The traffic and safety effect of smartphone texting and web surfing during driving in cities: A driving simulator study

Maria Oikonomou[1], Dimosthenis Pavlou*[2] and George Yannis[3]

[1, 2, 3] National Technical University of Athens, Department of Transportation Planning and Engineering, 5 Heroon Polytechniou str., GR-15773, Athens, GREECE
(E-mail: moikonomou@mail.ntua.gr, dpavlou@central.ntua.gr, geyannis@central.ntua.gr)

Keywords: driving behaviour, driver distraction, driving simulator, texting while driving, web-surfing while driving

ABSTRACT

Over the last years, in addition to the increasing use of smartphones, new vehicles are equipped with technologies that make it even easier to use a smartphone while driving [1]. For that reason, driver distraction by using a mobile phone is a cause of road traffic accidents [2-3]. International research has indicated that accident probability is increasing when a driver is being distracted [4-5] and especially for the young, distracted drivers this increase is reaching 8% [6]. Moreover, reading text messages while driving reduces the driving speed by 30% [7]. The objective of this study is to quantify the traffic and safety effect of texting and web surfing by a smartphone during driving in urban areas, through a driving simulator experiment.

The experimental procedure was carried out on the NTUA driving simulator which is a motion base quarter-cab manufactured by the FOERST Company. The simulator consists of 3 LCD wide screens 40'', driving position and support motion base. The choice of the sample scheme was focused on young people with a valid driving license. 36 drivers (19 males and 17 females) participated in the experiment, who had 5.4 years of driving experience on average. The sample scheme was clustered into two age groups, aged 18-24 and 25-33, in order to differentiate behavior based on their driving experience. A questionnaire was also developed to identify drivers' profiles and focused on the smartphone use and their familiarity with urban road. At the beginning of the experiment, each participant drove a test route on urban environment during daytime conditions, which was a different route from the scenarios' ones in order to get familiarized with the driving simulator and test for possible simulator sickness issues.

For the present study, the type of road that was examined was urban environment, which included a variety of complex urban conditions: roundabouts, signalized intersections, not-signalized intersections, which required increased cognitive load compared to rural driving environment. Four different scenarios were selected to

examine several factors that may have impact on driver's behavior, and the impact of smartphone use while driving. More specifically, the scenarios were distinguished by day and night driving conditions[1], each with a low (300 vehicles/hour) and high (600 vehicles/hour) traffic volume. In each scenario two unexpected events were programmed to appear in order to examine the accident probability. Drivers were asked by the experiment instructor to perform the following secondary tasks while driving each of the four sessions (day-night and high-low traffic): a) navigate in their Facebook feed, b) texting via Facebook Messenger and c) search for a location via Google Maps app (in random order during their route, but at specific timing given by the instructor).

The statistical analysis that was conducted, included two levels of analysis. The first one included five regression models which were developed in order to analyze the impact of smartphone use (scrolling Facebook feed, texting and Google Maps navigation) while driving on young drivers' behavior and safety in terms of mean driving speed, mean headway distance from the front vehicle and accident probability. The second step included generalized linear models in order to compare the different impacts of the use of different smartphone applications[2]. The elasticity of each independent variable was calculated in order to estimate the sensitivity of each dependent variable [8].

Moving on to the results of the analysis, the mean speed linear regression model indicated that the independent variables which were statistically significant at 95% level were: texting/web surfing distraction, traffic volume, if driver enjoys driving (variable extracted from the questionnaire) and driver's gender. The elasticity value showed that texting or web surfing while driving lead to 8% decrease of the mean driving speed.

The second linear regression model concerned mean speed variability and indicated that the independent variables which were statistically significant at 95% level were: texting/web surfing distraction, traffic volume, how driver changes driving behavior while using mobile phone and driver's daily frequency of texting/web surfing (the latter three variables extracted from the questionnaire). The elasticity value showed that texting or web surfing while driving lead to 26% decrease the mean speed variation. Regarding the mean speed variability, we moved on to the second analysis step with the first generalized linear model, which was also developed, showed (by comparing the significant coefficients) that, Google Maps application had the highest impact in the model, followed by Facebook Messenger and Facebook app. Additionally, the riskiest driver profile was a male driver who is distracted by using the Google Maps app.

Then, the headway distance linear regression model indicated that the independent variables which were statistically significant at 95% level were: texting/web surfing

[1] Nightime conditions were fully simulated not only at the driving scenario but also in the environment around the simulator during the experimantal procedure.

[2] The second step conducted only for two out of five examined dependent variables, as for the other three no statistically significant difference was observed between the three different distracted conditions.

distraction, traffic volume, if driver enjoys driving, how driver changes driving behavior while using mobile phone, driver's daily routes on urban roads, driver's gender and age. The elasticity value showed that texting or web surfing while driving lead to 5% decreased headway distance.

Then, a linear mean headway distance variability regression model was developed and showed that the independent variables which were statistically significant at 95% level were: texting/web surfing distraction, traffic volume, lighting conditions (day/night), driver's gender and weekly driven kilometers on urban roads. According to the elasticity values, texting or web surfing while driving lead to 19% decreased headway distance variation. For the mean headway variability, we moved on to the second analysis step with the second generalized linear model, which was also developed, showed (by comparing the significant coefficients) that, Facebook application had the highest impact in the model, then Google Maps and Facebook Messenger app. The riskiest condition was high traffic volume when driver is distracted by using the Facebook app.

Finally, a binary logistic regression model was developed for investigating accident probability, which indicated that the independent variables which were statistically significant at 95% level were: texting/web surfing distraction, traffic volume, driver's age group, lighting conditions (day/night) and driver's weekly days driving on urban roads. The elasticity value showed that texting or web surfing while driving lead to 75% increased accident probability.

Concluding, according to the results of the regression models, a key finding is that web surfing or texting distraction while driving has the greatest negative impact on driving behaviour compared to the other risk factors, such as traffic volume and lighting conditions. More specifically, smartphone use while driving increases significantly the accident probability, while at the same time reduces the mean driving speed. The increased accident probability may be explained by the fact that smaller headways are maintained from the vehicle in front and drivers while using a smartphone have a reduced perception of traffic, which makes them more vulnerable to a driving error and then a collision. Also, using the smartphone while driving reduces the mean speed variability because the distracted driver tries to compensate this risky behaviour by maintaining a steady speed, but this strategy is not successful as the accident risk is greater.

Then, moving on to the results of the generalized linear models, comparing the three different smartphone applications to each other, Google Maps had the highest impact on mean speed variability followed by Facebook Messenger and Facebook application. Combined with the impact of the driver's gender, the riskiest driver profile is a male driver who is distracted by using the Google Maps app. Several remedial measures should be implemented and enforced in order to reduce the use of smartphone while driving as its effect on road safety is detrimental.

References:

[1] WHO & NHTSA, "Mobile phone use: a growing problem of driver distraction", 2011

https://www.who.int/violence_injury_prevention/publications/road_traffic/distracted_driving_en.pdf
[2] Oviedo-Trespalacios O., King M., Haque M. M., Washington S. “Risk factors of mobile phone use while driving in Queensland: Prevalence, attitudes, crash risk perception, and task-management strategies” PLoS ONE, 12(9), 1–16, 2017 https://doi.org/10.1371/journal.pone.0183361
[3] Nasr Esfahani H., Arvin R., Song Z., Sze N. N. “Prevalence of cell phone use while driving and its impact on driving performance, focusing on near-crash risk: A survey study in Tehran” Journal of Transportation Safety and Security, 0(0), 1–21, 2019 https://doi.org/10.1080/19439962.2019.1701166
[4] Choudhary P., Velaga N. R., “Modelling driver distraction effects due to mobile phone use on reaction time”, Transportation Research Part C 77, Indian Institute of Technology Bombay, India, 2017
[5] Drews F. A., Yazdani H., Godfrey C.N., Cooper J. M., Strayer D. L., “Text Messaging During Simulated Driving”, Human Factors Vol. 51, University of Utah, Salt Lake City, 2009
[6] Ortiz C., Ortiz-Peregrina S., Castro J. J., Casares-López M., Salas C. “Driver distraction by smartphone use (WhatsApp) in different age groups” Accident Analysis and Prevention, 117(May), 2018, 239–249. https://doi.org/10.1016/j.aap.2018.04.018
[7] Yannis G., Laiou A., Papantoniou P., Christoforou C. “Impact of texting on young drivers’ behavior and safety on urban and rural roads through a simulation experiment” Journal of Safety Research, 49(February), 2014, 25.e1-31. https://doi.org/10.1016/j.jsr.2014.02.008
[8] Washington S. P., Karlaftis M. G., Mannering F. L., “Methods for transportation data analysis”, CRC Press, Boca Raton, 2011