**Road Safety and Simulation
International Conference
RSS2013**

**October 23-25, 2013
Rome, Italy**

Simulation of Texting Impact on Young Drivers' Behaviour and Safety in Urban and Rural Roads

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ABSTRACT

This research aims to investigate the impact of texting on the behaviour and safety of young drivers in urban and rural roads. In order to achieve this objective a driving simulator experiment was carried out, in which 34 young participants drove in different driving scenarios. Specifically, driving in good weather, in raining conditions, in daylight and in night were examined. Lognormal regression methods were used to investigate the influence of texting as well as various other parameters on the mean speed and mean reaction time. Binary logistic methods were used to investigate the influence of texting use as well as various other parameters in the probability of an accident. It appears that texting leads to statistically significant decrease of the mean speed and increase of the mean reaction time in urban and rural road environment. Simultaneously, it leads to an increased accident probability at incidents, due to driver distraction and delayed reaction at the moment of the incident. It appeared that drivers using mobile phones with a touch screen present different driving behaviour with respect to their speed, however, they had an even higher probability of being involved in an accident in case of an incident. The analysis of the distracted driving performance of drivers who are texting while driving may allow for the identification of measures for the improvement of driving performance e.g. restrictive measures, training and licensing, information campaigns etc.

Keywords: texting, road accidents, speed, reaction time, regression

BACKGROUND AND OBJECTIVE

In modern societies, where mobile phones have become a key communication and information means, the use of mobile phones while driving, and in particular texting, has been added to factors considered to have an influence on road safety. Several studies worldwide have revealed that percentages of drivers receiving, reading or replying to messages on their mobile phones while driving reach 70%, 81% and 92% respectively (Atchley, 2010; Nelson et al, 2009). Texting while driving remains a common behaviour even in countries where it is prohibited by law such as Australia where 27% of drivers admit texting while driving and the United States of America (USA) where the respective percentage among young drivers reaches 60% (White et al, 2010; Vlingo, 2009).

Identifying the exact impact of texting on road accidents is not easy because the use of mobile phones while driving is rarely recorded even in the case of serious accidents. However, texting while driving is considered to influence drivers' safety as it distracts them and leads to changes in driving behaviour and to increased accident risk. When the phone is used for texting, visual and physical distraction is usually important, in addition to cognitive distraction. Therefore, this behaviour is considered as even more hazardous than mobile phoning. When texting, drivers react more slowly to information in the peripheral field of vision, they drive more slowly, sway more and watch the road less often compared to using the call function (SWOV, 2010). Similar results have been found be Olson et al (2009), according to who accident risk is 23 times higher when texting and driving compared to free driving. The risk is lower when talking on the phone while driving. This is probably because while talking on the phone, the driver can still look on the road in contrast to texting that requires frequent and long observation of the mobile phone.

The exploration of the influence of texting on driving performance, revealed that driving performance was significantly impaired when texting while driving, such that lateral deviation increased by 280% compared to free driving. In addition, drivers changed their texting behaviour by shortening the length of their replies and typing at a slower speed. These results show that texting while driving has a severe negative effect on drivers' ability to maintain a central lane position. Attempts to reduce the workload of the texting task by typing shorter messages did not mitigate the effects of texting while driving (Cheung, 2010).

According to research published by the UK Institute of Advanced Motorists, using smart phones for social networking while driving is more dangerous than drink driving or drive under the influence of drugs. Twenty-four per cent of 17-24 year old drivers, a group already at higher risk of being in a crash, admit to using smart phones for email and social networking while driving. Texting was found to slow reaction times by 37.4 per cent (IAM, 2012).

Drews et al (2009) conducted a study into the effects of texting on drivers' performance in a high-fidelity driving simulator. Results showed a significant decrease in driving performance across all measured metrics: under the dual-task condition (texting while driving) compared to the baseline single-task (free) driving condition, drivers had slower brake onset times, more lane departures, reduced lane maintenance overall, and notably a six-fold increase in crash rate. Interestingly, participants increased their following distance in the dual-task condition; this may have been a conscious or unconscious attempt to create a safety buffer with the leading car to reduce crash likelihood. However, this strategy proved inadequate, as evidenced by the high crash likelihood.

Several studies regarding the influence of texting on driving performance and safety have been conducted using a driving simulator. The main advantage of diving simulators is that, without exposing the drivers to any danger, they allow for the collection of a large amount of data which would be very difficult to collect under real traffic conditions. Furthermore, the driving simulator provides the opportunity to simulate various situations on different road types, in different traffic conditions (normal, low, no traffic, only passing traffic, etc.) and in different weather and lighting conditions (sunshine, fog, rain, snow, day, night, etc), thus explore any possible driving scenario. In addition, driving conditions are identical for all drivers, something which is impossible to achieve in real traffic. Some issues that should be taken into account during a simulator study include the fact that the simulated road environment and driving conditions cannot be totally realistic; 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 dizziness that might be caused after a long drive.

The results described above indicate that texting while driving has an important impact on driver behaviour and consequently on road safety. A raising issue is the degree to which young drivers are affected by this impact. Young drivers have been found to be more willing to text than experienced drivers, while not having the experience necessary to drive with limited attention. Young drivers have also been considered more vulnerable to distraction: it was predicted that more resources would be allocated to driving, leaving fewer resources for secondary tasks and thus impacting driving performance when tasks needed to be balanced (Hosking et al, 2009). In addition, young drivers usually overestimate their driving abilities. So far, there has been limited research on texting specifically and how this activity affects driving performance; the various factors which affect the success of both activities simultaneously is still not fully understood (Drews et al, 2009).

Within this context, the present research aims to investigate the interrelation between texting while driving, speed, reaction time and accident probability by means of a driving simulator experiment on a group of young drivers. In particular, the research aims to analyse the effect of texting in combination with the effects of the road and traffic environment (urban, rural), environmental conditions (good weather, rain, night), driver characteristics (gender, annual mileage, driving habits) and incident occurrence.

METHOD AND DATA

The impact of texting on driving was explored, in combination with specific driver and road environment characteristics, through a simulation experiment (Christoforou, 2012). The experiment concerned the behaviour of 34 young drivers aged between 18 and 28 years. The sample of drivers consisted of 19 males and 15 females, 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. During the experiment, each participant used his/her own mobile phone in order to be familiar with the device.

The experiment had two parts. In the first part, drivers were asked to fill in a questionnaire on their personal characteristics and their driving behaviour with regard to texting. Then, the necessary directions were given and the simulator was shortly described. All participants were asked to follow their usual driving behaviour and try not to be affected by any other factors. It is noted that driving conditions in the virtual environment cannot be identical to those perceived by the driver in the real world, especially in rainy weather, however, the relative influence of the various parameters on driver's behaviour and safety should not be significantly affected by the use of a simulator. The second part of the experiment concerned the data collection in four different phases. First, all participants had a practice drive in a random route for approximately five minutes, in order to get familiar with the simulator. Subsequently, participants drove the same route three times. Each drive, one in good weather conditions, one in rainy weather conditions and one during night, lasted approximately five minutes. During all drives, participants had to read and reply to the sms they received. The order in which participants were tested under different conditions was different for each third of them (i.e. one third of the participants were tested under good weather conditions first, one third under raining conditions and the other third was tested during night first) so that their familiarization with the simulator during the third drive would not influence the results.

The driving scenario used in the specific research (Figure 1) included driving on a circular route comprising of two rural sections separated by an urban section under moderate traffic. Speed limits for urban and rural section(s) are 50 and 70km/h respectively. This route simulates the driving through a small town during a trip along a rural road.

The conduct of the experiment was supervised by a surveyor who could watch 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 (i.e. he recorded the position where a message was sent to the driver as well as the time spent for reading it and for replying to it). Each texting process (reading/writing) usually lasted 30 to 40sec and aimed to putting the driver into a thinking process as it required some mental alertness. While driving in rural sections, drivers were asked to read a message thanking them for participating to the experiment and to write the first two lines of the national anthem in a message. In urban areas, drivers were asked to read a message comprising of an approximately

30 character simple question and reply to it.

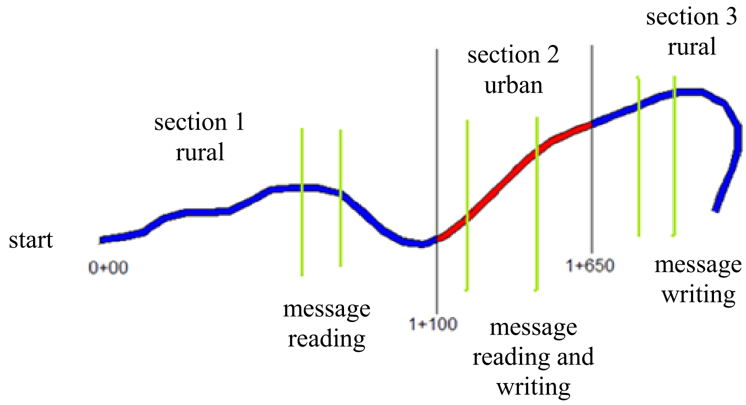

Figure 1: Features of the simulated drive

Moreover, during the experiment, incidents were scheduled to occur at various points of the selected route, like the sudden appearance on the road of an animal. For each driver, there was approximately one incident per requested message reading/writing, in each area type of each drive i.e. for each drive (good weather, rain or night) one incident occurred while reading an sms in the first rural section, one while reading and one while writing an sms in the urban section and one while writing an sms in the second rural section. These were not scheduled to occur at specific locations or time points, in order to avoid learning effects among the different drives - however care was taken that no other confounding factor was involved at these locations (e.g. horizontal curve, opposite traffic, traffic sign or signal, heavy goods vehicle etc.), so that drivers' reactions could be comparable overall. The drivers' reaction in these unexpected situations while texting or not is expected to be a key parameter in the investigation of the impact of texting on driver safety. Reaction time was automatically measured by the simulator as the time between the first move of the animal towards the road and the braking time.
The information collected from the questionnaire revealed the self-reported frequency of texting while driving and the related precautions taken (i.e. stop on the side of the road to read/write a sms) among participants. As shown in Table 1, 47% of the participants often use their mobile phone for reading or writing sms while driving, 24% of them quite often and 20% always. On the other hand, the majority of them never stop by the road in order to read/write a sms. These finding indicate 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 mind taking measures to compensate for it.

Table 1: Self Reported 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%

Table 2 shows the mean speed, the mean reaction time and the frequency of accidents by area type, use of mobile phone and weather conditions, as recorded in the simulator experiment. Mean speed is higher in rural areas compared to urban areas; moreover, mean speed is higher when not using a mobile phone while driving, both in urban and rural areas. There appears to be no difference in mean speed under rainy conditions and during night while under good weather conditions the mean speed is slightly lower. Mean reaction time is higher when the driver is reading or writing a sms compared to free driving, in both rural and urban areas. The same result was recorded under rainy conditions and during night compared to driving under good weather conditions. Regarding accident occurrence, the number of accidents was higher while reading or writing a sms under all different conditions and in all areas. It should be remembered that that incident occurrence during the simulator experiment was partly random, i.e. not scheduled to take place at fixed points along the route. Moreover, the length of the drives in rural areas was longer than the length of the drives in urban area, and this accounts for the larger number of incidents in these areas.

Table 2: Mean Speed, Mean Reaction Time and Number of Accidents on Urban and Rural Roads under Different Conditions and for Different Distraction Factors

		Good weather conditions			Rainy conditions			During night		
		Free driving	Reading sms	Writing sms	Free driving	Reading sms	Writing sms	Free driving	Reading sms	Writing sms
Urban	Speed (km/h)	37.17	25.46	20.59	35.07	26.5	22.56	35.03	25.23	21.4
	Reaction time (s)	1.10	1.29	1.39	1.18	1.44	1.57	1.08	1.33	1.53
	Accidents	2	9	17	5	16	20	2	11	17
Rural	Speed (km/h)	49.92	41.08	39.16	46.26	40.49	36.9	46.96	40.44	35.78
	Reaction time (s)	0.77	1.01	1.13	1.08	1.35	1.41	0.91	1.20	1.21
	Accidents	0	5	7	6	15	12	8	7	9

Another characteristic that was recorded during the experiment concerned whether the driver used a mobile phone with a touch screen or not. Table 3 shows the total number of accidents and the percentage of accidents while using a mobile phone with a touch screen, under different conditions and in different areas. A clear pattern is identified. In particular, drivers using a mobile phone with a touch screen had more accidents than those using a mobile phone with a keyboard under all different environmental conditions and regardless of the area type.

Table 3: Percentage of Accidents while Using a Mobile Phone with a Touch Screen on Urban and Rural Roads and under Different Conditions

	Good weather conditions		Rainy conditions		During night	
	Total number of accidents	Percentage of accidents using a mobile with a touch screen	Total number of accidents	Percentage of accidents using a mobile with a touch screen	Total number of accidents	Percentage of accidents using a mobile with a touch screen
Urban	28	64%	41	61%	30	73%
Rural	12	58%	33	81%	24	54%

MODELS' DEVELOPMENT

Six models were developed, in order to analyse the impact of texting on young drivers' behaviour and safety in terms of speed, reaction time and accident probability. In particular, log-normal linear regression models were developed for mean speed and mean reaction time, as the logarithms of these two variables were found to conform to a normal distribution. Moreover, binary logistic regression models were developed for accident probability. In each case, separate models were fitted for urban and rural areas.

In binary logistic regression models, parameter estimates β_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.

The variables were extracted either from the simulator's data recordings of the three routes or from the survey questionnaire. A large number of variables were available, as shown in Table 4, where the variables available from the output of the simulator range from 1 to 28, and the variables obtained from the questionnaire range from 29 to 57. Nevertheless, not all variables were considered in the analysis. A variable selection procedure was implemented as follows: univariate tests were initially carried out, in which each variable was tested alone and its statistical significance was determined by means of a t- or Wald test. Otherwise, the variable is not considered statistically significant and it is not included in the models. Then, for the statistically significant variables of the univariate analysis, correlation tests were carried out in order to identify correlated variables. In case 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. In this way, the sets of explanatory variables to be included in the multivariate models were defined.

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. Specifically, in order for a variable to be considered statistically significant, the respective value of the t-test (in case of log-normal regression models) or of the Wald test (in case of binary logistic regression models) should be higher than 1.7. 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 in order 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 4: Variables Available for the Analysis

1	Rainy	rainy weather (1:yes, 0:no)
2	Night	driving during night (1:yes, 0:no)
3	Good	good weather conditions (1:yes, 0:no)
4	rspur	mean distance from the central axis (m)
5	rspur_max	maximum distance from the central axis (m)
6	rspur_min	minimum distance from the central axis (m)
7	logrspur	logarithm of the distance from the central axis (m)
8	speed	mean speed (km/h)
9	logV	logarithm of the mean speed
10	v_max	maximum speed (km/h)
11	brk	% route the brake was used
12	acc	% route the accelerator was used
13	rpm	mean motor revolution per minute
14	dleft	mean distance from the left edgeline (m)
15	dright	mean distance from the right edgeline (m)
16	acc_no_deer	occurrence of an incident without the presence of animals
17	acc_deer	occurrence of an incident with the presence of animals
18	accident	accident occurrence (1:yes, 0:no)
19	RT	mean reaction time (sec)
20	logRT	logarithm of the reaction time
21	Out _Free	free driving in rural area (1:yes, 0:no)
22	Out_Read	message reading while driving in rural area (1:yes, 0:no)
23	Out_Write	message writing while driving in rural area (1:yes, 0:no)
24	In_Free	free driving in urban area (1:yes, 0:no)
25	In_Read	message reading while driving in urban area (1:yes, 0:no)
26	In_Write	message writing while driving in urban area (1:yes, 0:no)
27	Vi/Vm_In	ratio of each driver's speed to the mean speed in urban areas
28	Vi/Vm_Out	ratio of each driver's speed to the mean speed in rural areas
29	age	driver's age
30	gender	driver's gender
31	d_experience	driver's driving experience in years (1-3years:1, 4-6years:2, >7years:3)
32	dist_week	distance travelled per week
33	love_d	driver enjoying driving (1:yes, 0:no)
34	acc_in	self reported accident occurrence while sms reading or writing in urban areas (1:yes, 0:no)
35	acc_out	self reported accident occurrence while sms reading or writing in rural areas (1:yes, 0:no)
36	in_freq	self reported frequency of driving in urban areas (once per day:1, once per week:2, once per month:3, never:4)
37	out_freq	self reported frequency of driving in rural areas (once per day:1, once per week:2, once per month:3, never:4)
38	in_freq_rain	self reported frequency of driving in rainy conditions in urban areas (once per day:1, once per week:2, once per month:3, never:4)
39	out_freq_rain	self reported frequency of driving in rainy conditions in rural areas (once per day:1, once per week:2, once per month:3, never:4)
40	dang_in_good	perceived risk emerging from sms reading/writing while driving in good weather, in urban areas (none:1, low:2, medium:3, high:4, very high:5)

41	dang_in_night	perceived risk emerging from sms reading/writing while driving during night, in urban areas (none:1, low:2, medium:3, high:4, very high:5)
42	dang_out_good	perceived risk emerging from sms reading/writing while driving in good weather, in rural areas (none:1, low:2, medium:3, high:4, very high:5)
43	dang_out_night	perceived risk emerging from sms reading/writing while driving during night, in rural areas (none:1, low:2, medium:3, high:4, very high:5)
44	b_rain	change of behaviour when driving in rainy conditions (1:reduce speed, 2:pull over, 3:keep right, 4:none)
45	b_sms	change of behaviour when sms reading/writing while driving (1:reduce speed, 2:pull over, 3:keep right, 4:none)
46	freq_sms	frequency of sms reading/writing while driving (1:never, 2:seldom, 3:few times, 4:often, 5:always)
47	freq_stop	frequency of pulling over for sms reading/writing (1:never, 2:seldom, 3:few times, 4:often, 5:always)
48	red_sms	speed reduction while reading/writing sms (km/h) (1:0-10, 2: 11-20, 3: >20)
49	red_night	speed reduction while driving during night (km/h) (1:0-10, 2: 11-20, 3: >20)
50	red_rain	speed reduction while driving in rain (km/h) (1:0-10, 2: 11-20, 3: >20)
51	touch	mobile phone with a touch screen (1:no, 0:yes)
52	wm_fail_ingood	failure to compose the requested sms while driving in good weather, in urban area (1:no, 0:yes)
53	wm_fail_outgood	failure to compose the requested sms while driving in good weather, in rural area (1:no, 0:yes)
54	wm_fail_inrainy	failure to compose the requested sms while driving in rainy conditions, in urban area (1:no, 0:yes)
55	wm_fail_outrainy	failure to compose the requested sms while driving in rainy conditions, in rural area (1:no, 0:yes)
56	wm_fail_innight	failure to compose the requested sms while driving during night, in urban area (1:no, 0:yes)
57	wm_fail_outnight	failure to compose the requested sms while driving during night, in rural area (1:no, 0:yes)

Modelling Mean Speed

Two log-normal linear regression models were developed for drivers' mean speed: one for the urban section of the route and one for the rural section. The models developed for mean speed, for urban and rural roads are included in Table 5, in which the parameter estimates (β_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.
The results in Table 5 indicate that sms reading has a 6 times higher influence on mean speed than the "regular drivers" variable, on both urban and rural roads. On urban roads, sms reading has the double influence on mean speed comparing to that on rural roads. This indicates that while driving on urban roads tend to reduce their speed more probably because of the many other distraction factors existing in urban areas such as pedestrians, traffic signs, frequent intersections, parked cars and building that are not regularly met on rural roads.
On rural roads the variable with the greater influence is acceleration which has a three times higher influence than sms reading on mean speed. The variable mean motor revolution per minute appears to have no influence on mean speed on rural roads.
On urban roads, mean speed is influenced by the mean distance from the central axis of the road

while on rural roads, by the minimum distance from the central axis. The urban roads model shows that drivers closer to the central axis of the road have higher speeds and sms reading has only 1.17 times higher influence than mean distance from the central axis on mean speed. On rural roads, the negative sign of the "minimum distance from the central axis" variable indicates lower speeds for those drivers who kept higher minimum distances from the central axis. The overall influence of the variable on mean speed is 0.35 times lower than that of sms reading.
Regarding the variable related to the use of a mobile phone with a touch screen, the influence on mean speed is 12.4 and 6.8times lower than that of sms reading on urban and rural roads respectively. It is concluded, thus, that drivers using mobile phones with a touch screen tend to reduce their speed more probably because they look more often and for more time to their mobiles.
It is noted that the variables concerning driving during night and in rainy conditions were also examined but did not prove to be statistically significant with regard to the mean speed.

Table 5: Model Results for Mean Speed

Independent Variables	Urban roads				Rural roads			
	β_i	t	e_i	e_i^*	β_i	t	e_i	e_i^*
free driving					0.157	12.36	0.05	8.17
sms reading	-0.177	-18.43	-0.06	-12.40	0.134	10.79	0.04	6.83
sms writing	-0.244	-24.45	-0.09	-17.20				
mean distance from the central axis	-0.045	-3.36	-0.05	-10.60				
mean motor revolution per minute	0.00007	15.88	0.15	30.20				
minimum distance from the central axis					-0.035	-4.59	-0.02	-2.83
acceleration					0.060	13.95	0.12	20.60
touch screen	-0.014	-1.92	-0.01	-1.00	-0.021	-2.31	-0.01	-1.00
regular drivers	0.030	3.50	0.01	2.00	0.022	1.78	0.01	1.12
speed reduction while reading/writing sms					-0.021	-2.29	-0.01	-1.00
R^2	0.700				0.542			

Modelling Reaction Time

Concerning the driver's reaction time, again, two log-normal linear regression models were developed: one for the urban section of the route and one for the rural section. The models developed for driver's reaction time, for urban and rural roads are included in Table 6, in which the parameter estimates (β_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.
As shown in Table 6, sms reading and writing have an influence on reaction time on urban roads. On urban roads, the variable with the greatest influence on reaction time is "mean distance from the central axis" which has an influence of 2.5 and 1.78 times higher than sms reading and sms writing respectively. Again on urban roads, sms reading has a greater influence on reaction time

than sms writing. In addition, sms reading has a greater influence on reaction time by 2.5 times comparing to driving during night, 1.14 times comparing to driving in rainy conditions and 2 times comparing to reading/writing sms often.
Accident occurrence has an influence on reaction time on both urban and rural roads with drivers who had an accident tending to need more time to react. On urban roads, accident occurrence has an influence on reaction time 1.04 times higher than that of sms writing, 1.44 times higher than that of sms reading, 1.65 times higher than driving in rainy conditions and 3.6 times higher than driving during night. On rural roads, accident occurrence has a 3.7 times higher influence on reaction time than sms reading, 2.27 times higher than driving in rainy conditions and 4 times higher than driving during night.
In contrast to the results concerning mean speed, variables “driving during night” and “driving in rainy conditions” are statistically significant with regard to reaction time. Driving in rainy conditions has an influence 2.2 and 1.72 times higher than driving during night has on reaction time, on urban and rural roads respectively.

Table 6: Model Results for Reaction Time

Independent Variables	Urban roads				Rural roads			
	β_i	t	e_i	e_i^*	β_i	t	e_i	e_i^*
driving during night	0.029	1.86	0.15	1.00	0.036	2.34	0.85	1.03
driving in rainy conditions	0.064	4.09	0.34	2.21	0.062	4.02	1.47	1.77
free driving					-0.141	-8.40	-3.35	-4.03
sms reading	0.073	4.17	0.39	2.53	-0.038	-2.25	-0.90	-1.09
sms writing	0.102	5.63	0.54	3.52				
mean distance from the central axis	0.054	2.25	0.96	6.23	0.037	1.61	3.12	3.65
accident occurrence	0.106	7.12	0.56	3.66	0.141	8.36	3.35	4.03
reading/writing sms often	0.106	7.12	0.56	3.66	0.141	8.36	3.35	4.03
R^2	0.249				0.276			

Modelling Accident Probability

Accident probability was modelled as a binary variable, equal to one when an accident occurred as a result of an unexpected incident during the simulated drive, and equal to zero otherwise. Two different binary logistic regression models were developed, one for each driving environment (urban and rural).
The respective models for accident probability are included in Table 7; 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.
Based on the model results, accident probability on urban roads is 2.9 times higher while reading sms and 8.3 times higher while writing sms comparing to free driving. On rural roads, accident probability is 1.4 times higher while reading sms and 1.5 times higher while writing sms comparing to free driving.
Driving during night and driving in rainy conditions increase accident probability on both urban and rural roads. On rural roads it was revealed that driving during night and driving in rainy conditions have even greater influence than distraction factors on accident probability.

Drivers with a touch screen showed an increased accident probability. Comparing to sms reading, the touch screen has a 2.19 and a 1.33 times lower influence on accident probability on urban and on rural roads respectively.
Accident probability is also affected by the ratio of driver's speed to the mean speed. In particular, drivers with speeds higher than the mean speed, have an increased accident probability on both urban and rural roads.
When sms reading is compared to sms writing with regard to their influence on accident probability it is shown that sms writing has a higher influence than sms reading. Specifically, on urban roads, sms writing has a 2.8 times higher influence on accident probability than sms reading. On rural roads, though, the influence of sms writing is only 1.1 times higher than that of sms reading.
In both models, driving in rainy conditions increases the accident probability more than driving during night. Particularly, driving in rainy conditions has a 2.3 times higher influence on accident probability than driving during night on rural roads and a 2.1 times higher influence on urban roads.

Table 7: Model Results for Accident Probability

Independent Variables	Urban roads				Rural roads			
	β_i	Wald	e_i	e_i^*	β_i	Wald	e_i	e_i^*
driving during night	0.477	3.76	0.29	2.42	0.481	3.88	0.33	1.65
driving in rainy conditions	0.914	14.53	0.62	5.17	0.923	14.99	0.75	3.75
sms reading	0.581	5.41	0.35	2.92	0.411	2.65	0.28	1.40
sms writing	1.270	21.41	1.00	8.33	0.436	2.77	0.30	1.50
touch screen	0.268	1.82	0.16	1.33	0.283	2.05	0.21	1.05
driver's gender	-0.229	1.41	-0.12	-1.00	-0.375	3.59	-0.20	-1.00
failure to compose sms					-0.787	9.38	-0.40	-2.00
mean distance from the right edgeline					0.14	2.02	0.03	1.00
driver's speed / mean speed	0.648	3.74	0.13	1.00	1.43	21.03	0.19	6.33
Null log-likelihood	378.089				337.109			
Final log-likelihood	655.364				662.262			
Degrees of freedom	7				9			

CONCLUSIONS

The aim of the present research is to investigate the impact of texting on the behaviour and safety of young drivers in urban and rural roads with the use of driving simulator. The effects of texting were examined in combination with the traffic environment (urban / rural), the weather conditions (good / rainy weather), driver characteristics, self-reported driving behaviour and incident occurrence while driving.
It was concluded that driving behaviour and safety are both affected by texting. Sms reading or writing while driving increase accident probability considerably, despite the potential decrease on speed, and this may be due to the increased reaction time. Specifically, sms writing has a more negative effect to safety than sms reading, probably because it is a more demanding task in terms of mental awareness. On urban roads, mean speed while reading a sms was reduced by

30% in good weather, 24% in rainy conditions and 28% during night. The respective reductions while reading a sms on rural roads were 18%, 12% and 14%. Speed reductions were even higher while writing a sms. Specifically, speed was reduced by 45% in good weather, 35% in rainy conditions and 39% during night on urban roads while, on rural roads, by 22%, 20% and 24% under the respective conditions. It is clear that under all different conditions, speed reductions are higher on urban roads. Driving in rainy conditions and during night were found not to have a statistically significant impact on mean driving speed.

Mean driving speed is generally reduced because of texting on both urban and rural roads. It is possible that speed reduction provides drivers with a feeling of safety and thus compensates for the increased mental work load requirements of texting while driving.

Texting also proved to have a negative impact on driver's reaction time on both urban and rural roads. While reading a sms, reaction time was increased by 17% in good weather, 22% in rainy conditions and 23% during night. On rural roads, even higher increased were recorded and specifically by 30% in good weather, 25% in rainy conditions and 31% during night. Sms writing caused generally higher reaction time increase. Specifically, an increase in reaction time equal to 26% in good weather, 33% in rainy conditions and 29% during night was recorded on urban roads. The reductions while writing an sms on rural roads were 46%, 33% and 30% respectively. These results show higher reaction time under all different conditions on rural roads.

Concerning accident probability, it was found that both reading and writing sms lead to its increase. This is probably because of the driver's need to have his look on the mobile phone instead of on the road more often and for more time. On urban roads, accident probability is 2.9 times higher when reading sms and 8.3 times higher when writing comparing to free driving. The respective accident probability is 1.4 and 1.5 times higher on rural roads. Although speed reduction leads to reduced accident probability it cannot compensate for the increase in accident probability induced by texting. Driving in rainy conditions and during night also increases accident probability, especially on rural roads where these two variables had the greatest impact. On urban roads, accident probability is increased for women, drivers using a mobile phone with a touch screen and for those driving at a speed higher than the mean speed. The same apply on rural roads in addition to increased accident probability for those that successfully sent the requested sms during the experiment as well as for those keeping longer distances from the right edgeline of the road.

As far as the method used for the collection of the necessary data for this study is concerned, it should be noted that the specific experiment was quite demanding in terms of the use of the mobile phone while driving. The need to measure adequately the parameters of interest while keeping the duration of the experiment to a minimum may lead to over demanding distracted driving tasks assigned to participants to simulator experiments on mobile phone use (Kaas et al., 2007; Bruyas et al., 2009; Schlehofer et al. 2010). Despite the driving experience and the frequent use of a mobile phone while driving, the number of sms requested to be received and replied, in combination to the length of the drives, may have been relatively too demanding comparing to the everyday driving habits of some of the drivers participating in the experiment. Generally, 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.

The results of this study may be 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 sequence of accidents per area type or different driving conditions with the use of mobiles with touch screen or not could also be examined as well as differences in the behaviour of regular and non-regular mobile phone users while driving. New technologies used for texting in modern devices could be explored with regard to their contribution to the improvement of road safety. Finally, the comparison of different distraction factors such as smoking, discussion with passengers, eating, music etc. would allow for their classification in terms of risk.

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