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Discrepancy analysis of driving performance of taxi drivers and non-professional drivers for red-light running violation and crash avoidance at intersections

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ABSTRACT

Due to comfort, convenience, and flexibility, taxis have become increasingly more prevalent in China, especially in large cities. However, many violations and road crashes that occurred frequently were related to taxi drivers. This study aimed to investigate differences in driving performance between taxi drivers and non-professional drivers from the perspectives of red-light running violation and potential crash involvement based on a driving simulation experiment. Two typical scenarios were established in a driving simulator, which includes the red-light running violation scenario and the crash avoidance scenario. There were 49 participants, including 23 taxi drivers (14 males and 9 females) and 26 non-professional drivers (13 males and 13 females) recruited for this experiment. The driving simulation experiment results indicated that non-professional drivers paid more attention to red-light running violations in comparison to taxi drivers who had a higher probability of red-light running violation. Furthermore, it was found that taxi drivers were more inclined to turn the steering wheel in an attempt to avoid a potential collision and non-professional drivers had more abrupt deceleration behaviors when facing a potential crash. Moreover, the experiment results showed that taxi drivers had a smaller crash rate compared to non-professional drivers and had a better performance in terms of crash avoidance at the intersection.

1. Introduction

Owning to the improvement of people's living standards in China, taxis are getting more popular among the general public transportation systems because of comfort, convenience, and flexibility. According to the statistics from Beijing Municipal Bureau of Statistics (2008), there were more than 69,000 taxis in Beijing, which was six times larger than 20 years ago. The number of passengers who chose taxis for their traveling increased steadily in recent years (Beijing Transporation Research Center, 2012). Generally, there is no significant difference between taxis and ordinary cars from the aspects of vehicle size and performance. When collecting traffic volume data, a taxi is also considered as one ordinary passenger car. However, in terms of driving behaviors, taxi drivers are quite different from non-professional drivers. In China, taxi drivers often look for customers by cruising in the urban road networks. Therefore, they would stop, accelerate, or decelerate more frequently when hunting customers, which may result in some traffic problems and safety issues (Yang, 2007).

According to an investigation on traffic violation, a total of 17,242 taxi violations, including parking violations and red-light running, happened in Beijing during only one month in 2003. It indicated that 27% of taxi drivers received penalties (CPPCC, 2008). Furthermore, taxi drivers also had a larger number of traffic crashes. The data showed that nearly 20% of taxis were involved in traffic crashes each year. However, taxis occupied only 3.4% of the total vehicles in Beijing, indicating a high probability of taxi crashes (Jing et al., 2014). A similar phenomenon was also found in other countries, such as Canada (Maag et al., 1997) and Norway (Nordfjaern et al., 2012).

Several researches studied on the reasons why taxi drivers had a high probability of traffic crashes. One reason was that taxi drivers were usually under fatigue driving conditions for a long period, which might change the driving behavior and driving habits (Meng et al., 2015). Due to the particularity of the taxi industry in China,

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taxi drivers have flexible work schedule, which means that they can set their working hours as they prefer. The taxi drivers could have a rest when they feel tired, which may help them reduce the driving fatigue. However, the taxi drivers in China usually work for 11 h per day and 27.8 days per month, which is far more than the legal limit of 8 h per day and 21.8 days per month. This high work intensity may be an actual reflection of the typical taxi drivers' work conditions in China (Deng and Ou, 2009). The reason is that the income of the taxi drivers heavily depends on their driving time and driving distance every day. Taxi drivers need to pay a relatively high licensed fee monthly to their taxi companies or contractors as well as the gas and vehicle maintenance costs (Jing et al., 2014). In fact, if taxi drivers work only under the limitations of the legal working hours, they could probably not earn enough money or could even lose money. Therefore, it can be inferred that nearly 25% of work time for taxi drivers is under fatigue driving conditions in Beijing. The previous studies demonstrated that fatigue driving results in reduction in alertness, longer reaction times, and poor psychometric coordination, which is more dangerous than normal driving (e.g., Dalziel and Job, 1997; Zhang et al., 2016; Merat and Jamson, 2013; Du et al., 2015). Therefore, long period in the fatigue driving state might change the taxi driver's driving behavior, which would result in higher probability of traffic crashes.

In addition, one of the important reasons about why the taxi drivers had a higher violation rate is the attitude to the traffic violation. Botes (1997) investigated the taxi drivers' attitudes to traffic violation in North Africa. It was found that there was a poor communication between law enforcers and taxi drivers, which might lead to high-risk driving behaviors among taxi drivers (Peltzer and Renner, 2003). Rosenbloom and Shahar (2007) also attempted to identify the attitude toward traffic violations in male taxi drivers in Israel. The results indicated that professional drivers were more influenced by the traffic laws compared to the non-professional driver. Hence, professional drivers were more likely to consciously disobey them. Furthermore, the level of education is another potential factor that affects the violation rate. According to the survey, most taxi drivers had junior or senior middle school certificates, and only 1.8% of taxi drivers had university or higher certificates (Meng et al., 2015). The drivers with low levels of education were more likely to lead to unsafe driving behaviors than the drivers with high levels of education (Newnama et al., 2014), which implies that the taxi drivers would be more likely to have a higher traffic violation rate.

Although a few previous studies analyzed taxi drivers' characteristics of crash-involvement risk and traffic violation from different aspects, few researchers investigated taxi drivers' driving performance based on vehicle operation data. It was still uncertain about whether the taxi drivers' the driving performance, such as the ability to avoid crashes and the red-light running behaviors, are different from non-professional drivers or not. In this study, a driving simulator is used to better understand the driving performance of taxi drivers. Driving simulators can provide a well-controlled experimental condition to compare with the drivers' performance in road network. Another advantage of using driving simulator is that it can collect the data which are difficult to extract in the real world, especially in dangerous scenarios, such as violations and potential crashes (Creaser et al., 2007). Several previous studies demonstrated the potential of using driving simulators to assess driving performance and traffic safety (e.g., Montella et al., 2014; Bham et al., 2014; Liu et al., 2015), but none of these studies focused on taxi drivers. Based on the driving simulation experiment, the experiment results can not only help traffic engineers develop more traffic safety management strategies specifically for taxi drivers, but also provide taxi companies a reference to establish a better regulation rules.

This paper aims to identify the difference in driving performance between taxi drivers and non-professional drivers through a two-scenario driving simulation experiment, including red-light running violation scenario and crash avoidance scenario at signalized intersections. Furthermore, this study is based upon testing the hypotheses that the occupation factor (taxi drivers vs. non-professional drivers) would lead to the differences in driving performance between taxi drivers and non-professional drivers when facing a potential red-light running event and precrash event at signalized intersections, such as decision on the red-light running and the ability to avoid traffic collisions.

2. Methodology

2.1. Participants

A total of 55 drivers, who were local residents in Beijing, China, with at least one year of driving experience, participated in this experiment. Because six drivers could not complete the experiment due to the motion sickness, finally, 23 taxi drivers (14 males and 9 females) and 26 non-professional drivers (13 males and 13 females) finished the experiment successfully. All of the taxi drivers were full-time job drivers from different taxi companies. The non-professional drivers were from different occupations, such as teachers, company employees, and students. Since the population of female taxi drivers is much smaller than that of male taxi drivers in taxi companies, it is quite difficult to recruit female taxi drivers, which lead to a relatively unbalanced gender distribution for taxi drivers in the experiment. The average age of the participants was 34, ranging from 20 to 52 years old (S.D. = 10). According to the t-test ($t = 1.33$, p-value = 0.192), it was found that the difference in age between taxi driver group and non-professional group was not statistically significant. The taxi drivers had an average mileage of 72.6 thousand kilometers per year. By contrast, the non-professional drivers had an average mileage of 12.6 thousand kilometers per year. Regardless of that fact, the driving experience was not considered in the analysis. Each participant was required to finish the two scenarios in the driving simulator and obtained 500 Chinese RMB (around 80 U.S. dollars) as a compensation for the participation.

2.2. Apparatus/equipment

This study used a driving simulator for the experiment and data collection, which was located in Beijing Jiaotong University in China (see Fig. 1). According to the driving simulator classification scheme (Saluaar, 2000), the simulator is the one between mid-level and high-level simulator, which has a linear motion base with one degree of freedom and a shaking simulation system. It includes a visual system (5 channels of front view and three rear view mirrors), a full-size cabin of Ford Focus with real interface, a digital sound simulation system and the central console. The simulated environment is projected at a resolution of 1400×1050 pixels for each channel. The software, including Simvista and Simcreator, can be applied for researchers to create driving scenarios with the virtual traffic environments and the virtual road networks. The data sampling frequency is up to 60 Hz.

A surveillance system was also installed. Five cameras were installed inside and outside the cabin to ensure subjects' safety in the driving simulator and the camera videos would be displayed on another monitor in the central console so that the supervisors could watch the participants' performance at the same time. An emergency stop button was installed both inside the cabin and in front of the central console so that the supervisors and subjects could discontinue the experiment at any time.