# Impact of Texting on Young Drivers' Behaviour and Safety on Motorways by the Use of a Driving Simulator

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## Abstract

Texting while driving seems to be a widespread behaviour, which has been associated with a non negligible proportion of road accidents, especially among younger drivers. The impairment of the driver's behaviour and the related risks may be increasing on motorways, if we take into consideration the fact that there are high vehicle speeds and the necessary reaction time is decreased.

This research aims to investigate the impact of texting on young drivers' behaviour and safety on motorways. On this purpose, a driving simulator experiment was carried out, in which 34 young participants drove in different driving scenarios. Lognormal regression methods were used to investigate the influence of text messaging as well as various other parameters on the mean speed and the mean headway. Binary logistic methods were used to investigate the influence of texting and other parameters on the probability of an accident. The models' application showed that texting leads to statistically significant decrease of the mean speed and to increased headway in normal and in specific conditions on motorways. Simultaneously, it leads to an increase of accident's probability, probably due to increased reaction time of the driver in case of an incident.

## Introduction

Driver distraction and inattention are contributing factors to more than one quarter of recorded road accidents (Stutts et al, 2005).Among the main causes of driver distraction and inattention are talking on the mobile phone, texting, eating, smoking and having a conversation with the passengers.

Texting is considered even more dangerous than talking on the mobile while driving, as accident probability increases by 23.3 and 5.9 times respectively, comparing to free driving. Texting is found to cause difficulty in retaining a stable position within the traffic lane (Crisler at al, 2008) and to double reaction time (Cooper et al, 2011). In addition, looking away from the road, as while texting, for more than 3 seconds increases the accident probability (Klauer et al, 2006). Simulator experiments have shown that participants maintain longer headways while texting (Drews et al, 2009). In vehicle technologies have also be related to approximately half a million road accidents per year due to driver's distraction (Owens et al, 2010).

As far as texting while driving is concerned, 95% of the respondents to a relative survey in the USA admitted adopting this behaviour even though they recognize the increased associated risk (Atchley et al, 2011). Specifically, the risk associated to texting while driving is estimated 5 times higher than that associated to driving under alcohol influence (Klauer et al, 2006). Although cognitive load consistently impairs driving performance, distracted drivers do sometimes adapt their behaviour in ways that might allow them to remain safe despite their delayed responses (Horrey and Simons, 2007). Among young drivers, very few alter their driving behaviour in order to contemplate the recognized increased risk of texting while driving (Nelson et al, 2009, Atchley et al, 2011).

The use of driving simulators for the examination of the influence of texting on driving performance and safety is quite common. Driving simulators allow for the collection of a large amount of data which would be very difficult to collect under real traffic conditions, without exposing the drivers to any danger. Any possible driving scenario can be explored as various situations on different road types, in different traffic conditions and in different weather conditions may be simulated. Moreover, in simulator experiments, driving conditions are identical for all drivers, something which is impossible to achieve in real traffic. On the other hand, simulator studies have a few disadvantages that should be acknowledged. Such disadvantages are the non totally realistic simulated road environment and driving conditions; the possibility of adopting a different driving behaviour when drivers are not under observation; the feeling of safety provided while driving on the simulator as well as some driver dizziness that might be caused after a long drive.

The present research aims to explore the interrelation between texting while driving, speed, headways and accident probability of young drivers on motorways through a driving simulator experiment. In particular, the research aims to analyse the effect of texting in combination to the effects of the road type (motorway) and traffic (moderate, heavy), environmental conditions (good weather, rain) and driver characteristics (gender, annual mileage, driving habits).

## Method and data

The impact of texting on driving in combination with specific driver and road environment characteristics, was explored through a driving simulator experiment (Gkartzonikas, 2012). The main goal of the participants' recruitment was to achieve approximately equal numbers of male and female young drivers as well as equal numbers of drivers using mobile phones with touch and non-touch screens. The behaviour of 19 male and 15 female drivers, aged 18 to 28 years old, most of which were students of the National Technical University of Athens with a valid driving license and an average driving experience of 3.5 years was examined. 20 participants used mobile phones with touch screens and 14 participants used mobile phones without touch screens. In order to be familiar with the device, each participant used his/her own mobile phone during the experiment. Foerst Driving Simulator FPF, a quarter-cab simulator with a motion base and three 40'' LCD monitors was used for the experiment.

The driving scenario used in this research included driving on a motorway entry ramp,in moderate traffic, and then driving on a motorway, first in moderate traffic and then in heavy traffic. The speed limit on the motorway was 100km/h.In addition, two different weather conditions, good weather and rain were examined. It is noted that in the rain scenario, grip on the road as well as sight conditions-visibility are decreased.

Finally, besides sending/receiving sms while driving, the activation of the alarm function of the mobile phone was included in the driving scenario.

In the first part of the experiment, a questionnaire on personal characteristics and driving behaviour with regard to texting was filled-in by drivers. In the second part of the experiment, data collection was conducted in three different phases. Firstly, in order to get familiar with the simulator, participants had a test drive for approximately five minutes without reading or sending any sms (free driving). Then, participants had to read or write an sms, as many times as asked while driving the same route in good weather and in rain. Each journey lasted again approximately five minutes. After a brake, the driver drove the same route as in the second part of the experiment but under the opposite weather conditions (good weather or rain). Half of the participants drove firstly in good weather and half in rain so that their familiarization with the simulator during the third drive would not influence the results. Drivers were asked to follow their usual driving behaviour throughout the experiment and try not to be affected by any other factors.

The experiment was supervised by a surveyor watching each participant, in real time, through a pc connected to the simulator and located in some distance from it in order to avoid any potential distraction of the driver. At specific, pre-defined locations of the journey, the surveyor sent and received text messages to and from the driver. At the same time, he recorded potential comments regarding the driver's behaviour and the progress of the experiment. Each texting process usually lasted 60 to 90sec and aimed to making the driver think as it required some mental alertness. While driving in moderate traffic, drivers received a 180 character sms asking for specific directions on traveling from the centre of Athens to the NTUA campus by public transport. In heavy traffic, drivers again received a 180 character sms asking for directions on how to prepare a simple recipe. In both cases, drivers had to send an sms reply. While still driving in heavy traffic, drivers were asked to set the alarm function on their mobile phones.

Based on questionnaire answers (Table 1), 47% of the participants use their mobile phone for reading or writing sms while driving often, 24% quite often and 20% always. Moreover, the majority never stop by the road to text. These results show that texting while driving is a very common behaviour among young drivers and it is not considered a risk increasing factor; therefore, very few young drivers try to compensate for it.

Table 1 Frequency of Texting While Driving and Pulling Over to Text

| | Always | Often | Quite often | Rarely | Never |
|---|---|---|---|---|---|
| Texting while driving | 20% | 47% | 24% | 6% | 3% |
| Pull over to text | 3% | 18% | 20% | 18% | 41% |

In Table 2, mean speed, mean headways and the frequency of accidents by traffic conditions, use of mobile phone and weather conditions, as recorded in the simulator experiment are shown. There appears to be no difference in mean speed under good weather and rain. Mean headway is shorter while texting compared to free driving, in both moderate and heavy traffic. Furthermore, headways are longer during rain compared to good weather. Regarding accident occurrence, reading or writing an sms increased the number of accidents under all different conditions. It is noted that the number of accidents is an indication of accident occurrence under different weather and traffic measure conditions and for different driving behaviours rather than a performance to compare and classify individual drivers' performance.

Table 2 Mean speed, mean headway and number of accidents for different traffic, weather conditions and distraction factors

| | | Good weather conditions | | | Rainy conditions | | |
|---|---|---|---|---|---|---|---|
| | | Free driving | Reading sms | Writing sms | Free driving | Reading sms | Writing Sms |
| Moderate traffic | Speed (km/h) | 94 | 84 | 79 | 90 | 85 | 79 |
| | Headways (m) | 300 | 220 | 180 | 420 | 290 | 200 |
| | Accidents | 0 | 2 | 3 | 1 | 9 | 4 |
| Heavy traffic | Speed (km/h) | 88 | 80 | 78 | 83 | 77 | 73 |
| | Headways (m) | 710 | 495 | 405 | 780 | 560 | 450 |
| | Accidents | 0 | 2 | 3 | 2 | 6 | 4 |

**Models' development**

The impact of texting on young drivers' behaviour and safety on motorways and in terms of speed, headway and accident probability was analysed through the development of six different models. Specifically, as the logarithms of mean speed and headways were found to conform to a normal distribution, log-normal linear regression models were developed for these variables. Accident probability was modelled using binary logistic regression models. In binary logistic regression models, parameter estimates $\beta_k$ represent the mean change in the log-odds for a unit change in $x_k$, holding other explanatory variables fixed; therefore the odds ratios can be calculated as $\exp(\beta_k)$; these are used for the assessment of the relative effect of different variables on accident probability.In each case, separate models were fitted for moderate and heavy traffic.

Variables available for the analysis are shown in Table 3, with variables derived from the output of the simulator ranging from1 to 30, and variables obtained from the questionnaire ranging from 31 to 54. For the selection of variables, univariate tests were carried out in which variables were tested and their statistical significance were determined by means of a t- or Wald test. The selection of independent variables was based on an established method such as a manual stepwise selection. Then, for the statistically significant variables of the univariate analysis, correlation tests were carried out to identify correlated variables. In case that two or more variables were correlated, the variable to be included in the model was selected on the basis of its statistical significance and its relevance to the objectives of the analysis. This way, the sets of explanatory variables to be included in the multivariate models were defined. The current method was selected among others as the most common in similar studies internationally.

A variable was kept in the final model if the corresponding parameter estimate was significant at 90% confidence level, by means of t- or Wald- tests – a more relaxed confidence level was considered acceptable for the present analysis, given the relatively small sample size. The quality of the model was determined by means of the $R^2$ coefficient for the linear regression models and by means of the likelihood ratio test (LRT) for the binary logistic regression models. In particular, the final binary logistic regression models were compared to the 'null' (i.e. empty) ones, by comparing the likelihood ratio (i.e. the difference in log-likelihood) with the value of a chi-square distribution with degrees of freedom equal to the difference in the number of parameters between the 'null' and the final model (Ben-Akiva & Lerman, 1985).

Estimating the responsiveness and sensitivity of the dependent variable with respect to changes in each independent variable was also needed to allow the comparison of the impact of different variables on using a mobile phone while driving. This was achieved by calculating the elasticity of each independent variable (Washington, Karlaftis & Mannering, 2003). The elasticity value of a continuous variable is defined as the percentage change in the dependent variable resulting from small, incremental changes in an independent variable. Elasticity can be particularly useful because it is dimensionless, unlike any estimated coefficient of regression parameter, which depends on the units of measurement of each parameter. The relevant elasticity ($e_i^*$) of each variable was also calculated by dividing the elasticity of the specific variable by the elasticity of the variable with the lowest impact on the dependent variable. This allows for the classification of variables with respect to the magnitude of their effect on the dependent variable in a straightforward way.

**Table 3 Variables available for the analysis**

| no | code | description | values or units |
|---|---|---|---|
| 1 | Rain | rainy weather | (1:yes, 0:no) |
| 2 | Good | good weather conditions | |
| 3 | rspur | mean distance from the central axis of the road to the central axis of the vehicle | (m) |
| 4 | rspur max | maximum distance from the central axis of the road to the central axis of the vehicle | |
| 5 | rspur min | minimum distance from the central axisof the road to the central axis of the vehicle | |
| 6 | Logrspur | logarithm of the distance from the central axis of the road to the central axis of the vehicle | |
| 7 | Speed | mean speed | (km/h) |
| 8 | logV | logarithm of the mean speed | |
| 9 | v max | maximum speed | (km/h) |
| 10 | Brk | % route the brake was used | |
| 11 | Acc | % route the accelerator was used | |
| 12 | Rpm | mean motor revolution per minute | |
| 13 | Dleft | mean distance from the left edgeline | (m) |
| 14 | Dright | mean distance from the right edgeline | |
| 15 | Incident | occurrence of an incident | (1:yes, 0:no) |
| 16 | Water | occurrence of aquaplaningeffect | |
| 17 | HWay | distance from the rear bumper of the vehicle ahead | (m) |
| 18 | log HWay | logarithm of thedistance from the rear bumper of the vehicle | |
| 19 | THead | time distance from the rear bumper of the vehicle ahead | (sec) |
| 20 | log THead | logarithm of the time distance from the rear bumper of the | |
| 21 | THead min | minimum distance from the rear bumper of the vehicle | (sec) |
| 22 | Q | traffic conditions on the motorway | (1: heavy, 0: moderate) |
| 23 | Free Q1 | free driving in moderate traffic | (1:yes, 0:no) |
| 24 | Rm 1 | message reading while driving in moderate traffic | |
| 25 | Wm 1 | message writing while driving in in moderate traffic | |
| 26 | Time fix | alarm function activation while driving in moderate traffic | |
| 27 | Free Q2 | free driving in heavy traffic | |
| 28 | Rm 2 | message reading while driving in heavy traffic | |
| 29 | Wm 2 | message writing while driving in in heavy traffic | |
| 30 | Time fix | alarm function activation while driving in heavy traffic | |
| 31 | Age | driver's age | |
| 32 | Gender | driver's gender | |
| 33 | d experience | driver's driving experience in years | (1-3years:1,4-6years:2,>7years:3) |
| 34 | dist week | distance travelled per week | |
| 35 | love d | driver enjoying driving | (1:yes, 0:no) |
| 36 | acc ak | self reported accident occurrence while texting on motorway | |
| 37 | Touch | mobile phone with a touch screen | (1:no, 0:yes) |
| 38 | ak_freq | frequency of driving on the motorway | (1: once a day, 2:once a week, 3:once a month, 4:never) |
| 39 | ak_freq_rain | frequency of driving on the motorway, in rain | |
| 40 | dang_ak_rain | perceived risk caused bysms texting while driving in good weather | (none:1, low:2, medium:3, high:4, very high:5) |
| 41 | dang_ak_day | perceived risk caused by texting while driving during daytime | |
| 42 | b rain | change of behaviour when driving in rainy conditions | (1:reduce speed, 2:pull over, 3:keep right, 4:none) |
| 43 | b_sms | change of behaviour when texting while driving | |
| 44 | freq sms | texting while driving | (1:never, 2:seldom, 3:few times, 4:often, 5:always) |
| 45 | freq stop | pull-over for texting | |
| 46 | red sms | speed reduction while texting sms | (km/h) (1:0-10, 2: 11-20, 3: >20) |
| 47 | red night | speed reduction while driving during night | |
| 48 | red rain | speed reduction while driving in rain | |
| 49 | wm1 ak good | 1st sms sent while driving in good weather | (1: success, 2: failure, 3:with difficulty) |
| 50 | wm2 ak good | 2nd sms sent while driving in good weather | |
| 51 | alarm good | activation of alarm function in good weather | |
| 52 | wm1 ak rain | 1st sms sent while driving in rain | |
| 53 | wm2 ak rain | 2nd sms sent while driving in rain | |
| 54 | alarm rain | activation of alarm function in rain | |

*Modelling mean speed*

Two log-normal linear regression models were developed for drivers' mean speed: one for the moderate and one for heavy traffic. These models are shown in Table 4, in which the parameter estimates ($\beta_i$) and the related t values for each variable are presented together with the $R^2$ coefficient. The elasticity and relevant elasticity values for each independent variable used in the models are also shown.

**Table 4 Model results for mean speed**

| Independent variables | Moderate traffic | | | | Heavy traffic | | | |
|---|---|---|---|---|---|---|---|---|
| | $\beta_i$ | t | $e_i$ | $e_i^*$ | $\beta_i$ | t | $e_i$ | $e_i^*$ |
| Rain | -0.011 | -2.40 | -0.003 | -1.00 | -0.009 | -1.95 | -0.002 | -1.00 |
| Free driving | 0.065 | 10.30 | 0.016 | 5.61 | | | | |
| sms reading | 0.026 | 4.05 | 0.007 | 2.36 | -0.033 | -4.77 | -0.009 | -3.67 |
| sms writing | | | | | -0.049 | -6.98 | -0.013 | -5.44 |
| Alarm activation | | | | | -0.037 | -5.38 | -0.010 | -4.11 |
| Touch screen | 0.015 | -2.95 | -0.004 | 1.36 | -0.014 | -2.70 | -0.004 | -1.56 |
| Mean distance from the central axis (rspur) | -0.012 | -9.23 | -0.046 | -16.14 | -0.013 | -9.37 | -0.049 | -20.78 |
| Driver's gender | 0.013 | 2.85 | 0.003 | 1.18 | 0.014 | 2.85 | 0.004 | 1.56 |
| Driver enjoying driving (love_d) | -0.048 | -4.84 | -0.012 | -4.35 | -0.051 | -4.93 | -0.013 | -5.65 |
| Distance travelled per week | 0.00005 | 3.43 | 0.004 | 1.31 | 0.00005 | 3.16 | 0.004 | 1.56 |
| Accident occurrence | 0.034 | 4.45 | 0.009 | 3.09 | | | | |
| Failure to send sms | | | | | 0.023 | 2.64 | 0.006 | 2.56 |
| $R^2$ | 0.484 | | | | 0.385 | | | |

The results in Table 4 indicate that texting in heavy traffic leads to reduction of mean speed. Based on the signs of the corresponding coefficients ($\beta_i$) it is shown that, in moderate traffic, driving in rain, an increase in mean distance from the central axis and driver enjoying driving cause reduction in mean speed while free driving, sms reading, the use of mobile phone with touch screen, being male driver, travelling longer distances per week and accident occurrence lead to an increase in mean speed. In heavy traffic, the results are quite different with all independent variables except from being a male driver, travelling longer distances per week and failing to send sms while driving, causing a decrease in mean speed.

Sms reading/ writing variables are not the ones with the highest impact on mean speed among the examined. In moderate traffic, the variable with the highest impact on mean speed is the mean distance from the central axis, result found also in other studies (Hosking et. al, 2006). Specifically, the impact of this variable on mean speed is 16.14 times higher than that of driving in the rain. Free driving has a 2.38 times higher impact on mean speed than sms reading. On the other hand, the use of a mobile with a touch screen, the driver's gender and the travelled distance per week seem to have similar effect on mean speed as sms reading.

In heavy traffic conditions, the mean distance from the central axis is again the variable with the highest impact on mean speed with a 20.78 times higher impact than driving in the rain. Sms writing has a 1.48 times higher impact on mean speed than sms reading and 1.32 times higher than alarm activation. In addition, it appears that sms writing has a 3.5 times higher impact on mean speed than using a mobile with a touch screen, the driver's gender and the travelled distance per week.

Generally, it was shown that for young drivers on a motorway, with either moderate or heavy traffic, the variable with the highest impact on mean speed is the mean distance from the central axis of the road. Specifically, this variable has an impact on mean speed that is 6.84 and 5.66 times higher than sms reading, in moderate and heavy traffic respectively.

Mean speed is also affected by the use of mobile phones with or without a touch screen by the drivers. Those using a mobile phone with a touch screen tend to keep a lower speed. The touch screen variable has a 1.74 and 2.35 times higher impact on mean speed than sms reading in moderate and heavy traffic respectively.

Drivers that expressed an enjoyment of driving also tend to drive at lower speeds. Enjoying driving has a 1.84 times higher impact on mean speed than sms reading in moderate traffic and a 1.53 times higher impact in heavy traffic.

Although the $R^2$ values are relatively low they are still acceptable. However, they indicate that the examined independent variables can partially predict the dependent one. The inclusion in the models of other independent variables which have not been included in the specific analysis because they were either not recordable or partially recorded, and thus excluded, may provide more insight on the examined dependent variables.

*Modelling headway*

Regarding the headways, again, one log-normal linear regression model for moderate traffic and one for heavy traffic were developed. These models are included in Table 5, in which the parameter estimates ($\beta_i$) and the related t values for each variable are presented together with the $R^2$ coefficient. The elasticity and relevant elasticity values for each independent variable used in the models are also shown.

**Table 5 Model results for headways**

| Independent variables | Moderate traffic | | | | Heavy traffic | | | |
|---|---|---|---|---|---|---|---|---|
| | $\beta_i$ | t | $e_i$ | $e_i^*$ | $\beta_i$ | T | $e_i$ | $e_i^*$ |
| Rain | 0.14 | 2.31 | 0.056 | 2.07 | 0.164 | 2.71 | 0.063 | 2.52 |
| Free driving | 0.187 | 1.91 | 0.072 | 2.67 | 0.229 | 1.69 | 0.088 | 3.52 |
| sms reading | 0.154 | 2.16 | 0.059 | 2.19 | 0.182 | 1.86 | 0.070 | 2.80 |
| Alarm activation | | | | | 0.122 | 1.85 | 0.047 | 1.88 |
| Touch screen | 0.116 | 2.31 | 0.030 | 1.11 | 0.127 | 2.75 | 0.049 | 1.96 |
| Driver's gender | -0.071 | -1.92 | -0.027 | -1.00 | -0.065 | -1.84 | -0.025 | -1.00 |
| Distance travelled per week | -0.001 | -2.9 | -0.077 | -2.65 | -0.001 | -3.228 | -0.077 | 3.08 |
| $R^2$ | 0.312 | | | | 0.307 | | | |

As shown in Table 5, being a male driver and travelling longer distances per week cause a reduction in headways in both moderate and heavy traffic while all the other independent variables in the respective models have a positive impact on headways.

Results indicate that, in both moderate and heavy traffic, the variable with the greatest impact on headways is free driving. In moderate traffic, free driving has a 1.2 times greater impact on headways than sms reading and a 2.7 times higher impact than driver's gender. Rain and sms reading have an impact on headways analogous to that of driver's gender and touch screen respectively. Sms reading has an impact on headways greater than that of driver’s gender by 2.2 times. As far as distance travelled per week is concerned, it has a 2.6 times higher impact than touch screen has on headways.

In heavy traffic, similar results considering free driving were found. This is the variable with the greatest impact on headways. Specifically, its impact is 3.5, 1.3 and 1.9 times higher than rain, sms reading and alarm activation respectively. The impact of rain is approximately 1.3 times higher than that of alarm activation and touch screen. Finally, distance travelled per week, has a 1.6 times higher impact on headways than touch screen.

In general, the above results indicate that sms reading free driving, the touch screen and the distance travelled per week are variables with significant impact on headways. Specifically, sms reading was found to cause reduced headways. The same applies for drivers of longer distances per week, probably due to their larger driving experience. On the contrary, drivers using mobile phones with touch screens tend to keep longer distances from the vehicle ahead.

Although the $R^2$ values are relatively low they are still acceptable. However, they indicate that the examined independent variables can partially predict the dependent one. The inclusion in the models of other independent variables which have not been included in the specific analysis because they were either not recordable or partially recorded, and thus excluded, may provide more insight on the examined dependent variables.

*Modelling accident probability*

Accident probability was modeled as a binary variable, equal to one when an accident occurred during the simulated drive, and equal to zero otherwise. Two different binary logistic regression models were developed, one for each different traffic conditions scenario (moderate, heavy).

The respective models for accident probability are included in Table 6; in this case LRT results and Wald test values are reported for each model and variable. The elasticity and relevant elasticity values for each independent variable used in the models are also shown.

**Table 6 Model results for accident probability**

| Independent variables | Moderate traffic | | | | Heavy traffic | | | |
|---|---|---|---|---|---|---|---|---|
| | $\beta_i$ | Wald | $e_i$ | $e_i^*$ | $\beta_i$ | Wald | $e_i$ | $e_i^*$ |
| Rain | 1.372 | 11.51 | 1.976 | 3.55 | 1.410 | 13.13 | 2.160 | 5.02 |
| sms reading | 0.971 | 4.92 | 1.053 | 1.89 | 0.725 | 2.51 | 0.760 | 1.77 |
| sms writing | 1.051 | 4.73 | 1.113 | 2.00 | 0.691 | 1.83 | 0.710 | 1.65 |
| Touch screen | 0.569 | 2.17 | 0.556 | 1.00 | 0.439 | 1.65 | 0.430 | 1.00 |
| Driving experience >3years | 0.715 | 3.20 | 0.706 | 1.27 | 0.807 | 4.34 | 0.990 | 2.30 |
| Minimum distance from the central axis(rspur_min) | -0.213 | -4.75 | -0.793 | -4.13 | -0.206 | -5.19 | -0.830 | -1.00 |
| Time distance from the vehicle ahead (THead, sec) | -0.038 | -1.69 | -0.192 | -1.00 | | | | |
| Driver's speed / mean speed | 4.495 | 10.46 | 2.610 | 12.54 | 4.479 | 11.16 | 2.780 | 3.35 |
| Null log-likelihood | 133.927 | | | | 246.312 | | | |
| Final log-likelihood | 229.778 | | | | 148.758 | | | |
| Degrees of freedom | 8 | | | | 7 | | | |

According to Table 6, minimum distance from the central axis and time distance from the vehicle ahead are the variables with a negative impact on accident probability both in moderate and heavy traffic. The rest of the independent variables in the respective models have a positive impact on accident probability.

In the moderate traffic scenario, among the examined discrete variables, the one with the highest impact on accident probability is rain. Specifically, the impact of rain is 3.6, 1.9, 1.8 and 2.8 times higher than that of touch screen, sms reading, sms writing and driving experience over 3years respectively. In addition, sms writing has an impact on accident probability 2.0 and 1.1 times higher than that of the touch screen and sms reading respectively. Among the continuous variables, the one with the greatest impact is the ratio of driver's speed to mean speed. The impact of this variable is 12.5 times higher than the one of time distance from the vehicle ahead and 3 times higher than that of minimum distance from the central axis.

In heavy traffic conditions, rain and the ratio of driver's speed to mean speed are again the discrete and the continuous variables, respectively, with the greatest impact on accident probability. In this case, the impact of rain is 5.0, 2.8, 3.0 and 2.2 times higher than that of touch screen, sms reading, sms writing and driving experience over 3years respectively. Furthermore, the impact of sms reading on accident probability is 1.8 and 1.1 times higher than that of touch screen and sms writing respectively. As far as the ratio of driver's speed to mean speed is concerned, its impact is 3.4 times higher than that of the other continuous variable in the model, the minimum distance from the central axis.

Texting was found to increase accident probability in both traffic scenarios. In moderate traffic, accident probability is 1.9 and 2 times higher when driver reads or writes a sms comparing to free driving. Respectively, it is 1.8 and 1.7 times higher in heavy traffic. In moderate traffic, sms writing increases accident probability by 1.1 times comparing to sms reading. The opposite applies in heavy traffic where sms reading increases accident probability by 1.1 times comparing to sms writing. This might be an indication that both sms reading and sms writing are equally dangerous during driving.

Accident probability is also affected by the ratio of the driver's speed to the mean speed. Those driving faster showed an increased accident probability in both traffic scenarios. The same result is also expected for those using a mobile phone with a touch screen, drivers with an experience of less than three years and those driving close to the central axis of the road.

## Conclusion

The aim of the present research is to investigate the impact of texting on the behaviour and safety of young drivers in motorways with the use of a driving simulator. The effects of texting were examined in combination with the traffic environment (moderate, heavy traffic), the weather conditions (good weather, rain) and driver characteristics (gender, annual mileage, driving habits). Statistically significant variables were identified based on a number of tests. Correlations between variables were also checked and variables included in the analysis were selected on the basis of their statistical significance and their relevance to the objectives of the analysis.

It was concluded that sms reading and writing during driving, increases the accident probability despite a reduction in speed. During the experiment, speed was reduced by 11% for sms reading in good weather and moderate traffic (see Table 2). In rainy conditions, the respective percentage was 6%. In heavy traffic, the percentages were 9% and 7% respectively for good weather and rain. In the case of sms writing, speed reduction was higher, reaching 15% and 11% in good weather and in rain for moderate traffic and 12% and 13% in good weather and in rain for heavy traffic.

Both sms reading and writing were also found to increase headways in either moderate or heavy traffic conditions. This also happens when driving in rainy weather. On the contrary, driving experience seems to lead to reduction in headways.

If sms reading and writing are compared, it is found that, in moderate traffic, sms writing causes higher speed reduction but shorter headways and higher accident probability than sms reading. In heavy traffic, sms writing causes greater speed reduction than sms reading as well as a very small accident probability reduction. This shows that there is no significance difference between sms reading and writing in association to risk.

Moreover, it was found that drivers using mobile phones with touch screens tend to reduce their speed more and keep a longer distance from the vehicle ahead (headway). However, their accident probability is higher than that of the other drivers.

The examination of the different traffic conditions, showed that distraction factors have a greater impact in moderate traffic when reductions in speed and headway are lower. This is probably due to the more defensive driving behavior which is usually adopted in heavy traffic.

With regard to the method used for the collection of the necessary data for this study, it should be noted that no matter how well a simulator experiment is designed, it is rather unlikely that drivers perform exactly as they would in actual conditions (GHSA, 2011). This is due to the fact that several issues such as the feeling of speeding, rainy weather etc. cannot be fully represented, and this is a know limitation of simulator experiments.

This study may serve as a basis for further research using a similar experiment on a larger sample with participants of various age groups. According to previous studies, although young drivers may show an increased ability to share attention between two concurrent tasks than older ones, they are more vulnerable to the effects of distraction (Young & Regan, 2007).Moreover, different driving environments and different traffic conditions should be further investigated, to explore the impairment caused by texting in more complex road environments (e.g. urban areas, unfamiliar environment), more traffic density, adverse weather conditions etc. The comparison of different distraction factors such as smoking, discussion with passengers, eating, music etc. would allow for their classification in terms of risk. Finally, new technologies used for texting in modern devices could also be examined with regard to their contribution to the improvement of road safety.

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