

Stress State of Driver: Mobile Phone Use While Driving

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Abstract

The use of mobile phone is increasing during driving in China. Due to the mobile phone use while driving, traffic accidents in emergency increase. This study concerns how commonly mobile phone is used and what stress state and behavior drivers have when driving. The stress state is defined and physiological traits of driver stress are gathered by Polygraph. The indoor experiment was made in the driving simulator system, with the heart rate and respiratory rate as physiological indicators. The reliability of indicators was studied. The simulator system loaded designed dangerous scenes before the experiment and participants were divided into two groups, i.e. mobile phone use group and no mobile phone use group. All the participants reported that they were worse drivers and had wrong maneuvers in the stress state. When using mobile phone in driving, they usually did not pay attention to surrounding conditions and couldn't perceive emergency. The results showed that the heart rate and respiratory rate sharply increased when the dangerous traffic accident happened. The heart rate and respiratory rate are higher than no-mobile phone use group. The use of mobile phone while driving increased the stress state of driver and then the precautionary measures were discussed.

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Selection and peer-review under responsibility of Chinese Overseas Transportation Association (COTA).

Keywords: Driver stress; Driving simulator; Accidents; Safety

1. Introduction

Using a mobile phone while driving is very dangerous (Gras et al. 2007; Sullman & Baas, 2004). Some research found that over 57 percent of the drivers used a hand-held mobile phone at least 'occasionally' while driving in New Zealand and Spain (Sullman & Baas, 2004; Gras et al., 2007). More and more research can be shown in that mobile phone use was higher and higher amongst younger driver. There're no gender differences in

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using a mobile phone while driving (Mark & Peter). And some research showed that male and younger were more likely to use a mobile phone, but there were not gender difference in day (Horberry et al., 2001).

There has been an extensive amount of research on the impact of using a mobile phone while driving. Drivers have much slower reactions than nonusers when they keep speaking on a mobile phone or sending a text message while driving, which is thought to increase the risk of crash at least fourfold (Redelmeire and Tibshirani, 1997; Violanti and Marshall, 1996). The observational studies found that using a mobile phone while driving led to driving distraction and it was one of the many distracters. But some research showed that using a mobile phone while driving was not the most frequently observed distractions but eating and drinking were (Stutts et al., 2005). One criticism of these studies is that they were based on self-report than observation of actual behavior.

Using a mobile phone while driving is illegal, and it is forbidden by law in many countries. But some research asserted that using a mobile phone while driving is not risky in many situations, for example the car is at a standstill in gridlocked traffic etc. And hands-free mobile phone should not be forbid (Robert Trapp 2009).

The problem which was easily being neglected was that using a mobile phone while driving would always confronted dangerous scenes. Research has shown that phone conversations using mobile phone while driving impair performance. It is difficult to quantify this impairment.

The aim of the present study was, therefore, to research the performance of driver and driver stress status using a mobile phone while driving on driving simulator. The driving simulator was developed in a previous research and loaded 14 dangerous scenes (Chen Ying, 2012). The former studies showed that pedestrian is one of most important stressor, and there were gender difference in dangerous scenes which involved this stressor (Chen Ying, 2012). The present study choose a typical dangerous scene involved pedestrian and focused on novice drivers study, 60 participants were asked to perform the experiment in driving simulator while driving through a virtual world and physiological indicators were gathered throughout each driver by polygraph.

2. Method

Gathering the physiological indicators in natural world is very dangerous and impossible. Some research asserts that the driving simulator has proved the validity. We asked drivers to perform dangerous tasks in driving simulator while driving through a virtual world (Virtual experiment is the only method.). The participants' physiological indicators were gathered throughout each driver by polygraph.

2.1. Participants

The study focused on novice drivers. A total of 40 male drivers and 20 female drivers were divided into two groups of participants. Each group of 30 participants had 20 men and 10 women. (a) No using a mobile phone while driving; (b) using a mobile phone while driving. They were recruited from the master students of Shan'dong Jiaotong University in China in the study (they are all novice drivers). The same recruitment was used to recruit the participants from different driver groups in order to eliminate the possible sampling bias. All the participants were assured of anonymity and confidentiality. Due to difficulties with polygraph for participants wearing, all participants have normal physiological function.

2.2. Apparatus

2.2.1 Driving Simulator

The driving simulator setup consists of single screen, authentic cockpit (e.g. SANTANA 2000 cockpit) and self developed driver stress response training software. The virtual environment was shown on the screen at a resolution of 1024 × 768 pixels and at a frequency of 60 Hz. The participant sat in the driving simulator cockpit

and operated the controls, moving through the virtual world according to self designed scene. The audio was controlled by a separate system which consisted of two mid/high frequency speakers located on the left and right sides of the car and two sub-woofers located under the hood of the car. This system provides realistic road, wind and other vehicle noises with appropriate direction. Training scenes and driver records were recorded by software.



Figure. 1 A dangerous scene involved pedestrian

The typical dangerous scene was described as follows (see Figure 1): When the participants drive on the city road, the sight horizon will be limited due to in front of road construction. When the participants arrived in the area of construction on the narrow road, one person suddenly ran from the construction area. This dangerous scene will cause a terrible collision accident.

2.2.2 Polygraph

Multipurpose polygraph MP150 (Polygraph developed by BIOPAC company) was used to collect the physiological traits data for each driver. It has a system consist electrocardiogram wires (2 shielding lines and 1 un-shielding line), electrode slice, data gathering machine, transducer, and amplifier.

In the test, the participants wear physiological characteristics sensor. The installation of sensor should not affect the driver's arm, hand movement, feet on the throttle and brake control should be advisable. Skin conductance sensor (GSR) is settled on the right hand forefinger and middle finger place, respiration sensor is located in lung diaphragm place, temperature sensor is located in the alar place, ECG sensor installed in the driver's chest, through the conductive SMT and electrode and wire connection. Then the skin conductance, ECG data, skin temperature and respiratory data can be gathered by TEL100M-C model of MP150, and the data can be disposed by AcqKnowledge software.

2.3. Experimental Procedure

The participant was fitted with the polygraph which was calibrated within the simulator. After calibration, participants were given a practice drive to familiarize them with the driving simulator to eliminate difference of participants. During the experimental drive, the participant followed the instructions on the screen. The speed limit for the city road was 60 mph. The dangerous scene was timed to appear such that they would be visible to the participant for approximately 120.0 s when driving at 60 mph. When the scene was visible, the participant operated according to the scene. After finished single training, the system will repeat. After ending the experiment, the heart rate and time that dangerous scene were triggered were recorded by MP150. Data gathering software (AcqKnowledge software) calculated physiological indicators in instant.

3. The signals and Results

There were four kinds of signal were monitored in the test: skin conductance, respiration, skin temperature and heart activity. The reason of choosing these sensors was based on no invasive and continuous monitoring of the driver driving stress reaction.

(1) Skin Conductance

Skin conductance is the most rapid reaction which is accompany with stress response. It has been using to determine the driver stress. It is also the most reliable autonomic nervous system activity determination method and it is not invasive. Selye and other researchers have confirmed that skin conductance accompanying with stress is closely related to the awakening of the autonomic nervous system. When the driver was in the stress state, the signal of skin conductance will appear on a characteristic orientation response, or "startled". In order to detect these reactions, first of all, the skin conductance signal was gathered on 20 Hz frequency, after smoothing processing, the initial forward difference was calculated as a threshold. The more than the threshold value was showed as a slope and was related to the edge of alert, the orienting response was finally detected.

(2) Heart Rates

Heart activity is a very valuable measure of the psychological state test. Sports, high decibel noise, tension and high strength mental activities can lead to the heart rate speeding up. Lower heart rate is related to relaxation condition or joyful experience. Blood volume pulse (BVP) module was used to determine the heart rates on 20 Hz frequency. And the ECG operation module computed heart rate in real-time.

(3) Respiratory

The excited mood and physical activity were reported can lead to faster and deeper breathing, and quiet rest and relaxation will lead to shallow and quiet breathing. Therefore, repeated respiratory can characterize psychological state. However, driver stress state, such as fear, often can cause respiratory instant stopped. The measurement of breathing is primarily through respiration sensor to detect the driver's breathing rate. Respiratory module was used to determine the respiratory, amplifier gain was set on 10 Hz, high-pass filter was set on 0.5 Hz, low pass filter was set on 1 Hz. The respiration rate channel calculate breathing rate on real-time and the maximum was set on 60.

(4) Skin temperature

Skin temperature can characterize tense, and can be acquired through the TSD202 temperature sensor, the high-pass filter was set on DC, low pass filter was set on 10 Hz. The skin temperature ($^{\circ}\text{C}$) was calculated on real-time.

Through the filter processing and threshold value analysis processing, get the driver the physiological indicators are as follows:

Table. 1 Physiological Indicators Data

States	normal driving		In emergency		
	Heart rates	Skin Conductance (micromho)	respiratory	Skin Temperature($^{\circ}\text{C}$)	
calm	75.451	75.451	0.00305	56.872	36.22053
no using mobile phone	78.563	104.285	0.00987	60	36.22094
using mobile phone	87.456	120.234	0.01272	60	36.22087

As it is shown in above table, the drivers' heart rate accelerated in dangerous, and heart rates became higher if they drove while using the mobile phone. Skin conductance data showed that the drivers' sweat gland secretion increased in emergency, it meant using mobile phone while driving exactly increase the state of driver stress. Respiratory rate is more than the maximum sixty, it showed that drivers had shortness of breath in driving. Skin temperature had little changes, and driving task makes drivers' temperature higher than theirs in peace. Drivers' skin temperature when they using a mobile phone while driving were higher than normal driving.

4. Discussion

Inferring the significance of physiological events in the natural environment is difficult and requires using driving simulator and sensors to capture context. Stress reactions using a mobile phone while driving can occur more terrible accident from both physical and mental stressors. Obviously, heart rates and skin conductance can explain it more visualized. Using these data, we hope to explain that using a mobile phone should be banned.

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ACKNOWLEDGEMENT

This research is sponsored by the Research Fund of Shandong Jiaotong University in Shandong province in China (Z201238) and Youth science fund project of the national natural science fund (51108036). We also acknowledge the editors and anonymous reviewers, for their detailed suggestions, precise comments and continuous helps, which lead to the belief that their dedication contributes to this research work and it would not have been feasible without their support.

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