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Bus drivers' mood states and reaction abilities at high temperatures

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ABSTRACT

High temperatures can affect a bus driver's mood states and reaction ability. We used the Profile of Mood States (POMS) scale to measure the effect of temperature on mood. Reaction ability was evaluated by testing speed estimation, choice reaction, and action judgment. Data for the analysis were retrieved from the Harbin public transport survey of July to October 2014. A total of 680 bus drivers participated in the investigation, and 654 questionnaires and 605 test data were collected.

Bus drivers with different characteristics showed different moods and reactions at high temperatures. Young drivers, novice drivers, and drivers who drove for long periods of time without breaks had more negative moods. Continuous driving time had no significant effect on vigor, and all drivers showed low energy. Fatigue increased with continuous driving hours. Older and highly experienced drivers had higher speed estimation accuracy. Speed estimation accuracy and reaction time decreased with sustained driving hours. Before 45 years of age, the number of choice errors increased with age, but no significant changes were found after 45 years of age. Drivers between the ages of 55 and 60 showed the worst response times and the maximum number of errors. Negative moods were negatively correlated with speed estimation accuracy and were positively correlated with the number of choices or judgment errors. The vigor was positively associated with speed estimation accuracy and negatively correlated with the number of judgment errors.

The findings of the current study provide a comprehensive picture of bus drivers' reaction ability at high temperatures and could help to take targeted measures to reduce the negative impact of heat exposure.

1. Introduction

As concluded in numerous research papers, drivers may easily develop unfavorable feelings, such as tiredness, depression, or fatigue, when the environment's temperature is higher than 35 °C and the humidity is higher than 80% during the summertime (McCartt, Ribner, Pack, & Hammer, 1996; González-Alonso, Teller, & Andersen, 1999; Salminen, Perttula, & Merjama, 2005; Muraoka and Ikeda, 2015). Previous studies also demonstrated that driving at high temperatures could change the driving behaviors of the drivers. For example, high temperature can lead drivers to become hostile to others (Fay and Maner, 2014; Anderson, 2001; DeWall and Bushman, 2009; Wilkowski, Meier, Robinson, Carter, & Feltman,

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2009) and increase their chance of developing anger and aggressive driving behaviors (Ellison, 1995; Maxwell, Grant, & Lipkin, 2005; Wickens, Mann, & Wiesenthal, 2013). Furthermore, high temperatures were also found to have significant impacts on driver reaction ability. A large number of studies on the relationship between driver response and traffic accidents show that drivers with long reaction times are prone to accidents, as are drivers with many errors in complex reactions (af Wåhlberg, 2008; Eli, Li, & Ma, 2009; Yakovlev and Inden,2010; Basagaña, Escalera-Antezana, & Dadvand, 2015).

All of the related previous studies focused on the impacts of high temperature on passenger-vehicle drivers. Meanwhile, bus drivers have attracted insufficient attention. As mentioned previously, bus drivers are more likely to suffer worse driving conditions than passenger-vehicle drivers. Specifically, in some less developed areas, it is common for buses not to be equipped with air conditioning, which may result in a higher in-vehicle temperature during summer days (on average, the in-vehicle temperature is 5 °C to 10 °C higher than the outside environment). In addition, considering their work schedule, some drivers have to drive the buses in these kinds of conditions for about 8 h a day, whereas such a long driving time is quite uncommon among passenger-vehicle drivers. However, only a few previous papers considered the combined effects of high temperature and corresponding long-time exposure; therefore, more effort should be made to figure out their underlying impacts on bus drivers and bus traffic safety.

The study of bus driving at high temperature involved theories such as industrial psychology and driving aptitude. The theory of industrial psychology shows that the heat effect of high temperature environment can reduce the excitability of the central nervous system, weaken the body's thermoregulatory function, easily destroy the heat balance, and promote heatstroke. When the body temperature rises to more than 38 °C, the effect on neuropsychological is more obvious. If timely cooling measures are taken to reduce the body temperature to 37 °C, the workers will feel comfortable, and the error rate will be reduced accordingly (Page and Sheppard, 2016). Driving aptitude is a kind of occupational aptitude, which refers to the basic physiological and psychological qualities that a driver can safely and effectively engage in driving work. It can be expressed as $P = f(Q, H, L)$. Psychological quality(Q) and physiologic quality (H) include tension, anger, hostile and fatigue and so on. Operation skills (L) include speed anticipation ability (in the course of driving, the drivers should have a good grasp of the speed of his own vehicle and the surrounding vehicles), information processing ability (the drivers have the ability to select and handle the feedback information from the driving process) and reaction ability (the drivers should respond quickly and correctly to the surrounding environment and emergency situations) (Eli et al., 2009).

Prolonged exposure to a hot environment can produce psychological and physical discomfort and result in adverse moods, mistakes, and even traffic accidents. The current study investigated the effect of high temperature on bus drivers' mood states and reaction ability. The Profile of Mood States (POMS) scale was used to measure mood states; Speed expectation, choice reaction, and action judgment were test to determine the reaction ability. Statistical tests were used to analyze the mood state and reaction ability of bus drivers with different characteristics at high temperatures. Pearson correlation analysis was used to quantify the correlation between mood and reaction.

2. Method

2.1. Response ability test

We examined the sensitivity of the driver in various complex traffic conditions in the course of driving, and whether the driver could handle the changing traffic scene correctly and rapidly during driving. Three different indexes, including speed expectation, choice reaction, and action judgment, were used to evaluate drivers' response ability. The instrument of LJ910X-B was used to test these three indexes. The test details are described as follows:

(1) Speed estimation test. This test requires participants to sit on a chair 1.5 m from the dashboard and observe how fast the lights are moving on the screen. When the indicator light enters a certain area, the participant needs to estimate the time it will take to pass the area and record the time using a switch. Each test participant performs five tests. The final result is the average of the five tests. In this test, we adjusted the actual speed of the indicator to 0.146 m/s. Correspondingly, the exact time for this indicator to pass through this area should be 2,080 ms. If the experimental participant's estimated passage time is 1980–2180 ms, then the person's estimate is considered to be accurate; if the estimated time is 1360–1970 ms or 2190–2470 ms, the person's speed estimation accuracy is considered average; if the estimated time is 150–1350 ms, or more than 2480 ms, the person's speed estimation accuracy is considered poor; if the estimation time is less than 1140 ms, the person's speed estimation accuracy is considered to be very poor. This index is used to assess the participants' speed prediction skill.

(2) Choice reaction test. This test requires participants to judge the red, yellow, and blue lights on the screen and use their left hand, right hand, and right foot to react to these colors. Their reaction time and the number of wrong choices are automatically recorded. Each participant practices eight times first and then is formally tested 16 times. If the reaction time is less than 620 ms, their selection accuracy is considered to be high; if the reaction time is 630–980 ms, their selection accuracy is considered to be normal; if the reaction time is 990–1340 ms, their selection accuracy is considered to be poor; if the reaction time is greater than 1350 ms, then their selection accuracy is considered to be very poor. The number of wrong choices is also used to measure their selection accuracy. If the number of errors is 0, then the selection accuracy is considered to be good; 1–4 is average; 5–6 poor; greater than 7 is very poor. These two factors are used to assess the agility of the participants.

(3) Action judgment test. In this experiment, participants need to steer the steering wheel to move a pointer with 16 markers on the dial. If the pointer touches the marker line, the operator is considered to have a deviation, and the result is recorded once. The indicator dial rotates at a uniform speed six times and is judged based on the results recorded by the instrument. If the total number of deviations is 0–76, the person's handling ability is considered to be superior; if the number is 77–120, he is considered to have normal control; if it is 121–140, he is considered to have poor control; if the number is greater than 141, his handling ability is considered to be very poor. This index is used to assess participants' attention allocation and coordination capabilities.

2.2. Questionnaire

Mood is a certain emotional state that persists in a person over a long period of time. It is continuous, weak, stable, and dispersed, affecting the whole mental life of a person. Mood, as a form of emotion, has the function of monitoring and controlling other mental activities and behaviors. Mood is divided into positive and negative. A pleasant mood plays a positive role, while a depressed mood has negative effects. The purpose of the questionnaire was to explore the driver's mood in a high-temperature environment and the relationship between mood and behavior. The mood was measured by the mood state scale. The scale contains 65 items for a total of six subscales: tension, depression, anger, vitality, fatigue, and confusion (see appendix). Respondents rate their level of sensation on a five-point scale (0 = no; 1 = very little; 2 = medium; 3 = considerable; 4 = extreme). The questionnaire also surveyed the basic characteristics of drivers, including gender, age, bus driving experience, and continuous working hours.

2.3. Procedure

Drivers volunteered to participate in the experiment according to their departure timetable. Before the experiment, the bus companies trained the drivers to understand the purpose of the survey, the test method, and how to fill out the questionnaire. When the volunteers arrived at the terminal, they were asked to test the reaction immediately and then fill out the questionnaire. The room temperature during each test was 5–8 °C higher than the outside temperature. The entire test process lasted for about 30 min, and participants were given RMB 20 yuan in remuneration. The sample data came from the Harbin Public Transport Survey from July to October 2014. A total of 680 bus drivers participated in the survey. Eventually, we collected 654 valid questionnaires and 605 test data records.

3. Data analysis

3.1. Sample characteristics

The sample was described in Table 1. Most bus drivers were male (79.2%) with a prevalence of 26–55 years old (86%). Approximately 45% of the drivers had less than 5 years of driving experience, and of these, 4.9% were novice drivers (less than 2 years). Two-thirds of drivers continuous driving time was less than 2 h (66.2%). 39.6% participants reported that they had at least one at-fault accident due to prolonged exposure to high temperature conditions.

Table 1
Sample characteristics.

Variable	Categories	Percentage
Sex	Male	79.2
	Female	20.8
Age*	26–35	6.8
	36–45	37.3
	46–55	41.9
	55–60	14
Driver's experience years	<2	4.9
	2–5	38.6
	5–10	39.6
	>10	16.9
Continuous working time	<1	20.1
	1–2	46.1
	2–3	24.4
	3–4	9.1
Have at least one at-fault accident	yes	39.6
	no	60.4

* : "Provisions on the Application for and Use of Driving Licenses (Chinese)": When age over 26 years old, they are eligible to apply for license for large-size passenger vehicles; when reach 60 years old, they are not allowed to continue to drive these vehicles.

3.2. Mood state analysis

Drivers with different characteristics may show different mental states. Table 2 shows the mental states of drivers with different characteristics.

There was no gender difference in emotional state. The degree of tension (3.14) and degree of anger (3.48) in the 26–35 age group were significantly higher than those in other age groups. None of the age groups showed significant depression (between 2.05 and 2.64), but the 36–45 group had significantly higher depression (2.64) than the others. Vitality scores ranged from 1.90 to 2.60, indicating that all age groups were inactive. The drivers showed age-related fatigue characteristics. Fatigue increased with age, and the 55–60 group showed significantly higher fatigue (3.81) than the others. Confusion scores ranged from 1.10 to 2.71, and scores from 26 to 45 years were significantly higher than those from 46 to 60 years.

For different consecutive driving times, significantly higher tension was found in the 3–4 h range. There was no significant difference in depressed mood and anger between different driving time groups. When the duration of driving was less than 3 h (2.31, 2.11, and 2.24), there was no apparent difference in vitality. The fatigue score for driving more than 2 h (3.56 and 3.59) was significantly higher than that for less than 1 h (3.32). The bus drivers did not show apparent confusion (between 2.04 and 2.37).

For different levels of driving experience, as driving experience increased, the sense of tension decreased (between 2.87 and 2.06), and drivers with less than two years of experience had significantly higher tension. Depressive mood scores ranged between 1.98 and 2.40, while depressed moods were the lowest in drivers with more than a decade of experience. Novice drivers (<2 years) had a significantly higher anger rating (3.20) than those who had more than five years of experience (2.75 and 2.65). Vigor scores ranged between 1.8 and 2.48, and the novices' motivation was the weakest. Drivers with more than 10 years of experience experienced significantly higher fatigue (3.79). The confusion scores ranged between 2.80 and 1.88 and were significantly higher in drivers with less than five years of experience (2.80 and 2.40) than in driers with more than five years of experience (2.13 and 1.88).

3.3. Reaction ability analysis

Table 3 presents the test results of reaction ability by driver characteristics. Drivers' gender had no significant impact on speed expectation, reaction time, the number of choice errors, or the number of judgment errors.

Table 2
Means and standard deviations of POMS scale by driver characteristics.

Variable	Categories	Tension		Depression		Anger		Vigor		Fatigue		Confusion	
		M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Gender	Male	2.21	0.623	2.32	0.503	2.81	0.624	2.23	0.599	3.41	0.625	2.21	0.555
	Female	2.23	0.182	2.41	0.531	2.72	0.555	2.30	0.371	3.45	0.379	2.28	0.269
	F(P)[a]	0.094(0.759)		1.113(0.292)		1.112(0.290)		0.637(0.425)		0.245(0.621)		0.784(0.377)	
Age	26–35^b	3.14	0.655	2.05	0.669	3.48	0.750	1.90	0.539	3.42	0.676	2.71	0.463
	36–45^c	2.18	0.708	2.64	0.550	2.90	0.627	1.94	0.358	3.19	0.634	2.42	0.649
	46–55^d	2.16	0.363	2.21	0.409	2.63	0.574	2.60	0.619	3.49	0.517	2.09	0.307
	55–60$_e$	2.02	0.266	2.07	0.552	2.70	0.637	2.16	0.531	3.81	0.627	1.10	0.526
	F(P)[a]	23.962(0)		23.190(0)		13.123(0)		36.720(0)		12.746(0)		21.550(0)	
Multiple comparisons		(c-d)^{ns}		(b-e)^{ns}		**		(b-c)^{ns}		(b-d)^{ns}		**	
Continuous driving time	1^b	2.11	0.370	2.34	0.513	2.67	0.651	2.31	0.564	3.23	0.559	2.13	0.386
	1–2^c	2.23	0.649	2.42	0.645	2.87	0.707	2.11	0.542	3.39	0.654	2.37	0.647
	2–3^d	2.13	0.342	2.27	0.445	2.84	0.570	2.24	0.460	3.56	0.526	2.11	0.482
	3–4^e	2.56	0.947	2.15	0.362	2.56	0.056	2.81	0.921	3.59	0.501	2.04	0.192
	F(P)[a]	4.264(0.006)		2.56(0.055)		2.646(0.049)		12.044(0)		4.042(0.008)		6.266(0)	
Multiple comparisons		ns		ns		**		(b-d)^{ns}; (c-d)^{ns}		(b-c)^{ns}; (d-e)^{ns}		(b-d)^{ns}	
Drivers' experience years	<2^b	2.87	0.640	2.40	0.737	3.2	1.02	1.8	0.560	3.33	0.617	2.8	0.560
	2–5^c	2.28	0.780	2.44	0.531	2.86	0.622	2.06	0.474	3.24	0.620	2.40	0.628
	6–10^d	2.14	0.348	2.39	0.554	2.75	0.650	2.48	0.683	3.45	0.576	2.13	0.362
	>10^e	2.06	0.308	1.98	0.420	2.65	0.556	2.23	0.425	3.79	0.572	1.88	0.428
	F(P)[a]	9.207(0)		9.591(0)		3.422(0.018)		14.726(0)		10.684(0)		21.055(0)	
Multiple comparisons		**		(b-d)^{ns}		(b-c)^{ns}; (c-d)^{ns}; (c-e)^{ns}; (d-e)^{ns}		(b-c)^{ns}		(b-d)^{ns}		**	
At-fault accident	No	2.25	0.506	2.32	0.600	2.68	0.605	2.34	0.606	3.28	0.684	2.22	0.521
	Yes	2.16	0.694	2.39	0.506	2.88	0.676	2.24	0.602	3.51	0.562	2.24	0.591
	F(P) [a]	2.062(0.152)		0.799(0.372)		9.313(0.007)		0.013(0.908)		10.766(0.001)		0.063(0.082)	

[a] ANOVA and post hoc tests with LSD correction were conducted with the level of significance at 0.01. Multiple comparisons: (c-d)^{ns} denote there is no significant difference between group c and d.

** :There is a significant difference between every two groups. ns: there was no significant difference between every two groups.

Table 3
Means and standard deviations of speed expectation, choice reaction, and action judgment by driver characteristics.

Variable	Categories	Speed estimation(ms)		Choice reaction				Action judgment (number of judgment errors)	
				Reaction time (ms)		Number of choice errors			
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
Gender	Female	1660.60	119.94	721.34	63.83	2.54	0.664	101.2	12.07
	Male	1613.13	137.19	700.40	72.83	2.43	0.731	101.19	66.65
	F(P) [a]	6.382(0.012)		4.402(0.037)		1.153(0.284)		0(0)	
Age	26–35[b]	1578.95	96.26	716.33	55.44	1.62	1.07	85.26	9.23
	36–45[c]	1521.47	112.48	667.67	68.29	2.32	0.657	95.48	11.55
	46–55[d]	1687.98	107.76	721.89	68.55	2.62	0.515	102.77	16.20
	55–60$_e$	1721.07	83.94	724.09	75.19	2.88	0.762	112.67	10.64
	F(P)[a]	64.916(0)		9.613(0)		21.762(0)		28.610(0)	
Multiple comparisons		(d-e)^{ns}		**		**		**	
Continuous work time	1[b]	1667.67	166.79	660.05	71.09	2.23	0.766	86.59	11.72
	1–2[c]	1717.63	121.37	712.52	64.05	2.37	0.589	92.33	10.67
	2–3[d]	1563.40	124.75	717.93	75.24	2.48	0.509	94.24	16.81
	3–4[e]	1531.78	143.78	723.67	86.05	2.66	0.814	94.90	15.44
	F(P)[a]	38.084(0)		9.812(0)		2.017(0.112)		1.880(0.133)	
Multiple comparisons		**		**		ns		ns	
Drivers' experience years	<2[b]	1575.33	102.12	711.54	44.71	2.02	0.941	86.35	9.47
	2–5[c]	1544.82	126.42	687.0	74.57	2.38	0.608	98.94	11.76
	6–10[d]	1665.56	122.53	717.57	66.39	2.41	0.741	100.30	17.24
	>10[e]	1715.81	78.67	718.60	75.17	2.85	0.724	111.4	8.02
	F(P)[a]	34.807(0)		4.205(0.006)		6.738(0)		1.649(0.178)	
Multiple comparisons		**		(b-c)^{ns}; (d-e)^{ns}		(c-d)^{ns}		ns	
At-fault accident	No	1728.18	97.95	669.36	67.69	2.32	0.722	95.59	14.87
	Yes	1513.02	115.53	727.90	78.09	2.41	0.717	102.63	13.47
	F(P)[a]	37.647(0)		6.247(0.014)		1.871(0.165)		8.624(0)	

[a] ANOVA and post hoc tests with LSD correction were conducted with the level of significance at 0.01. Multiple comparisons: (d-e)^{ns} denote there is no significant difference between group d and e.

** There is a significant difference between every two groups. ns: there was no significant difference between every two groups.

Drivers aged 55–60 had the highest accuracy in speed expectation, which was significantly higher than that of drivers aged 26–35 and 36–45, and did not differ significantly from that of drivers aged 46–55. The average forecast time (1550 ms) for drivers under 45 years of age was 500 ms faster than the standard time (2080 ms). The 36–45-year-olds had the shortest response time, but it increased after the age of 45. Before the age of 45, the number of wrong choices increased with age, but after the age of 45, there was no significant change. The number of judgment errors increased with age, and there were significant differences between different age groups.

Speed estimation accuracy decreased with continuous driving time. Drivers who continued driving for 1–2 h had the highest speed estimation accuracy (1717.63 ms). The reaction time was significantly longer when driving continuously for 3–4 h compared to less than 2 h. The number of selection errors and the judgment error rate both increased with driving time, but there was no significant difference between different time groups.

Drivers with over 10 years of driving experience had the highest speed estimation accuracy (1715.81 ms). There was no significant difference in speed expectations between drivers with less than two years of driving experience and those with two to five years of driving experience. Drivers with two to five years of experience had the shortest response time (687 ms), while response time significantly increased with experience beyond five years. The number of wrong choices increased significantly with experience. There was no significant difference in the number of judgment errors between different experience groups.

3.4. Correlation between mood state and reaction ability

Drivers' mental changes may be reflected in their behavior. We used the Pearson correlation analysis method to quantify the relative coefficients and significance between each pair of variables. The results are shown in Table 4.

Depression mood and fatigue were negatively associated with speed expectation, while vigor was positively correlated with speed expectation. Anger and fatigue were positively correlated with reaction time. Only tension was positively associated with the number of reaction errors. Depression, anger, fatigue, vigor, and confusion were related to action judgment, and with the exception of vigor, moods were positive.

Table 4
Correlation between mood state and reaction ability.

Variable	Speed expectation	Choice reaction		Action judgment (number of judgment errors)
		Reaction time	Number of choice errors	
Tension	−0.181	−0.133	0.271**	−0.015
Depression	−0.193*	−0.089	0.152	0.222*
Anger	0.152	0.247**	−0.131	0.367**
Vigor	0.262**	0.066	−0.033	−0.202*
Fatigue	−0.422**	0.238*	−0.112	0.232*
Confusion	−0.06	0.157	0.105	0.293**

* $P < 0.05$.
** $P > 0.01$.

4. Discussion

4.1. Mood states

We found that drivers with different characteristics have different psychological responses at high temperatures. Drivers with less than two years of driving experience and drivers between 26 and 35 years of age are more likely to experience angry feelings during high-temperature driving. This may be because the novice driver is not able to adapt well to the high-temperature environment and thus suffers from emotional heatstroke. Some studies have found that approximately 16% of people suffer from emotional heatstroke in the summer; especially when the temperature is more than 35 °C and humidity is higher than 80%, the proportion of emotional heatstroke rises sharply (Zhou, Xin, & Bai, 2014; Liu, Zhang, & He, 2015). Furthermore, we found that older and more experienced drivers showed lower negative emotions. These drivers are experienced at high temperatures. When it comes to aggressive driving behavior or passenger complaints, they can control their emotions. In addition, our survey found that some experienced drivers like their job and think that it is very valuable to transport passengers to their destination. This may explain why they are not as depressed as less experienced drivers. This finding is also consistent with Herzberg's motivation-hygiene theory (Herzberg, 1959). We also found that fatigue increased with continuous driving hours, which agrees with previous research (Gander, Marshall, & Bolger, 2005; Gander, Marshall, & James, 2006; Dorrian, Baulk, & Dawson, 2011). Continuous driving time had no significant effect on vigor, and all drivers showed low energy. One explanation might be that physical work at high temperature can cause negative emotions rather than positive emotions.

4.2. Reaction abilities

Drivers with different characteristics exhibit different reaction capabilities at high temperatures. Older and experienced drivers have higher accuracy expectations than young and novice drivers. As shown in Table 2, our survey found that young drivers showed more nervousness than the elderly. This result is similar to previous studies that found that people are impatient in stressful situations, which leads to overestimation of speed (Eli et al., 2009).

Reaction time, the number of choice errors, and the number of judgment errors increased with age, and 55–60-year-old drivers showed the worst response times and the highest number of errors. This may be because the physiological function of older drivers had declined. The "China physical fitness monitoring report" showed that 60 years of age was a turning point in human body function (GASC, 2002).

Speed estimation accuracy and reaction time decreased and increased with sustained driving hours. Prolonged exposure to high temperature can cause mental fatigue and inattention, thereby reducing drivers' reaction ability (Meijman, 1997; Marcora et al., (2009); Brookhuis, 2010).

4.3. Relationship between mood states and reaction abilities

Tension was positively associated with the number of choice errors, indicating that the more nervous a driver was, the more errors they made. The result is consistent with previous research that found that people make more mistakes when they are nervous (Siren, 2011; Wessel, Danielmeier, & Ullsperger, 2011).

Depression was negatively related to speed estimation and positively related to action judgment. This mood can cause distraction, retardation of thinking, and physical fatigue, which reduced speed estimation accuracy and increased the number of judgment errors.

Anger was positively related to reaction time and action judgment. Previous studies found that anger affects the accuracy of judgment (Richards, 2006; Deffenbacher, 2011; Jeon, 2014).

Fatigue was negatively correlated with speed estimation and positively related to reaction time and action judgment. Several studies have demonstrated that mental fatigue can lead to distraction, lower work efficiency, and higher error rate (Meijman, 1997; Boksem, 2008; Marcora, 2009; Brookhuis, 2010).

Vigor was positively associated with speed estimation and negatively correlated with action judgment. Vigor is a positive mood and can improve concentration.

As expected, confusion was positively related to action judgment errors, the more confusion, the more judgment mistakes.

4.4. Recommendation to improve the impact of high temperature

The best solution to the high temperature of buses is to install air conditioners. However, due to economic reasons and the short duration of summertime, this method currently cannot be implemented. In order to reduce the adverse effects of high temperatures, other measures, such as management and technical methods, should be introduced.

Bus companies should organize heat-regulation training during the hot season to manage the impatient and angry moods of novice drivers. Enhanced heat resistance not only improves the efficiency of high-temperature operations but also helps prevent the occurrence of heatstroke (Glazer, 2005). Bus companies can use flexible schedules (for example, two days of work and one day of rest) to ensure that drivers have enough time to rest. For more than 2 h of continuous driving, the driver should rest no less than 15–20 min and drink water to restore his strength.

In addition, more attention should be paid to older drivers. Each year, these drivers should receive physical examinations to determine whether they have temperature-related, such as heart disease, hypoglycemia, and hypertension. At the same time, compared to young drivers, they need more time to maintain a better physical condition to drive accurately.

Finally, wearable cooling devices can reduce the impact of high temperatures on emotional state and responsiveness. Cooling of the head and cooling of the limbs have been shown to effectively relieve the body's thermal sensation (Li et al., 2015).

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Appendix A

POMS Questionnaire

Questionnaire consists of 65 adjective descriptions of moods, each with responses on a five point scale: 0 = Not at all; 1 = A Little; 2 = Moderately; 3 = Quite a Bit; 4 = Extremely. Please read each one carefully, then circle the one that best describes how you have been feeling at high temperature.

No.	Items	0	1	2	3	4	No.	Items	0	1	2	3	4
1	Friendly						34	Nervous					
2	Tense						35	Lonely					
3	Angry						36	Miserable					
4	Worn out						37	muddled					
5	Unhappy						38	Chearful					
6	Clear headed						39	Bitter					
7	Lively						40	exhausted					
8	Confused						41	Anxious					
9	Sorry for things done						42	Ready to fight					
10	Shaky						43	Good atured					
11	Listless						44	Gloomy					
12	Peeved						45	Desperate					
13	Considerate						46	Sluggish					
14	Sad						47	Rebellious					
15	Active						48	helpless					
16	On edge						49	Weary					
17	Grouchy						50	Bewildered					
18	Blue						51	Alert					
19	energetic						52	Deceived					
20	Panicky						53	Furious					
21	Hopeless						54	Efficient					
22	Relaxed						55	Trusting					
23	Unworthy						56	Full of pep					
24	Spiteful						57	Bad tempered					
25	Sympathetic						58	Worthless					

Appendix A. (*continued*)

No.	Items	0	1	2	3	4	No.	Items	0	1	2	3	4
26	Uneasy						59	Forgetful					
27	Restless						60	Carefree					
28	Unable to concentrate						61	Terrified					
29	Fatigued						62	Guilty					
30	Helpful						63	Vigorous					
31	Annoyed						64	Uncertain about things					
32	Discouraged						65	Bushed					
33	Resentful												

Tension: 2, 10, 16, 20, 22, 26, 27, 34, 41.
Depression: 5, 9, 14, 18, 21, 23, 32, 35, 36, 44, 45, 48, 58, 61, 62.
Anger: 3, 12, 17, 24, 31, 33, 39, 42, 47, 52, 53, 57.
Vigor: 7, 15, 19, 38, 51, 56, 60, 63.
Fatigue: 4, 11, 29, 40, 46, 49, 65.
Confusion: 8, 28, 37, 50, 54, 59, 64.

Appendix B. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.trf.2018.09.022.

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