction, it is widely accepted that driving behavior or performance is also affected by emotion in different way [20, 21]. As the most common emotional experience during driving, anger was an important contributor to aggressive or dangerous driving behavior and traffic violations, consequently leading to serious traffic conflicts even accidents [22–25]. For instance, Wan et al. found that anger was frequently related with bigger velocity and acceleration

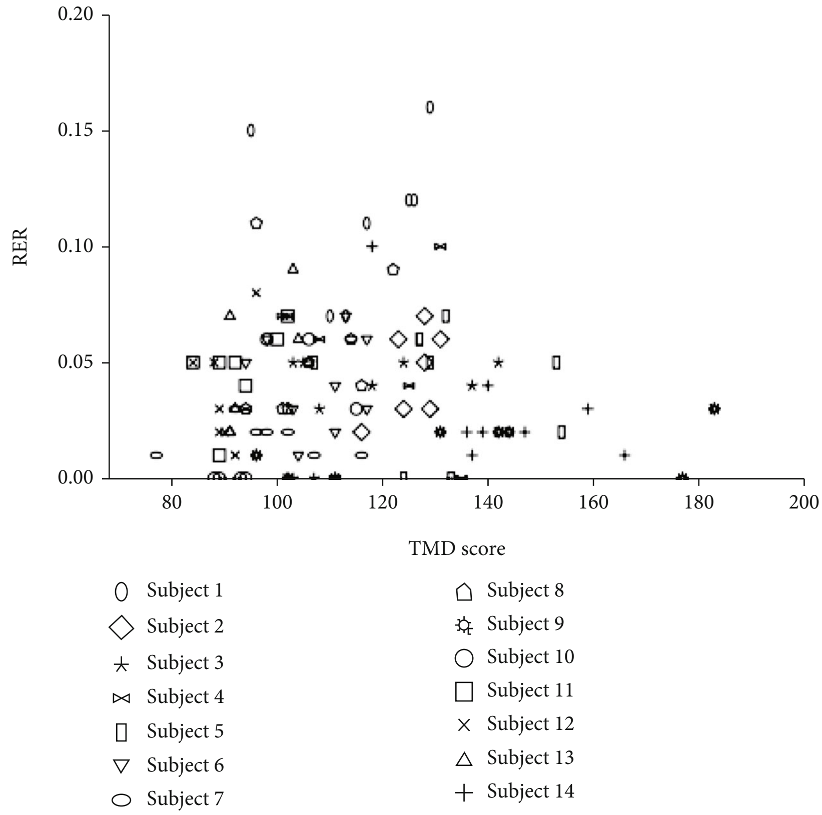


Figure 3: Relationship between *RER* and original *TMD* score for all 14 drivers.

Table 1: Pearson's correlation analysis between *RER* and original *TMD* score.

	Variables	*TMD*	*RER*
TMD	Pearson correlation	1	0.025
	Significance (two-tailed)		0.794
	Cases	107	107
RER	Pearson correlation	0.025	1
	Significance (two-tailed)	0.794	
	Cases	107	107

Table 2: Pearson's rank correlation between *TMD_R* and *RER*.

	Variables	*TMD_R*	*RER*
TMD_R	Pearson correlation	1	0.323**
	Significance (two-tailed)		0.002
	Cases	90	90
RER	Pearson correlation	0.323**	1
	Significance (two-tailed)	0.002	
	Cases	90	90

Notes: $^{**}p < 0.01$; $^{*}p < 0.05$.

and poorer lateral or longitudinal control of vehicle in general traffic situations [22]. Myounghoon et al. discovered that drivers in anger and sadness showed significantly more operational errors than those in neutrality and drivers in anger reported significantly higher physical workload than neutrality [26]. As a driver has to deal with emergency situations immediately, their driving behaviors or performances in emergency are crucial and inevitably affected by emotional states. Recently, there are some studies about the effect of emotional states on emergency response. Qian et al. discovered that drivers in anger or happiness were inclined to cost less time to collision and take a longer time to brake while following a vehicle than that in neutrality and drivers in happiness had a lower perceived accident risk than anger and neutrality [27]. Zhang et al. indicated that drivers with anger tended to perform harder braking when lane merging events happened and to have a closer headway during car-following [28]. Qi et al. found that drivers in high pressure (i.e., traffic congested state) had a significantly wider space range of fixation points' distribution and less fixation duration, as well as less blink rate than those in low pressure [29].

However, due to complexity of human affective state, a driver while driving is often not under an obvious emotion arising with clear reasons or causes in a short time. Frequently, before starting a vehicle, a driver is probably with a tender affective state, namely, a general affective background which has been lasting until present without clear reasons in past few days or even longer. This kind of tender affective state is usually called mood, while emotion is usually regarded as a kind of intense affective state [30]. Especially in fast-paced, fiercely competitive, and stressful

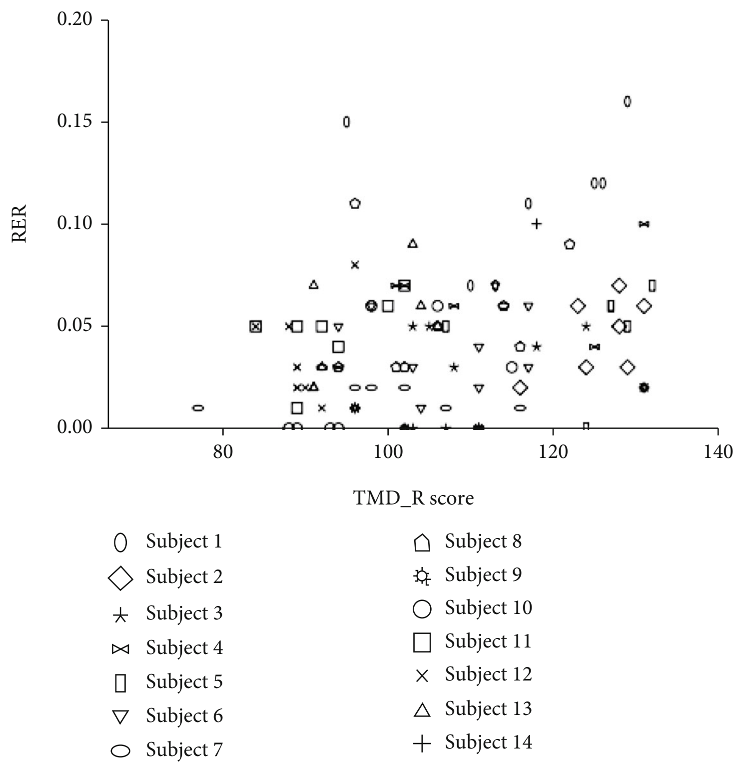


FIGURE 4: Relationship between *RER* and *TMD_R* score for all 14 drivers.

TABLE 3: Model gathering and model F tests results.

	Model abstract					Parameter estimating			
Model	R^2	F	df_1	df_2	Sig.	Constant	b_1	b_2	b_3
Log	0.117	12.246	1	87	0.001	Log	0.087	-0.360	
Linear	0.115	11.344	1	87	0.001	Linear	0.001	-0.044	
Quadratic	0.121	5.934	2	86	0.004	Quadratic	-0.002	1.400E-5	0.117

TABLE 4: Model parameters T tests.

	Unstandardized coefficients		Standardized coefficients		
	B	Std. error	Beta	t	Sig
ln (TMD)	0.087	0.026	0.334	3.310	0.001
(Constant)	-0.360	0.122		-2.943	0.004

urban life nowadays, it is an increasingly common psychological issue that most people are within negative or mixed moods. Nonetheless, most research aforementioned above has focused on the influence of emotion on drivers' emergency response; few research was conducted on the impact of mood on drivers' emergency response. Additionally, with rapid development of social economy, more and more young novice drivers are emerging on roads. Therefore, it is necessary to explore the effects of different moods on young novice drivers' emergency response capacity.

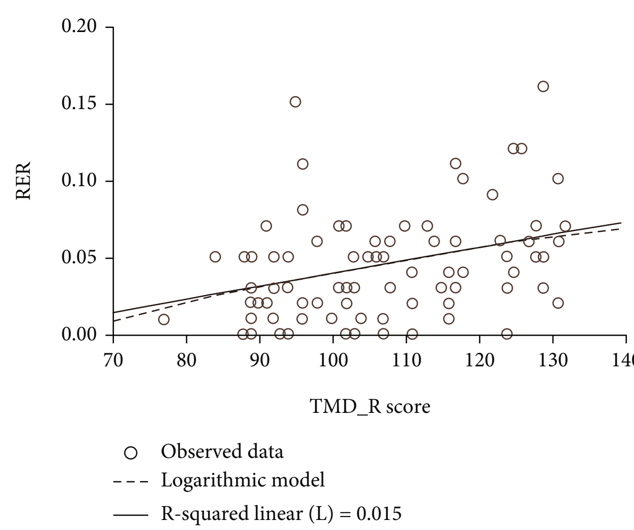


FIGURE 5: Curve fitting between *RER* and *TMD_R* score for young novice drivers.

2. Experimental Design

2.1. Participants. As this study focused on the impact of mood on emergency response capacity for only young nov-

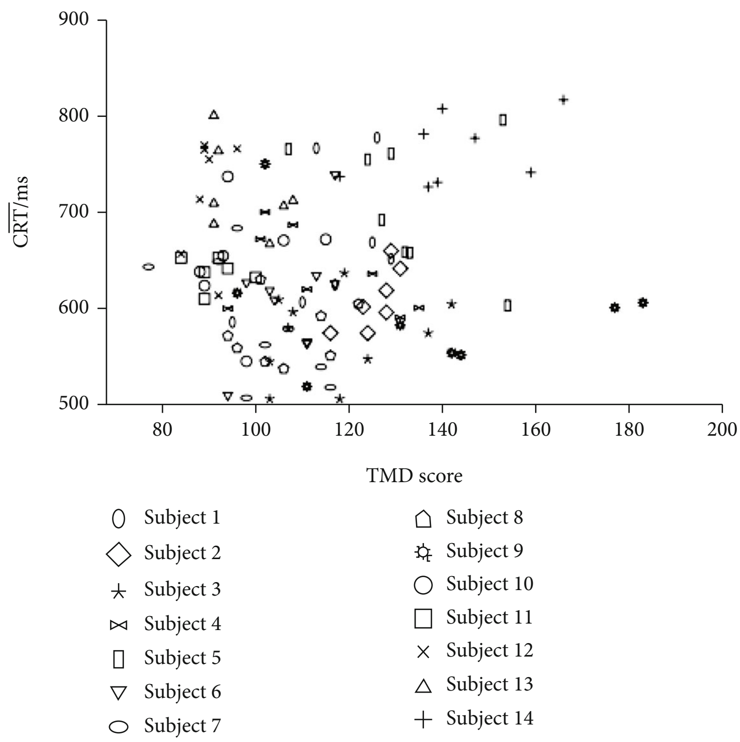


Figure 6: Relationship between young novice drivers' $\overline{CRT}$ and TMD.

ice drivers, a total of 14 college students including undergraduate and graduate students in East China Jiaotong University campus were recruited as subjects for the experiments. All of them were checked to have valid Chinese driving licenses (C1). The age of these participants ranged from 19 to 24 years old, with an average age of 21.43(±1.79). Moreover, the driving years of each subject were less than 3 years, with a driving mileage less than 40,000 kilometers, which was in accordance with definition of novice drivers by Ministry of Public Safety in China. Additionally, the number of male and female drivers was totally equal. It was noted that those subjects with college degree or above were recruited due to the consideration of representativeness of the group of young novice drivers in Chinese city, and all of them were checked to be without alexithymia. Further, for the sake of more accurate collection of all participants' moods, a psychological consultant was recruited to assist to complete relevant mood scale.

2.2. Test Scale. All participants' mood state in the last one week was measured by the Chinese version of Profile of Mood States (POMS) [31, 32] which was designed by Zhu et al. based on the version originated from Grove et al. The Chinese version of POMS scale, consisting of 40 items, was comprised of seven subscales including nervousness, anger, fatigue, depression, fluster, vigorousness, and self-esteem, with average Cronbach's α of 0.71. All participants were required to rate 40 items in all on 5-point scales (0-"not at all", 4-"quite a lot"). Then, every participant's total mood disturbance (TMD) score is calculated as follows:

$$TMD = S_{\text{negative}} - S_{\text{positive}} + 100, \quad (1)$$

where S_{negative} refers to the total score of all negative mood state components including nervousness, anger, fatigue, depression, and fluster, while S_{positive} refers to the total score of all positive mood state components including vigorousness and self-esteem. The higher the TMD score is, the more chaotic or annoyed or disordered the participant would be. Considering the objectivity of affective expression, every participant should accomplish the mood test within 5 to 8 minutes for avoiding deliberate thinking.

Table 5: Pearson rank correlation between TMD and $\overline{CRT}$, $\overline{CRT_f}$, and $\overline{CRT_h}$.

Variables		TMD	$\overline{CRT}$	$\overline{CRT_h}$	$\overline{CRT_f}$
TMD	Pearson correlation	1			
	Significance (two-tailed)				
	Cases	107			
$\overline{CRT}$	Pearson correlation	0.091			
	Significance (two-tailed)	0.350			
	Cases	107			
$\overline{CRT_h}$	Pearson correlation	0.061	0.976^{**}		
	Significance (two-tailed)	0.536	0.000		
	Cases	107	107		
$\overline{CRT_f}$	Pearson correlation	0.134	0.939^{**}	0.846^{**}	1
	Significance (two-tailed)	0.168	0.000	0.000	
	Cases	107	107	107	107

Notes: $^{**}p < 0.01$; $^{*}p < 0.05$.

Table 6: Pearson's correlation between *RER* and mood state components for young novice drivers.

Nervousness		Anger	Fatigue	Depression	Vigorousness	Fluster	Self-esteem
Correlation coefficient	0.290**	0.300**	0.278**	0.287**	-0.079	0.261*	0.066
Significance (two-tailed)	0.006	0.005	0.008	0.006	0.457	0.013	0.537
Cases	88	85	89	88	90	90	90

Notes: $^{**}p < 0.01$; $^{*}p < 0.05$.

2.3. Apparatus. Researches have shown whether a driver can successfully avoid an emergency risk is mainly affected by the speed and accuracy of his or her emergency response [33, 34]. Then, a specific equipment which can collect reaction time and response error rate was employed in this experiment. The equipment mainly includes a complex reaction judgment detector (TD-J902) and a workstation (see Figure 1). The detector contains a control unit which can control a buzzer and a set of lights with green, yellow, and red color for simulating kinds of emergency events. In order to simulate the traffic lights in signalized intersection, only one of three lights is lit every time, displayed by a bright spot with a diameter of 40 mm. At the same time, the buzzer may make sound or not. Every participant is required to use his or her left hand to press left button when the green light is lit or use right hand to press right button when the red light is lit, or use right foot to press braking pedal when the yellow light is lit. Additionally, no action should be taken once the buzzer makes sound. Every participant's action data including reaction time and response accuracy will be stored in the workstation simultaneously. It is noted that reaction time refers to the time interval between the moment on which the light is lit and the moment on which the participant begins to act.

2.4. Experimental Scene. In order to vividly simulate true traffic scenes and naturalist driving behaviors, all subjects should strictly obey the following operational standards when conducting experiments. Every subject was required to be sited down 180 cm directly in front of the complex reaction judgment detector, with left hand holding a button, right hand holding the other button, and with right foot staying right side of braking pedal, noted that each participant's hands should be placed 10 cm above their legs in order not to affect the free movements of their legs. Moreover, each subject was required to response within 2000 ms according to their own judgment once the light or the buzzer of the detector began to work. It was worthwhile to note that the work sequence of the lights and the buzzer was totally random to eliminate the participants' learning effect. The general experimental scene is shown in Figure 2.

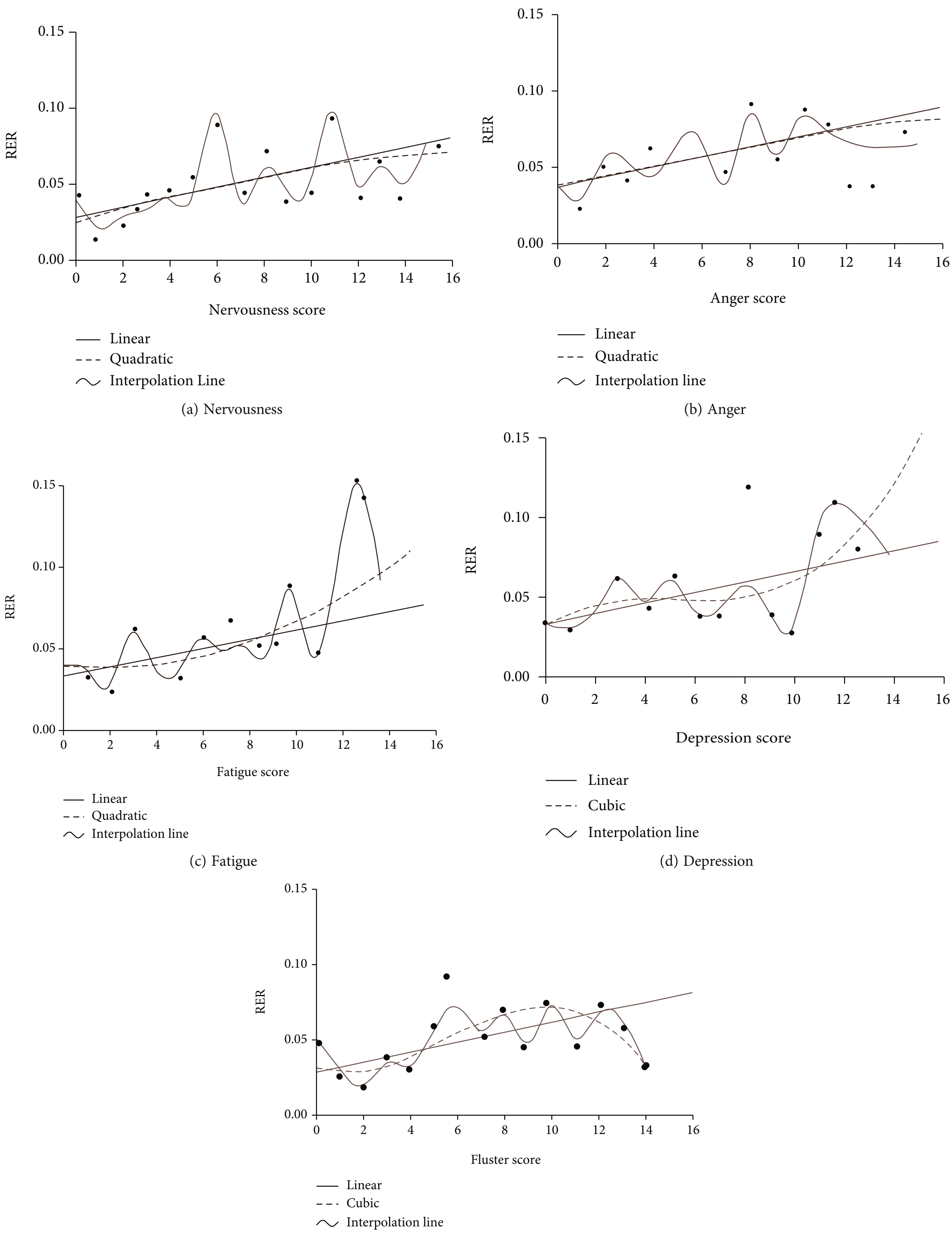
2.5. Experimental Process. Before starting the formal experiment, each subject firstly completed POMS scale and then finished the complex reaction test without any interference in a quiet lab. In order to eliminate the effect of time-of-day on participants' response capacity, each participant was required to conduct the experiment at 3:00 pm-5:00 pm. Then, the whole experiments lasted for almost 3 months after completing 10 groups of experiments, as every participant could take only one group of experiment every week. The procedure of a group of experiment was executed as follows.

(1) Experimental Protocol Informant. Every subject was informed with experimental requirements and payment. ① During the formal experiment, they had to devote themselves to the complex reaction test without any distraction like phone uses or interacting with other persons. ② When filling the POMS scale, they had to report their mood states objectively and truthfully without hiding their true feelings as they were informed that there was no right or wrong about their self-reports. ③ They could get paid of 100 RMB (Chinese currency) once they completed the experiment

(2) Mood States Collection. Every subject should objectively report their true mood states or feelings in the last one week through POMS scale within 5-8 minutes, and they could ask for interpretation from the psychological consultant if they felt confused about the items in the scale. Meanwhile, their personal characteristics like gender, age, and driving years were collected simultaneously

(3) Adaptive Test Practice. Before the formal experiment, each subject was firstly demanded to adjust their operation posture to the complex reaction judgment detector. Then, the subject was told how to respond to the light and the buzzer of the detector. After that, the subject was asked to conduct several groups of test practice to get used to the operational mode. It was noted that the participant should take corresponding action according to the light color and the buzzer immediately as the time interval of adjacent instructions was set to be 2 s

(4) Formal experiment. Each subject was required to devote themselves to the reaction detector without any distraction for every trail lasting 120 s. Then after a break of 10s, another trail repeated, until 10 trails were all completed by the subject. Meanwhile, every subject's reaction time from hand and foot and the operation accuracy were recorded by the workstation automatically. Then a week later, the subject restarted the next group of experiment in accordance with the four steps aforementioned. It was noted that the whole experimental process was recorded by two cameras, one of which was used



(a) Nervousness (b) Anger (c) Fatigue (d) Depression (e) Fluster

Figure 7: Curve fitting between *RER* and five negative mood state components.

Table 7: Regression models for *RER* and five negative mood state components.

Mood state components	Regression models
Nervousness	$y = 0.027 + 0.004x - 0.0001x^2$
Anger	$y = 0.034 + 0.004x - 6.583 \times 10^{-5}x^2$
Fatigue	$y = 0.039 - 0.002x + 0.0004x^2$
Depression	$y = 0.030 + 0.009x - 0.002x^2 + 0.0001x^3$
Fluster	$y = 0.032 - 0.004x + 0.002x^2 - 0.0001x^3$

for recording the subjects, the other one was used for recording the apparatus

3. Analysis of Experimental Results

As every subject completed 10 groups of experiments, with 10 trails in each group, then 1400 trails of experimental data in total were obtained preliminarily. After deleting invalid data due to the subjects' distraction and abnormal data, only 1060 trails of experimental data were effective to be used. In this study, drivers' emergency response capacity was evaluated with two indicators consisting of complex response error rate (*RER*) and complex reaction time (*CRT*) which was comprised of hand reaction time (CRT_h) and foot reaction time (CRT_f). Those indicators were defined as follows:

$$RER = \frac{N_{\text{false}}}{N_{\text{total}}}, \quad (2)$$

where N_{false} was the number of false responses when following the instructions of the complex reaction judgment detector while N_{total} was the total number of responses. The average complex reaction time $\overline{CRT}$, the average foot complex reaction time $\overline{CRT_f}$, and the average hand complex reaction time $\overline{CRT_h}$ were defined, respectively, as the following:

$$\begin{aligned} \overline{CRT_f} &= \frac{\sum_{i=1}^{m} CRT_{fi}}{m}, \\ \overline{CRT_h} &= \frac{\sum_{j=1}^{n} CRT_{hj}}{n}, \\ \overline{CRT} &= \frac{m\overline{CRT_f} + n\overline{CRT_f}}{m+n}, \end{aligned} \quad (3)$$

where CRT_{fi} means the *i*th foot reaction time and the total number of foot actions is *m* while CRT_{hj} means the *j*th hand reaction time and the total number of hand actions is *n*.

3.1. Relationship between ***RER*** *and* ***TMD*** *Score.* Complex response error rate (*RER*) is an important indicator widely used for evaluating drivers' emergency response capacity. Based on statistical analysis of the data originated from all subjects, we found that the average score of *TMD* from all subjects was 114, and 2.8% of the subjects scored less than 88 while 2.8% of the subjects scored higher than 160. The relationship between *RER* and total mood disturbance (*TMD*) score is shown in Figure 3. It was found that there was apparent law between *RER* and *TMD*. However, in terms of all 107 cases, the Pearson correlation analysis results illustrated that *RER* was not significantly correlated with *TMD*, because the significant level was bigger than 0.05, as shown in Table 1.

Some studies [35] discovered that the sensitivity and specificity of the POMS scale could be remarkably affected by range of the scale score. As the *TMD* score from 85% of the subjects was less than 132, then it was found that when the upper limit of *TMD* score was set to be 132, the Pearson correlation coefficient between the revised *TMD* (denoted by *TMD_R*) and *RER* was 0.323 with an observed significant level of 0.002 as shown in Table 2. Then, it was concluded that with the increase of *TMD_R*, the young novice drivers' complex response error rate (RER) grew significantly, as shown in Figure 4.

In line with Table 2 and Figure 4, it was inferred that there existed a functional relationship between *RER* and *TMD_R*; then, a regression analysis was conducted for studying the relationship. After comparing several kinds of curve fitting methods, a logarithmic model was finally selected to describe the relationship between *RER* and *TMD_R*, due to its better model parameters (R^2, F, p) significance than linear and quadratic model after *F* test and *T* test as illustrated Tables 3 and 4.

The curve fitting between the two variables is illustrated in Figure 5, and the logarithmic model was expressed as follows:

$$y = -0.360 + 0.087 \log(x), \quad (4)$$

where *x* denotes a driver's *TMD_R* score, while *y* denotes the driver's complex *RER*

As shown in Figure 5, both linear and logarithmic fitting curves indicated that drivers' response error rate (*RER*) increased with the increase of *TMD_R* score. Moreover, compared with linear fitting curve, the logarithmic curve became more gently when the horizontal coordinate was approaching 132, which further explained that the significant correlation between *RER* and *TMD* would disappear when drivers' *TMD* score was higher than 132 as shown in Figure 3.

3.2. The relationship between $\overline{\textbf{CRT}}$ *and* ***TMD*** *Score.* It is well known that the longer the reaction time is, the weaker a driver's emergency response capacity is. Firstly, the scatter diagram for describing relationship between average complex reaction time $\overline{CRT}$ and total mood disturbance (*TMD*) score from all participants is shown in Figure 6. In line with Figure 6, it was found that there was no obvious law between $\overline{CRT}$ and *TMD*. Further, the Pearson correlation analysis was conducted among $\overline{CRT}$, $\overline{CRT_f}$, $\overline{CRT_h}$, and *TMD*, as indicated in Table 5. It was shown that there was no significant relationship between *TMD* and $\overline{CRT}$, $\overline{CRT_h}$ and $\overline{CRT_f}$ as the observed significance level was 0.350, 0.536, and 0.168, respectively. However, in terms of $\overline{CRT}$, $\overline{CRT_h}$, and $\overline{CRT_f}$, there existed significant relationship between any two of them, namely, a young novice driver's hand reaction was

Table 8: T-test of regression models for *RER* and mood state components.

Mood state components		t test Non-standardized coefficient	Standardized coefficient	t	Sig.
Nervousness	Nervousness	0.004	0.427	1.279	0.204
	Nervousness ** 2	0.000	-0.144	-0.431	0.668
	(constant)	0.027		2.716	0.008
Anger	Anger	0.004	0.369	1.265	0.209
	Anger ** 2	-6.583E-005	-0.074	-.253	0.801
	(constant)	0.034		5.488	0.000
Fatigue	Fatigue	-0.002	-0.163	-0.543	0.589
	Fatigue ** 2	0.000	0.469	1.563	0.122
	(constant)	0.039		5.423	0.000
Depression	Depression	0.009	0.986	1.510	0.135
	Depression ** 2	-0.002	-2.151	-1.343	0.183
	Depression ** 3	0.000	1.565	1.490	0.140
	(constant)	0.030		4.076	0.000
Fluster	Fluster	-0.004	-0.425	-0.522	0.603
	Fluster ** 2	0.002	2.706	1.440	0.154
	Fluster ** 3	0.0001	-2.110	-1.810	0.074
	(constant)	0.032		2.664	0.009

Table 9: F test of the regression models for *RER* and five negative mood state components.

Mood state components	R	R^2	F test Adjusted R^2	F value	Sig.
Nervousness	0.294	0.086	0.065	4.016	0.022
Anger	0.301	0.091	0.069	4.090	0.020
Fatigue	0.321	0.103	0.082	4.938	0.009
Depression	0.356	0.127	0.096	4.077	0.009
Fluster	0.407	0.166	0.136	5.636	0.001

significantly correlated with her or his foot reaction, meaning that young drivers had good coordination of hands and feet.

As mentioned above, the sensitivity and specificity of the POMS scale could be remarkably affected by range of the scale score. Then, in this study, the quantile of the POMS scale score was set differently, like 70%, 85%, and 95%, respectively, and it was still found that there was no significant correlation between TMD and the subjects' average complex reaction time $\overline{CRT}$, average hand reaction time $\overline{CRT_h}$, and average foot reaction time $\overline{CRT_f}$. Therefore, it can be concluded that total mood disturbance (TMD) has no significant effect on young novice drivers' complex reaction time.

In conclusion, with the increase of TMD, the young novice drivers' mood state would be more negative like nervousness, fatigue, anger, depression, or fluster, leading to higher response error rate (*RER*) which meant young novice drivers' decision-making capacity or operational capacity would be impaired by negative mood state. Nevertheless, as a continuous and gentle affective state, the overall mood state, denoted by TMD score, had no significant relationship with complex reaction time (*CRT*) for young novice drivers.

*3.3. Relationship between **RER** and Score of Mood State Components.* Relevant studies showed that drivers' lateral and longitudinal control of the vehicle was remarkedly affected by positive emotions like happiness and negative emotions like anger [36–38]. As the outburst of a driver's certain emotion like anger at one moment may be involved from accumulation of their several negative moods in the last few days, it is of great necessary to further study the relationship between drivers' *RER* and mood state components which were defined from seven categories based on POMS scale.

Firstly, the Pearson correlation analysis was conducted between drivers' *RER* and seven mood state components comprised of five negative moods including nervousness, anger, fatigue, depression, and fluster, and two positive moods containing vigorousness and self-esteem. The correlation analysis results are as shown in Table 6.

According to Table 6, it was found that there existed positive and significant correlation between drivers' response error rate (*RER*) and five mood state components including nervousness, anger, fatigue, depression, and fluster, meaning that with the increase of scores of the five mood state components, the drivers' *RER* grew significantly. Especially, the drivers' *RER* was negatively correlated with vigorousness, namely, when a driver was more vigor, her or his *RER* would be lower when encountering emergency events. However, the driver's *RER* was positively correlated with self-esteem, which meant with the increase of the scores of

Table 10: Pearson's correlation between complex reaction time and mood state components.

		Nervousness	Anger	Fatigue	Depression	Vigorousness	Fluster	Self-esteem
$\overline{CRT}$	Correlation coefficient	0.222*	0.081	0.002	0.122	0.227*	0.273**	0.15
	Significance(two-tailed)	0.021	0.406	0.982	0.211	0.019	0.004	0.122
	Cases	107	107	107	107	107	107	107
$\overline{CRT}_h$	Correlation coefficient	0.214*	0.068	-0.033	0.097	0.258**	0.268**	0.184
	Significance(two-tailed)	0.027	0.489	0.736	0.322	0.007	0.005	0.058
	Cases	107	107	107	107	107	107	107
$\overline{CRT}_f$	Correlation coefficient	0.216*	0.095	0.067	0.156	0.16	0.263**	0.095
	Significance(two-tailed)	0.026	0.329	0.493	0.108	0.099	0.006	0.328
	Cases	107	107	107	107	107	107	107

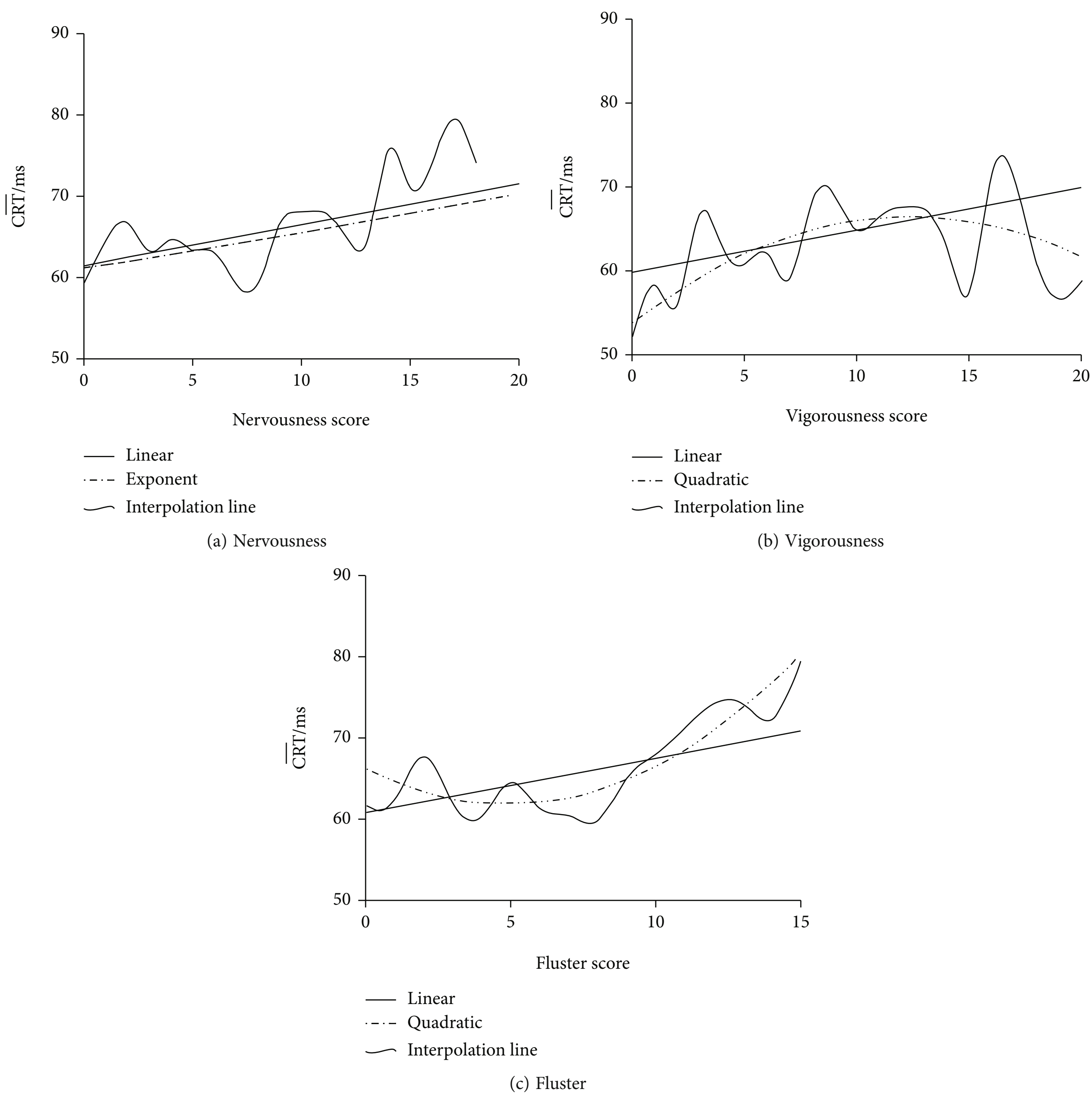


Figure 8: Curve fitting between $\overline{CRT}$ and the three mood state components.

Table 11: Regression models for $\overline{CRT}$ and the three mood state components.

Emergency response capacity	Mood state components	Regression model
	Nervousness	$y = e^{4.114+0.007x}$
Average complex reaction time ($\overline{CRT}$)	Vigorousness	$y = 53.779 + 2.048x - 0.083\,x^2$
	Fluster	$y = 66.323 - 1.791\,x + 0.182x^2$

Table 12: F test of the regression models for $\overline{CRT}$ and the three mood state components.

Mood state components	ANOVA (F test)				
	R	R^2	Adjusted R^2	F	Sig.
Nervousness	0.241	0.058	0.049	6.395	0.013
Vigorousness	0.305	0.093	0.075	5.282	0.007
Fluster	0.448	0.201	0.185	12.817	0.000

Table 13: T-test of regression models for $\overline{CRT}$and the three mood state components.

Mood state components		T test			
		Nonstandard coefficient	Standard coefficient	T	Sig.
Nervousness	Nervousness	0.007	0.241	2.529	0.013
	(constant)	4.114		185.903	0.000
Vigorousness	Vigorousness	2.048	0.914	2.787	0.006
	Vigorousness ** 2	-0.083	-0.719	-2.192	0.031
	(constant)	53.779		15.33	0.000
Fluster	Fluster	-1.792	-0.826	-2.567	0.012
	Fluster ** 2	0.182	1.18	3.669	0.000
	(constant)	66.323		33.172	0.000

self-esteem, drivers' *RER* also increased, meaning that over self-esteem was harmful to young novice drivers' response capacity. Therefore, positive mood state was not always beneficial to response capacity for young novice drivers.

Based on the mentioned significant correlations between young novice drivers' response error rate (*RER*) and the five negative mood state components, it was inferred that there existed a certain functional relationship between *RER* and those mood state components, respectively. According to the scatter diagrams described for the two kinds of variables, several curve fitting methods including linear, quadratic, and cubic regression were selected, as illustrated in Figures 7(a)–7(e). According to Figures 7(a) and 7(b), it was found that with the increase of the score of nervousness and anger, the young novice drivers' *RER* also grew as a quadratic function, and then the growth gradually flattened out. From Figure 7(c), it was found that when the score of fatigue increased, the young novice drivers' *RER* grew as a quadratic function, with continuous increase. As interpreted in Figure 7(d), with the increase of the score of depression, the young novice drivers' *RER* grew as a cubic function, namely, the growth gradually flattened out in the beginning and then became faster. Finally, based on Figure 7(e), we could see that with the increase of the score of fluster, the young novice drivers' *RER* grew as a quadratic function, but the growth gradually flattened out in the beginning and then became negative. The expressions of these optimal regression models are presented in Table 7. Moreover, the T test and F test (analysis of variance, ANOVA) of these models' parameters were conducted, as shown in Tables 8 and 9, respectively, which further verified the selected models were effective to fit the relationship between *RER* and mood state components for young novice drivers.

3.4. The Relationship between $\overline{\mathbf{CRT}}$ *and Score of Mood State Components.* Although there existed no significant relationship between total mood disturbance (TMD) score and complex reaction time (CRT) for young novice drivers, it was necessary to further study the effect of different mood state components on average complex reaction time ($\overline{CRT}$) or average hand reaction time ($\overline{CRT_h}$) and average foot reaction time ($\overline{CRT_f}$). The Pearson correlation between mood state components (nervousness, anger, fatigue, depression, vigorousness, fluster, and self-esteem) and complex reaction time ($\overline{CRT}$, $\overline{CRT_h}$, and $\overline{CRT_f}$) for young novice drivers were analyzed with the results shown in Table 10. In terms of significance level and correlation coefficient, it was found that there existed positive and significant correlation between $\overline{CRT}$ and the score of three mood state components including nervousness, vigorousness, and fluster. In other words, with the increase of the score of nervousness, vigorousness, and fluster, young novice drivers' complex reaction time increased significantly. It was noted that both positive mood state component like vigorousness and negative mood state components like nervousness and fluster would increase young novice drivers' reaction time, leading to reduction of emergency response capacity. Additionally, the score of nervousness, vigorousness, and fluster were also significantly and positively correlated with average hand reaction time ($\overline{CRT_h}$), while only the score of nervousness and fluster were significantly and positively correlated with average foot reaction time ($\overline{CRT_f}$).

Based on the mentioned significant correlation between young novice drivers' complex reaction time including $\overline{CRT}$, $\overline{CRT_h}$, and $\overline{CRT_f}$ and the score of the three mood components including nervousness, vigorousness, and fluster, it was inferred that there existed a certain functional relationship between the dependent variables and the independent variables. As average complex reaction time ($\overline{CRT}$) was defined as arithmetic mean value of all hand reaction time and foot reaction time samples, only $\overline{CRT}$ was used to establish a regression model for the three mood state components when considering representativeness and simpleness.

According to the scatter diagrams describing the relationship between $\overline{CRT}$ and the scores of nervousness, vigorousness, and fluster, several curve fitting methods including linear, quadratic, and exponent regression were chosen, as shown in Figures 8(a)–8(c). According to Figure 8(a), it was found that with the increase of the score of nervousness, the young novice drivers' $\overline{CRT}$ grew as an exponent function. From Figure 8(b), it was indicated that with the increase of the score of vigorousness, the young novice drivers' $\overline{CRT}$ increased firstly and then decreased as a quadratic function. As interpreted in Figure 8(c), with the increase of the score of fluster, the young novice drivers' $\overline{CRT}$ decreased firstly and then increased as a quadratic function. The expressions of these optimal regression models are presented in Table 11. Moreover, the F test and T test of these models' parameters were conducted, as shown in Tables 12 and 13, respectively, which further verified the selected models were effective to fit the relationship between $\overline{CRT}$ and mood state components.

4. Discussions and Conclusions

This study mainly studied the effect of a tender and consistent affective state, namely, mood and mood state components on young novice drivers' emergency response capacity including complex reaction time (CRT) and response error rate (RER). The most important contribution of this study was to preliminarily quantize the effect by regression models which could broaden and deepen the research domains of traffic psychology, especially driver affective state.

Firstly, in order to quantitatively investigate young novice drivers' emergency response, a simple simulation experiment was designed by using a complex reaction judgment detector which could provide visual and auditory stimulations in a controllable program and recorded the drivers' complex reaction time and response error rate synchronously. Particularly, as a tender, consistent, and long-term affective state, mood also imperceptibly influences a young novice drivers' emergency response capacity. Therefore, a valid profile of mood state (POMS) scale was adopted to study the drivers' total mood disturbance (TMD) as well as mood state components like nervousness, anger, fatigue, depression, fluster, vigorousness, and self-esteem.

Secondly, the TMD score could reflect a person's overall mood state as it is calculated based on the scores of all negative and positive mood state components from that person in the past one or more weeks. The study results showed that the young novice drivers' RER was positively and significantly ($p < 0.05$) correlated with their score of TMD-R whose upper limit was set to be 132. Moreover, a logarithmic regression model was established to describe the significant relationship with a good fitting effect. The results indicated that for young novice drivers, with the increase of TMD score, their decision-making capacity decreased, leading to an increasing RER when encountering emergency events. Hence, this finding further verified that the young novice drivers were inclined to be involved in traffic conflicts or accidents due to the poor decision-making ability, especially under negative mood states. However, the study showed that there existed no significant correlation between young novice drivers' complex reaction time (CRT) and TMD score. The reason for this may be that physic behavior speed was not significantly influenced by mood state for young drivers.

Thirdly, except for total mood disturbance (TMD) score for describing the overall mood state, relationship between emergency response capacity and mood state components like nervousness, anger, fatigue, depression, fluster, vigorousness, and self-esteem was further researched in this study. In terms of RER, the study results indicated that young novice drivers' RER was positively and significantly correlated with score of negative mood state components such as nervousness, anger, fatigue, depression, and fluster. Therefore, it is better for young novice drivers to drive in real traffic environment without negative mood states. Further, three different regression models based on quadratic functions were established with a good fitting effect for describing the relationship between RER and the score of nervousness, anger, and fatigue, while two different regression models based on cubic functions were established for depression and fluster. In terms of complex reaction time, the study results indicated that young novice drivers' $\overline{CRT}$ was positively and significantly correlated with score of nervousness, vigorousness, and fluster. Coincidently, a previous study [39] manifested that both risk perception and risk driving behavior were positively and significantly correlated with drivers' dejection and anger mood state. Therefore, it could be inferred that too negative or positive mood state is harmful to young novice drivers' emergency response capacity from the perspective of reaction time. Further, two regression models based on quadratic functions were established with a good fitting effect for describing the relationship between $\overline{CRT}$and the score of vigorousness and fluster, while one regression model based on exponential function was suitable for nervousness state.

Nevertheless, there still exist several obvious limitations in this study. Firstly, only simple stressful scenes based on traffic lights and sounds were designed and used to simulate traffic emergency situations; hence, more vivid traffic scenes like surrounding vehicles' unexpected cutting in line or pedestrian's abrupt jaywalking should be designed to make more comprehensive evaluation of drivers' emergency response capacity. Secondly, only relatively small numbers of undergraduate and postgraduate students in a university were recruited to preliminarily study their emergency response capacity under different mood states. Therefore, in order to enhance the universality of regression models proposed in this study, more young novice drivers with different educational degrees should be added in the future as the young novice drivers with different educational degrees may have different mood states and response characteristics. Thirdly, due to the small numbers of subjects, the effect of gender differences on the emergency response capacity was neglected; hence, the gender differences should be considered by recruiting more participants. Fourthly, in order to highlight the characteristics of emergency response capacity from young novice drivers, some old novice drivers should be enrolled for comparison in future, as more and more old drivers begin to swarm into road with the development of social economic in aging society nowadays.

Data Availability

The data were generated from experiments and can be made available by the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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