CELL PHONE USE AND DRIVING PERFORMANCE OF DIFFERENT AGE GROUPS

C. Antoniou
NTUA
antoniou@central.ntua.gr **P.**

Papantoniou
NTUA
ppapant@central.ntua.gr

E. Papadimitirou
NTUA
nopapadi@central.ntua.gr

D. Pavlou
NTUA
dpavlou@central.ntua.gr

G. Yannis
NTUA
geyannis@central.ntua.gr

J. Golias
NTUA
igolias@central.ntua.gr

ABSTRACT

The objective of this research is the analysis of the driving performance of drivers from different age groups, while talking on the cell phone. For this purpose, a large driving simulator experiment is carried out, in which 72 drivers from three different age groups (young, middle aged and older) were asked to drive under different types of distraction (no distraction, conversation with passenger, cell phone use) in rural and urban road environment, in low and high traffic. To achieve the objectives set out in this paper, an appropriate staged modelling methodology has been developed, comprising exploratory components, such as boxplots and other descriptive statistics, and generalized linear mixed models for the investigation of the effect of cell phone use, age group, area type and other variables on traffic speed and space headways. Results indicate that the cell phone use while driving leads to reduced speed for all drivers especially in urban areas. In particular, regarding the driving performance of different age groups, older drivers reduce their speed by twice as much as middle aged drivers. This distraction is also reflected in increased space headways associated with cell phone use for all drivers. The increase is more pronounced on older drivers who intend to keep more than 5 times higher distance from the vehicle in front than middle aged drivers. Cell phone use results in lower speeds and higher space headways, suggesting a driver's compensatory effect, also identified in previous research. Although it can be assumed that the results are generally correlated with lower accident risk, they reveal, apart from the physical distraction of the handheld mode, a systematic attempt of drivers to counter-balance the increased mental workload resulting from the conversation.

KEYWORDS

Driver distraction, cell phone, age groups, average speed

INTRODUCTION

Although driver distraction can be considered as part of everyday driving, the penetration of various new technologies inside the vehicle, and the expected increase of use of such appliances in the next years, makes the investigation of their influence on the behavior of drivers and on road safety very essential (Piotrowski and Kass, 2103). One of the most frequently reported is the use of a mobile, or cellular, phone. Undoubtedly, the cell phone is a ubiquitous feature of modern life (Levinson, 2004, Wei, 2001). Cell phone ownership has grown exponentially with 1.6 billion units in global sales in 2010. Recent estimates indicate that over 90% of the U.S. population has access to a cell phone (Dula et al., 2011).

Drivers tend to reduce their speed during a mobile phone conversation and reduced speed is generally associated with lower accident risk; however, drivers using their mobile phone while driving present up to 4 times higher accident risk, most probably as a result of increased workload and delayed reaction time (McEvoy et al., 2005). Furthermore, several studies have demonstrated that the distracting effect of cell phone use on driving performance measures is affected by age (Nilsson and Alm, 1991; Cooper and Zheng, 2002). More specific areas of degradation that have been shown to be exaggerated among drivers include detection time, visual scanning, lane keeping and driving speed, visual fixation and recognition memory, and time to dial and answer the phone (McKnight and McKnight, 1993; Reed and Green, 1999; McCarley et al., 2004).

The objective of this research is the analysis of the driving performance of drivers from different age groups while talking on the cell phone. The paper is structured as follows: In the beginning, a thorough literature review is presented regarding the effect of cell phone use and age in driving performance through driving simulator experiments. Then, a large driving simulator experiment is presented, in which participants from three different age groups were asked to drive under different types of distraction (no distraction, conversation with passenger, mobile phone use) in rural and urban road environment. Finally, all statistical steps of the analyses are presented (descriptive statistics, Generalized Linear Models, Generalized Linear Mixed Models) and discussed while some concluding remarks are provided.

BACKGROUND

The term distraction has been defined as “a diversion of attention from driving, because the driver is temporarily focusing on an object, person, task or event not related to driving, which reduces the driver’s awareness, decision making ability and/or performance, leading to an increased risk of corrective actions, near-crashes, or crashes” (Young and Regan, 2007). While driver distraction is estimated to be an important cause of vehicle accidents the use of mobile phones is considered a major factor that distracts driver attention. More specifically, a range of driving simulator studies have shown that the use of cell phones has adverse consequences on driver’s behavior and the probability of being involved in an accident (e.g., Strayer and Johnston, 2001; Strayer et al., 2003; Rakauskas et al., 2004; Svenson and Patten, 2005; Horrey et al., 2008; Nasar et al., 2008).

Haigney et al. (2000) examined the effects on driving performance of engaging in a mobile phone task using hand-held and hands-free mobile phones. Thirty participants completed four simulated drives while completing a grammatical reasoning task designed to simulate a mobile phone conversation. The results revealed that mean speed and the standard deviation of acceleration decreased while participants were conversing on the mobile phone. Using a driving simulator, Strayer et al. (2003) found that conversing on a hands-free mobile phone while driving led to an increase in following distance from a lead vehicle and this increase was particularly pronounced under high traffic density conditions. Rakauskas et al. (2004) used a driving simulator to determine the effect of easy and difficult cell phone conversations on driving performance, and found that cell phone use caused participants to have higher variation in accelerator pedal position, drive more slowly with more variation in speed, and report a higher level of workload regardless of conversation difficulty level.

Furthermore, Kass et al. (2007) examined the impact of cell phone conversation on situation awareness and performance of novice and experienced drivers. The performance of 25 novice drivers and 26 professional drivers was measured by the number of driving infractions committed such as speeding, collisions, pedestrians struck, stop signs missed, and centerline and road edge crossings. The results indicated that novice drivers committed more driving infractions and were less situationally aware than their experienced counterparts during the cell phone conversation. Bruyas et al. (2009) investigated whether making a conversation asynchronous (using an answer phone instead of a cell phone) reduces the negative impact of phone calls, as the communication in this occasion is under the driver’s control, allowing allows him/her to pace the interaction better. The results showed better scores for correct responses to stimuli for answer phone communications than for phone communications, although response times were higher in both communication conditions than in the driving alone condition.

Shinar et al. (16) found that 96 min of dual-task simulator-based practice, distributed over 5 days, was sufficient to eliminate driving impairment from cell phone use in a group of considerably more experienced drivers. Notably, dual-task learning was primarily observed on the mean and standard deviations of lane position, steering angle, and speed. Additionally, learning was greatest when driving was coupled with a math task rather than naturalistic conversation. From these results, Shinar et al. (2005) concluded that previous driving research had likely overestimated real-world impairment by forcing the driving pace, using unnatural conversation surrogates, and failing to repeat the driving condition. Schlehofer et al. (2010) explored psychological predictors of cell phone use while driving for 69 college students who firstly completed a survey and predicted their driving performance both with and without a simultaneous phone conversation and finally drove on a driving simulator. Cell phone use was found to reduce their performance on the simulation task.

Driver demographic characteristics are also considered to be important factors moderating drivers’ engagement in mobile phone use while driving. Some studies have examined the impact of age and gender on drivers’ mobile phone use and on the perceived risk of this behaviour. Evidence indicates that younger drivers tend to use mobile phones while driving more often than older drivers. Backer-Grøndahl and Sagberg (2011) found that only 27.8% of older drivers (55+ years) reported using a mobile phone while driving, compared to 69.8% of middle-aged drivers (aged 26–54 years) and 69.6% of young drivers (aged 18–25 years). In this framework, similar studies (Lamble et al., 2002; Brusque and Alauzet, 2008) also found that young drivers reported a much higher level of mobile phone use while driving than did older drivers. When examined in combination with gender, research shows that the youngest drivers

and males use their phones while driving more often than older drivers and females (Brusque and Alauzet, 2008) and that females are almost twice as likely to restrict mobile phone use than males (Lamble et al., 2002).
Zhou et al.'s study (2009b) indicated that males learning to drive reported relatively stronger perceived behavioural control for using a mobile phone when driving than females. Moreover, these two individual factors also influenced the drivers' perceived risk of mobile phone use while driving. Another survey conducted in Australia indicated that young drivers rated most items on a list of distracting and risky activities (e.g., dialing, answering and talking on a mobile phone while driving) as less dangerous than the older drivers rated them (Backer-Grøndahl and Sagberg, 2011). Furthermore, Lesch and Hancock (2004) conducted a study examining the extent to which different driver groups are aware of the distracting effect of mobile phone use while driving. The authors focused on older (55-65 years) and younger (25-36 years) drivers' a priori ratings of confidence in their ability with regard to mobile phone use and relationship between their confidence level and the observed actual decrement in their driving performance. Most participants (67%) reported feeling comfortable dealing with distraction while driving, with younger drivers reporting the greatest confidence. The association between actual performance and drivers' perception was weak. Many drivers were relatively unaware of the decrements in their actual driving performance resulting from concurrent mobile phone use.
Indeed, Horberry et al. (2006) examined the effects of distraction on driving performance for drivers in three age groups: younger (under 25); middle-aged (30-45 years); and older (60-75 years). Participants were required to perform two secondary tasks while driving: a hands free mobile phone task, in which they answered a series of general-knowledge questions, and an entertainment system task, in which they were required to tune the radio, change the radio's bass/treble and speaker balance, and insert and eject cassettes while driving in both simple (no billboards and few buildings and traffic) and complex (many billboards, buildings, and oncoming vehicles) simulated driving environments. Measures of mean speed, speed deviation from the posted speed limit, perceived workload, and responses to hazards were recorded. The authors noted that both in-vehicle tasks impaired several aspects of driving performance, with use of the entertainment system distracter having the greatest negative impact on performance.

METHODOLOGY

Driving Simulator Experiment

Within this research, a large driving simulator experiment was including different driving scenarios. The design of the distracted driving scenarios is a central component of the experiment and includes driving in different road and traffic conditions, such as in a rural, urban area with high and low traffic volume. More specifically, this assessment includes an urban driving session with up to six trials and a rural driving session with up to six trials. These trials aim to assess driving performance under typical conditions, with or without external distraction sources. The driving simulator experiment takes place at the Department of Transportation Planning and Engineering of the National Technical University of Athens, where the Foerst Driving Simulator FPF is located. It is a quarter-cab simulator with a motion base.

Familiarization

A familiarization session or 'practice drive' is typically the first step of all simulator experiments. During the familiarization with the simulator, the participant practiced in handling the simulator (starting, gears, wheel handling etc), keeping the lateral position of the vehicle, keeping stable speed, appropriate for the road environment and braking and immobilization of the vehicle. When all criteria mentioned above were satisfied (there was no exact time restriction), the participant moved on to the next phase of the experiment

Overview of the experiment

After the practice drive, each participant drives the two sessions (~20 minutes each). Each session corresponds to a different road environment:

- A rural route that is 2.1 km long, single carriageway and the lane width is 3m, with zero gradient and mild horizontal curves.
- An urban route that is 1.7km long, at its bigger part dual carriageway, separated by guardrails, and the lane width is 3.5m. Moreover, narrow sidewalks, commercial uses and parking are available at the roadsides.

Within each road / area type, two traffic scenarios and three distraction conditions are examined in a full factorial within-subject design. The distraction conditions examined concern undistracted driving, driving while conversing with a passenger and driving while conversing on a mobile phone. The traffic scenarios are:

- QL: Moderate traffic conditions – with ambient vehicles' arrivals drawn from a Gamma distribution with mean m=12 sec, and variance σ2=6 sec2, corresponding to an average traffic volume Q=300 vehicles/hour.

- QH: High traffic conditions – with ambient vehicles' arrivals drawn from a Gamma distribution with mean m=6 sec, and variance $\sigma 2=3$ sec2, corresponding to an average traffic volume of Q=600 vehicles/hour.

Consequently, in total, each session (urban or rural) includes six trials, i.e. six drives of the simulated route.

Incidents

During each trial of the experiment, 2 unexpected incidents are scheduled to occur at fixed points along the drive (but not at the exact same point in all trials, in order to minimize learning effects). More specifically, incidents in rural area concern the sudden appearance of an animal (deer or donkey) on the roadway, and incidents in urban areas concern the sudden appearance of an adult pedestrian or of a child chasing a ball on the roadway.

Randomization

The first principle of an experimental design is randomization, which is a random process of assigning treatments to the experimental units. The random process implies that every possible allotment of treatments has the same probability. An experimental unit is the smallest division of the experimental material and a treatment means an experimental condition whose effect is to be measured and compared. The purpose of randomization is to remove bias and other sources of extraneous variation, which are not controllable. Another advantage of randomization (accompanied by replication) is that it forms the basis of any valid statistical test (Boyle, 2011).

Questionnaire

Each participant is requested to fill in a questionnaire about their driving habits and their driving behaviour. The questions are chosen carefully on the basis of the existing literature on drivers' self-reported behavior. The sections of the questionnaire are:

- Driving experience - car use
- Self -assessment of the older driver
- Distraction-related driving habits
- Emotions and behaviour of the driver
- Anger expression inventory during driving
- History of accidents, near misses, and traffic violations

Conversation topics

As mentioned each trial is about different driving distractor and different traffic volume. The trials that demand conversation as a distractor are covered by the following topics: Family, Origin, Accommodation, Travelling, Geography, Interests, Hobbies, Everyday life, News, Business.

Sample characteristics

The sample of participants is 72 healthy participants aged 18-75 years old who have completed the driving trials. More specifically, 25 young drivers aged 18-34 years old, 25 middle aged drivers aged 35-54 years old and 22 older driver aged 55-80 years old consist the sample of the analyses.

Analysis Method

To achieve the objectives set out in this paper, an appropriate modeling methodology - presented in this section - has been developed, regarding average speed and average headways. The methodology is consisted of several steps as follows.

In the first step, in order to analyze these key measures, a descriptive analysis took place through box plots. A box plot (also known as a box-and-whisker chart) is a convenient way to show groups of numerical data, such as minimum and maximum values, upper and lower quartiles, median values, outlying and extreme values. The spacing between the different parts of the box plot indicates the degree of dispersion (spread) and skewness in the data and identifies outliers. More specifically, regarding box plots:

- The line in the middle of the boxes is the median
- The bottom of the box indicates the 25th percentile. Twenty-five percent of cases have values below the 25th percentile. The top of the box represents the 75th percentile. Twenty-five percent of cases have values above the 75th percentile. This means that 50% of the cases lie within the box.

In the next step, in order to estimate the effect of cell phone while driving in different age groups, generalized linear models were developed as they facilitate the analysis of the effects of explanatory variables in a way that closely resembles the analysis of covariates in a standard linear model, but with less confining assumptions. This is achieved by specifying a link function, which links the systematic component of the linear model with a wider class of outcome variables and residual forms.

A key point in the development of GLM was the generalization of the normal distribution (on which the linear regression model relies) to the exponential family of distributions. This idea was developed by Fisher (1934). Consider a single random variable y whose probability (mass) function (if it is discrete) or probability density function (if it is continuous) depends on a single parameter θ. The distribution belongs to the exponential family if it can be written in the form (Eq. (1)):

$$f(y;\theta) = s(y)t(\theta)e^{a(y)b(\theta)} \tag{1}$$

where a, b, s, and t are known functions. The symmetry between y and θ becomes more evident if Eq. (1) is rewritten as Eq. (2):

$$f(y;\theta) = \exp[a(y)b(\theta) + c(\theta) + d(y)] \tag{2}$$

where s(y)=exp[d(y)] and t(θ)=exp[c(θ)]. If a(y)=y then the distribution is said to be in the canonical form. Furthermore, any additional parameters (besides the parameter of interest θ) are regarded as nuisance parameters forming parts of the functions a, b, c, and d, and they are treated as though they were known. Many well-known distributions belong to the exponential family, including –for example– the Poisson, normal, and binomial distributions. On the other hand, examples of well-known and widely used distributions that cannot be expressed in this form are the student's t-distribution and the uniform distribution.

In the third step, generalized linear mixed models are implemented as the data used in this research involve repeated measures observations from each individual drive (each driver completes six drives in rural and six drives in urban environment). When dealing with such panel data it is often useful to consider the heterogeneity across individuals, often referred to as unobserved heterogeneity. The generalized Linear mixed Model generalizes the standard linear model in three ways: accommodation of non-normally distributed responses, specification of a possibly non-linear link between the mean of the response and the predictors, and allowance for some forms of correlation in the data (Breslow and Clayton, 1993).

Finally, in order to confirm that the random effect was statistically significant, and therefore the Generalized Linear Mixed Models were superior to the respective Generalized Linear Models, likelihood ratio test (Ben Akiva and Lerman, 1985) were performed between each set of models. The likelihood ratio test (LRT) is a statistical test of the goodness-of-fit between two models. A relatively more complex model is compared to a simpler model to see if it fits a particular dataset significantly better. If so, the additional parameters of the more complex model are often used in subsequent analyses. The LRT is only valid if used to compare hierarchically nested models. That is, the more complex model must differ from the simple model only by the addition of one or more parameters. Adding additional parameters will always result in a higher likelihood score. However, there comes a point when adding additional parameters is no longer justified in terms of significant improvement in fit of a model to a particular dataset. The LRT provides one objective criterion for selecting among possible models.

The LRT begins with a comparison of the likelihood scores of the two models:

$$LR = 2*(\ln L_R - \ln L_U) \tag{3}$$

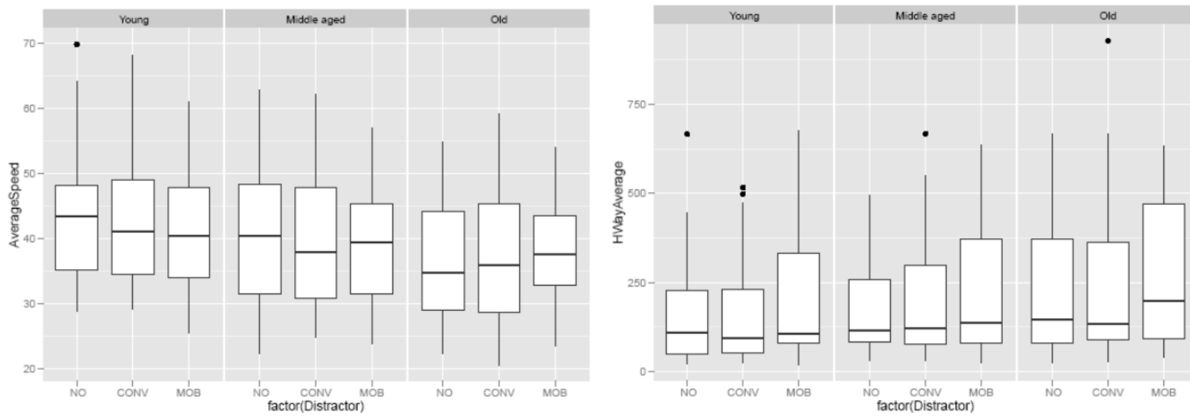
where L_R is the likelihood for the null/restricted model, while L_U is the likelihood for the alternative/unrestricted model.

This LRT statistic approximately follows a chi-square distribution. To determine if the difference in likelihood scores among the two models is statistically significant, we next must consider the degrees of freedom. In the LRT, the degrees of freedom are equal to the number of additional parameters in the more complex (unrestricted) model. Using this information we can then determine the critical value of the test statistic from standard statistical tables. All statistical analyses have been implemented and estimated in the R language for statistical computing (R Development Core Team, 2014).

RESULTS

In this section, all stages of the statistical analyses are presented together with an interpretation of the modeling results. Beginning with the descriptive analyses, in Figure 1, the mean speed and the average space headway of drivers are presented per distraction factor (no distraction, conversation with the passenger, mobile phone use) and per age group (young, middle aged, older).

Figure 1. Average speed and space headway per distraction factor and age group



Regarding average speed, it is observed that older drivers drive in lower speeds regarding young and middle aged drivers, while young and middle aged drivers reduce their speed, especially while talking on the mobile phone. On the other hand, while conversing with the passenger drivers do not change the mean speed in the different distraction situations.

Regarding average space headway it is clearly observed that, while talking on the mobile phone, young and older drivers keep much larger distances from the vehicle ahead compared to all other trials. Furthermore, no pattern can be identified between conversing with passenger and driving without any distraction.

In the next step, generalized linear models were developed. The first model concerned vehicle average speed and explanatory variables included the use of cell phone, middle aged drivers, older drivers, driver's gender, are type and traffic condition. The parameter estimates and their statistical significances are summarized in the left part of Table 1. It is noted that a variable is considered to be statistically significant at a 90% confidence interval, when its t-value is higher than 1.64 and consequently its p-value is lower than 0,100.

The use of a cell phone while driving results in reduced speeds for all drivers especially in urban areas. In particular, regarding the driving performance of different age groups, older drivers reduce their speed double than middle aged drivers. On the other hand, male drivers and in low traffic conditions intend to drive at higher speed. Focusing on the effect of cell phone use, it can be assumed that the reduction in vehicle speeds of drivers using their cell phone results in a road safety benefit; given that lower travel speeds are generally correlated with lower accident risk. However, it is revealing perhaps, apart from the physical distraction of the handheld mode, an attempt of drivers to counter-balance the increased mental workload resulting from the conversation.

Accordingly, following the results for drivers' speed, another model was developed for the effect of cell phone use on average vehicle space headway (left part of Table 2). In this case, statistically significant effects include the variables that were significant in the speed model (use of a cell phone, middle aged drivers, older drivers, driver's gender, are type, traffic condition) as well as the interaction between talking on the mobile phone while driving in urban area.

In particular, looking at the parameter estimates of this model, it may appear that the model yields negative headspaces, under certain conditions i.e. in urban area and male drivers. On the contrary, the use of a cell phone while driving results in increased speed. Furthermore, regarding different age groups, older drivers intend to keep more than 5 times higher distance from the vehicle in front than middle aged drivers. Again, it can be assumed that the increase in the headspace of drivers using their cell phone results in a road safety benefit, however, it is definitely revealing another attempt of drivers to counter-balance the increased mental workload resulting from the conversation.

Before accepting the results of both generalized linear models it is important to evaluate their suitability at explaining the data. One of the many ways to do this is to visually examine the residuals. If the model is appropriate the residual errors should be random and normally distributed. In addition, removing one case should not significantly impact the model’s suitability. R provides four graphical approaches for evaluating the models of average speed and average headways as presented in Figures 2 and 3, respectively.

Figure 2. Average speed GLM graphical approach of residuals

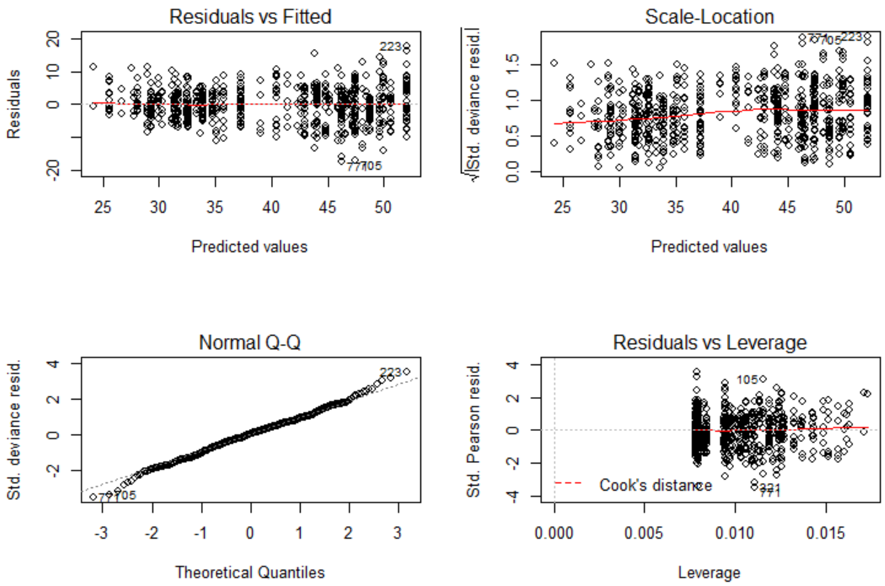
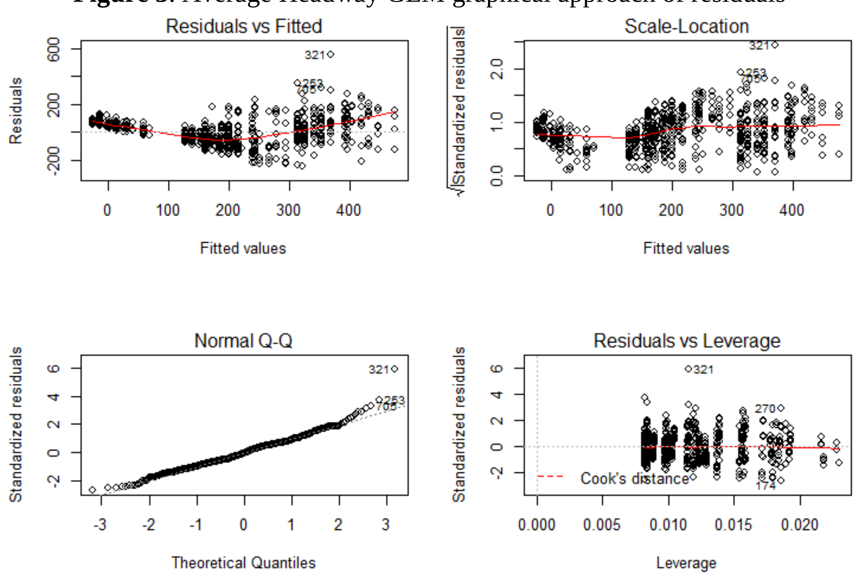


Figure 3. Average Headway GLM graphical approach of residuals



The plots in the upper left of each Figure show the residual errors plotted versus their fitted values. The residuals should be randomly distributed around the horizontal line representing a residual error of zero (there should not be a distinct trend in the distribution of points). The scale location plots in the upper right show the square root of the standardized residuals as a function of the fitted values. Again, there should be no obvious trend in this plot. The plots in the lower left are standard Q-Q plots, which should suggest that the residual errors are normally distributed, if the residuals fall on the dotted line. Finally, the plot in the lower right shows each point's leverage, which is a measure of its importance in determining the regression results. In Figures 2 and 3 all graphical approaches confirm the suitability of the models of average speed and average space headway.

However, as described in the methodology chapter, the data used in this research involve repeated measures observations from each individual drive, as each driver completes six drives in rural and six drives in urban environment. For this reason, in order to deal with the heterogeneity across individuals, generalized linear mixed models are implemented and presented in the right part of both Tables 1 and 2.

Table 1 Parameter estimates of the GLM and GLMM of average speed

	Generalised Linear Model		**Generalised Linear Mixed Model**	
Variables	**Est.**	**t value**	**Est.**	**t value**
Intercept	46,23	95,32	46,53	47,51
Cell phone	-1,47	-3,34	-2,03	-6,10
Age group - Middle aged	-2,15	-4,83	-2,86	-2,69
Age group - Older	-5,79	-11,35	-6,03	-5,32
Gender - Male	2,48	6,32	2,36	2,54
Area type - Urban	-14,81	-38,65	-14,92	-52,33
Traffic - Low	3,35	8,80	3,26	11,65
Random effect	---	---	3,60	
Summary statistics				
df	8		9	
Initial Log-Likelihood	-2.528,74		-2.528,74	
Final Log-Likelihood	-2.097,50		-1.960,28	
AIC	4.211,00		3.938,56	

Table 2 Parameter estimates of the GLM and GLMM of average headways

	Generalised Linear Model		**Generalised Linear Mixed Model**	
Variables	Est.	t value	Est.	t value
Intercept	188,57	2,01	186,22	14,01
Cell phone	78,33	7,02	83,04	7,95
Area type - Urban	-185,90	-22,18	-185,21	-23,79
Gender - Male	-27,98	-3,78	-29,29	-2,45
Age group - Middle aged	11,82	1,40	17,34	1,26
Age group - Older	55,95	5,80	63,91	4,25
Traffic - Low	153,35	21,30	154,86	23,30
Cell phone * Urban area	-67,46	-4,08	-64,46	-4,21
Random effect	---	---	39,54	
Summary statistics				
df	9		10	
Initial Log-Likelihood	-4.510,93		-4.510,93	
Final Log-Likelihood	-4.133,40		-4.089,12	
AIC	9.025,90			

Finally, the likelihood ratio test is taking place in each examined pair of model in order to examine the goodness-of-fit. Regarding average speed models LRav.speed= -274,44 (1 degree of freedom) while regarding average space headways models LRav.sp.headway= -88,56 (1 degree of freedom). Both values indicate that the random effect contributes significantly to the fit of the model and therefore the fit of the generalized linear mixed models outperforms respective generalized linear models.

CONCLUSIONS

This paper analyzed the driving performance of drivers of different age groups in order to investigate the effect of age and distraction on driving parameters. For this purpose, 72 participants from three different age groups were asked to drive under different types of distraction (no distraction, conversation with passenger, mobile phone use) in urban and rural road environment with low and high traffic volume. The results suggest that the specific methodology and design confirm the initial hypotheses and may reveal differences between driving without any distraction source and talking on the mobile phone for different age groups.

Focusing on the effect of cell phone use, it can be assumed that the reduction in vehicle speeds and the increase in headways results in a road safety benefit; given that both parameters are generally correlated with lower accident risk. However, it is revealing, apart from the physical distraction of the handheld mode, an attempt of drivers to counter-balance the increased mental workload resulting from the mobile phone use (compensatory behavior). In this framework, one fundamental question regarding the effect of distraction and especially of mobile phone use on driving performance is whether and how drivers self-regulate their driving to compensate for any decrease in attention to the driving task. Compensatory or adaptive behaviour can occur at a number of levels ranging from the strategic (e.g., choosing not to use a mobile phone while driving) to the operational level (e.g., reducing speed, reducing speed variability) (Poysti et.al, 2005). At the highest level, drivers can choose to moderate their exposure to risk by choosing not to engage in a potentially distracting task while driving. Research has shown, for example, that older drivers' driving performance is impaired to a greater degree than younger drivers when using a mobile phone and this results in compensatory behaviour at the highest level; many older drivers choose not use a mobile phone while driving (Alm and Nilsson, 1995; Lamble et.al., 2002).

This research suggests that drivers often engage in a range of compensatory strategies in an attempt to maintain an acceptable level of driving performance while interacting with in-vehicle distraction sources (mobile phone, conversation with the passenger). Furthermore, results indicate the different distraction mechanism between cell phone and conversation with the passenger which is correlated with driver's age. Mobile phone use distraction is consisted of prolonged and repeated glances to the mobile and older drivers have difficulty in maintaining mobile devices while driving because they are not as practiced and efficient as technological multi-taskers when compared to younger drivers.

More specifically, results indicate that older drivers drive in lower speeds compared to young and middle aged drivers. Furthermore, drivers of all age groups reduce their speed, while talking on the mobile phone. On the other hand, while conversing with the passenger, drivers do not change the mean speed in the different distraction situations. As would be expected, this reduced speed, in general, results under given ambient traffic conditions in increased headways. The increased headways regarding driving, while talking on the mobile phone, were observed in middle aged and older drivers while older drivers intend to keep more than 5 times higher distance from the vehicle in front than middle aged drivers.

The next steps of the present research could focus on the investigation of the interrelation between difference in speeds and difference in space headways between consecutive vehicles. The analysis of this potentially complex relationship might provide additional insight into the modeling results. In addition, it would be important to investigate the impact of mobile phone use, not only when the drivers talk on mobile phone using a hand-held device but also when they use a hands-free device, a Bluetooth, or when they type messages.

ACKNOWLEDGMENT

This paper is based on two research projects implemented within the framework of the Operational Program "Education and Lifelong Learning" of the National Strategic Reference Framework (NSRF), namely the Research Funding Program: THALES. Investing in knowledge society through the European Social Fund, and the Action: ARISTEIA (Action's Beneficiary: General Secretariat for Research and Technology), co-financed by the European Union (European Social Fund – ESF) and Greek National funds.

REFERENCES

Backer-Grøndahl, A., Sagberg, F. (2011). Driving and telephoning: relative accident risk when using hand-held and hands-free mobile phones. Safety Science 49 (2), 324–330

Ben Akiva, M. and Lerman, S. (1985). Discrete choice Analysis. Theory and application to travel demand, MIT press, Cambridge, Massachusetts, USA.

Boyle, L. (2011). Analytical Tools, In: Fisher, D., Rizzo, M., Caird, J., Lee J., Handbook of Driving Simulation for Engineering, Medicine and Psychology, CRC Press

Breslow, N.E. and Clayton, D.G. (1993). Approximate inference in generalized linear mixed models. Journal of the American Statistical Association 88: 9-25.

Brusque, C., Alauzet, A. (2008). Analysis of the individual factors affecting mobile phone use while driving in France: socio-demographic characteristics, car and phone use in professional and private contexts. Accident Analysis and Prevention 40, 35–44.
Bruyas, M., Brusque, C., Debailleux, S., Duraz, M. and Aillerie, I. (2009). Does making a conversation asynchronous reduce the negative impact of phone call on driving?, Transportation Research Part F, n.12, pp.12–20.
Cooper, P. and Zheng, Y. (2002). Turning gap acceptance decision making: The impact of driver distraction, Journal of Safety Research 33, 321-335.
Dula, C.S., Martin, B., Fox, R.T., & Leonard, R. (2011). Differing types of cellular phone conversation and dangerous driving. Accident Analysis and Prevention 43, 187-193.
Fisher, R. A. (1934), Two new properties of mathematical likelihood. Proceedings of the Royal Society A, 144, pp 285-307.
Haigney, D., Taylor, R. G. and Westerman, S. J. (2000). Concurrent mobile phone use and driving performance: task demand characteristics and compensatory processes. Transportation Research, Part F: Traffic Psychology and Behavior, n.3(3), pp.113-121.
Horberry, T., Anderson, J., Regan, M.A., Triggs, T.J. and Brown, J. (2006). Driver distraction: The effects of concurrent in-vehicle tasks, road environment complexity and age on driving performance. Accident Analysis and Prevention, n.38, pp.185-191.
Kass, S., Cole, K. and Stanny, C. (2007). Effects of distraction and experience on situation awareness and simulated driving, Transportation Research Part F, n.10, pp.321–329.
Lamble, D., Rajalin, S., Summala, H., 2002. Mobile phone use while driving: public opinions on restrictions. Transportation 29, 223–235.
Lesch, M.F. and Hancock P.A. (2004). Driving performance during concurrent cellphone use: are drivers aware of their performance decrements? Accident Analysis and Prevention, n.36(3), pp.471-480.
Levinson, P. (2004). Cellphone: The story of the world’s most mobile medium & how it has transformed everything! New York: Palgrave Macmillan.
McCarley, J.S., Vais, M.L., Pringle, H., Kramer, A., Irwin, D., and Strayer, D. (2004). Conversation discrupts chamge detection in complex traffic scenes, Human factors 46, 424-436.
McEvoy S.P. Stevenson M.R., McCartt A.T., Woodward M., Haworth C., Palamara P., Cercarelli, R. (2005). Role of mobile phones in motor vehicle crashes resulting in hospital attendance: a case - crossover study. British Medical Journal 331.
McKnight, A.J. and McKnight, A.S. (1993). The effect of mobile phone use upon driver attention. Accident Analysis and Prevention, n.25, pp.259-265.
Nasar, J., Hecht, P., Wener, R., 2008. Mobile telephones, distracted attention, and pedestrian safety. Accident Analysis and Prevention 40, 69–75.
Nilsson L. and Alm H. (1991). Effects of Mobile telephone use on Elderly’s driver behavior Including Comparison to Young drivers’ behavior, Swedish National Road and Transport Research Institute (VTI), Linkoping, Sweden.
Piotrowski C., and Kass, S. (2013). The Scope of Cell Phone Research in the Psychological Literature, Psychology and Education - An Interdisciplinary Journal, 50(2), 28-31.
R Development Core Team (2014). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0.
Rakauskas, M., Gugerty, L. and Ward, N. (2004). Effects of naturalistic cell phone conversations on driving performance. Journal of Safety Research, n.35, pp.453-564
Rakauskas, M.E., Gugerty, L.J., Ward, N.J., 2004. Effects of naturalistic cell phone conversations on driving performance. Journal of Safety Research 35, 453–464.
Reed, M. and Green, P. (1999). Comparison of driving performance onroad and a low-cost simulator using a concurrent telephone dialing task, Ergonomics 42, 1015-1037.
Schlehofer, M., Thompson, S., Ting, S., Ostermann, S., Nierman, A. and Skenderian, J., (2010). Psychological predictors of college students’ cell phone use while driving, Accident Analysis and Prevention, n.42, pp.1107–1112.
Shinar, D., Tractinsky, N. and Compton, R. (2005). Effects of practice,age, and task demands on interference from a phone task while driving. Accident Analysis and Prevention, n.37, pp.315–326.
Strayer, D.L. Drews, F.A. and Johnston, W.A. (2003). Cell phone-induced failures of visual attention during simulated driving. Journal of Experimental Psychology: Applied, n.9(1), pp.23-32.
Strayer, D.L., Drews, F.A., Johnston, W.A., 2003. Cell phone-induced failures of visual attention during simulated driving. Journal of Experimental Psychology: Applied 9 (1), 23–32.
Strayer, D.L., Johnston, W.A., 2001. Driven to distraction: dual-task studies of simulated driving and conversing on cellular telephone. Psychological Science 12, 462–466.

Svenson, O., Patten, C.J.D., 2005. Mobile phones and driving: a review of contemporary research. Cognition Technology and Work 7, 182–197

Wei, R. (2001). From luxury to utility: A longitudinal analysis of cell phone laggards. Journalism & Mass Communication Quarterly, 78(4), 702-720.

Young, K. & Regan, M. (2007). Driver distraction: A review of the literature. In: I.J. Faulks, M. Regan, M. Stevenson, J. Brown, A. Porter & J.D. Irwin (Eds.). Distracted driving. Sydney, NSW: Australasian College of Road Safety. Pages 379-405.

Zhou, R., Wu, C., Rau, P.-L.P., Zhang, W., 2009b. Young driving learners' intention to use a handheld or hands-free mobile phone when driving. Transportation Research Part F: Traffic Psychology and Behaviour 12, 208–217.