Transportation Research Part F 59 (2018) 436–444

Contents lists available at ScienceDirect

Transportation Research Part F

journal homepage: www.elsevier.com/locate/trf

Bus drivers' mood states and reaction abilities at high temperatures

Sun Xianglong [a,*], Zhao Hu [b], Feng Shumin [b], Li Zhenning [c]

[a] School of Civil Engineering, Northeast Forestry University, Harbin 150040, China
[b] School of Transportation Science and Engineering, Harbin Institute of Technology, Harbin 150090, China
[c] Civil Engineering Department, University of Hawaii, 200 West Kawili Street Hilo, HI 96720-4091, United States

ARTICLE INFO

Article history:
Received 25 April 2017
Received in revised form 25 September 2018
Accepted 26 September 2018

Keywords:
Bus driver
High temperature
Mood states
Reaction abilities

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,

* Corresponding author.
E-mail addresses: sunxianglong001@163.com (S. Xianglong), zhaohuber@163.com (Z. Hu), hitfsm@163.com (F. Shumin), fredtoby@yeah.net (L. Zhenning).

https://doi.org/10.1016/j.trf.2018.09.022
1369-8478/

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.