Driver distraction and road safety in Greece and internationally

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Abstract

This paper aims to provide a comprehensive picture of the impact of driver distraction on road safety in Greece and internationally. For that purpose a review of international literature and a synthesis of the results were carried out, concerning both in-vehicle distraction sources (e.g. mobile phone use, reading, adjusting the radio) and external distraction sources (e.g. advertising signs, destination search, pedestrian or cyclist). Subsequently, the results of analyses concerning basic in-vehicle and external driver distraction factors are presented. More specifically, the results of three studies on the effect of mobile phone use on road safety in Greece are presented and discussed. In these studies, the effect of mobile phone use on driver speed and headways was examined by means of different methods, including a naturalistic driving experiment, a roadside survey and a simulator experiment. All studies reveal a significant effect of mobile phone use on driver behaviour and safety. Furthermore, the results of a study on the effect of advertising signs on road safety in Greece are discussed. More specifically, the results of 'before-and-after' analysis of the placement or removal of advertising signs on 9 sites are presented. The results suggest that the effect of advertising signs on road safety is non significant. Overall, distraction related road accidents appear to be a relatively small yet non negligible proportion of road accidents, whereas in-vehicle distraction sources appear to have a far more significant effect than external ones. These results highlight the need for measures for the improvement of driver's behaviour due to distraction, given that more wireless communication, entertainment and driver assistance systems proliferate the vehicle market, and consequently the incidence of distraction related accidents is likely to escalate.
Key words: road safety; driver distraction; in-vehicle; external.

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1. Background and objectives

Driver distraction constitutes an important factor of increased risk of road accident in Greece and internationally. The level at which drivers' distraction affects the traffic circulation and the road safety has not been investigated sufficiently in the international literature. However, in existing research, it was revealed that approximately 30% of drivers that were involved in a road accident reported some source of distraction before the accident occurred (McEvoy et al. 2007). The penetration of various new technologies inside the vehicle (mobile telephones, navigation systems, sound system, other systems of assistance of driving etc.), but also the expected increase of use of such appliances in the next years, makes the further investigation of their influence on the attention of drivers, on traffic flow and on road safety very essential (Olsen et al. 2005).

Most existing researches emphasize on the in-vehicle sources of distraction, such as the use of mobile phone or a navigation / recreation system, discussing with another passenger, smoking, eating or drinking etc. (Yannis et al., 2008; Johnson et al., 2004; Lesch & Hancock, 2004; Strayer et al., 2003; Neyens & Boyle 2008; Bellinger et al. 2008), and report useful results on their influence on both traffic flow (e.g. in terms of driver speed and headways) and road safety (i.e. in terms of accident probability).

Moreover, driver distraction is also examined in terms of external distraction sources. These may concern various visual and mental stimuli, ranging from landscape and traffic (e.g. other vehicles or pedestrians), to traffic control and road signs, incidents, destination seeking and advertising signs (Stutts et al., 2001; Horberry, 1998; Sagberg, 2001; Regan et al., 2005). The related studies examine the influence of these distraction factors on both driver's attention (e.g. in terms of eye glances to the source of distraction), behaviour (e.g. in terms of speeding), and safety.

Within this framework, this paper aims to provide a comprehensive picture of the impact of driver distraction on road safety in Greece and internationally. For that purpose a review of international literature and a synthesis of the results were carried out, concerning both in-vehicle and external distraction factors. Subsequently, the results of analyses concerning basic in-vehicle and external driver distraction factors are presented. More specifically, the results of three studies on the effect of mobile phone use on road safety in Greece are presented, on the basis of different methods, including a basic naturalistic driving experiment, a roadside survey and a simulator experiment. Furthermore, the results of a study on the effect of advertising signs on road safety in Greece are discussed. The results of the international literature and the examined studies in Greece lead to the identification of critical parameters of driver distraction and their effect on traffic flow and road safety.

2. Review of Road Accident Contributory Factors

According to existing research results, human factors are the basic causes of road accident in 65-95% of road accidents (Sabey & Taylor, 1980; Salmon et al., 2011 ;Treat, 1980). The remaining factors include the road environment (road design, road signs, pavement, weather conditions etc.) and the vehicles (equipment and

maintenance, damage etc.), as well as combinations of these three contributory factors.

Moreover, human factors include a large number of specific factors that may be considered as accident causes, including (Department for Transport, 2008):

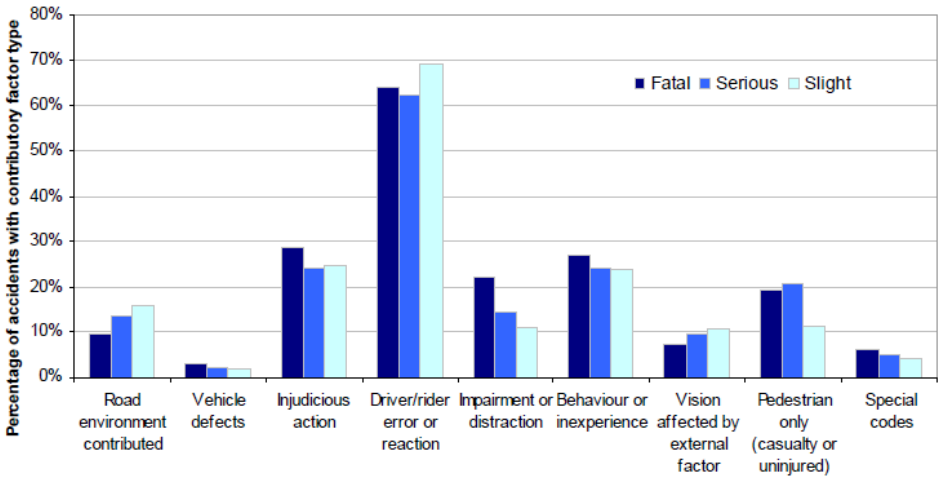
- driver injudicious action (speeding, traffic violations etc.)
- driver error or reaction (loss of control, failure to keep safe distances, sudden braking etc.)
- behaviour or inexperience (aggressive driving, nervousness, uncertainty etc.)
- driver distraction or impairment (alcohol, fatigue, mobile phone use etc.).

Driver distraction constitutes therefore a particular human factor of road accident causation. Driver distraction occurs when a driver's attention is, voluntarily or involuntarily, diverted away from the driving task by an event or object to the extent that the driver is no longer able to perform the driving task adequately or safely (Regan et al., 2008). More specifically, driver distraction involves a secondary task, distracting driver attention from the primary driving task (Donmez et al., 2006; Sheridan, 2004) and may include four distinct elements: visual, acoustic, motor and mental distraction (Ranney et al., 2000), which are often difficult to isolate.

In any case, it is noted that distraction may be considered to be a typical part of every day driving (Stutts et al. 2001). In several studies, the quantification of the effect of driver distraction on the number of road accidents is attempted. However, the results lie on a range of values, mainly due to the different definitions of driver distraction in each case, and the different distraction sources taken into account in each case. More specifically, it is reported in the international literature that driver distraction may be a contributory factor in a proportion of road accidents ranging from 10-15% (MacEvoy et al. 2007; Wang et al. 1996), whereas driver inattention may, together with other factors, affect up to 70% of road accidents (Dingus et al. 2006).

For example, Figure 1 shows the percentage of accidents in which each contributory factor was reported in Great Britain in 2008, including a breakdown by accident severity. Four of the five most frequently reported contributory factors were some kind of driver error or reaction, which includes 'failed to look properly' and 'failed to judge other person's path or speed'. Impairment or distraction factors account totally for 12% of all contributory factors.

Figure 1: Road accident contributory factors by accident severity
(Department for transport, 2008)



Moreover, in Table 1 the results are further analyzed in terms of the number of accidents reported in Great Britain for the contributory factor 'impairment or distraction'. The accidents are classified by severity and divided as per the type of impairment or distraction involved. It can be seen that distraction contributory factor account for less than 30% of all 'impairment and distraction' factors.

Table 1: Number of accidents for contributory factor 'impairment or distraction'
(Department for transport, 2008)

	Fatal Accidents		Serious Accidents		Sight Accidents		All Accidents	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Impairment of distraction	**479**	**22**	**2,924**	**14**	**12,159**	**11**	**15,562**	**12**
Impaired by alcohol	237	11	1,485	7	5,036	5	6,758	5
Impaired by drugs (illicit or medicinal)	56	3	207	1	424	0	687	1
Fatigue	64	3	374	2	1,374	1	1,812	1
Uncorrected, defective eyesight	18	1	44	0	163	0	225	0
Illness or disability, mental or physical	90	4	402	2	1,356	1	1,848	1
Not displaying lights at night or in poor visibility	4	0	92	0	321	0	417	0
Cyclist wearing dark clothing at night	9	0	84	0	365	0	458	0
Driver using mobile phone	16	1	60	0	247	0	323	0
Distraction in vehicle	**69**	**3**	**339**	**2**	**2,406**	**2**	**2,814**	**2**
Distraction outside vehicle	**34**	**2**	**219**	**1**	**1,650**	**2**	**1,903**	**1**

3. Review of Driver Distraction Factors

Driver distraction factors can be subdivided into those that occur outside the vehicle (external) and those that occur inside the vehicle (in-vehicle). Although different studies report different specific distraction factors in each category, one of the most complete and comprehensive approaches is presented in Table 2 (Regan et al., 2005).

Table 2: Driver distraction sources by category (in-vehicle / external)

Driver distraction sources	
In-vehicle	**External**
Passengers	Traffic control
Communication	Other vehicle
Entertainment systems	Seeking location / destination
Vehicle systems	Pedestrian / cyclist
Eating / drinking	Accident / incident
Smoking	Police / Ambulance / Fire brigade
Animal / insect in the vehicle	Landscape / architecture
Coughing / sneezing	Animal
Stress	Advertising signs
Daydreaming	Road signs and markings
	Sun / other vehicle lights

Moreover, the distraction factors that occur inside the vehicle seem to have greater effect on driver behaviour and safety. Horberry et al. (2006) confirm that in-vehicle distraction sources have a more important effect on driver performance, compared to the increased complexity of the stimuli received from the road and traffic environment. Moreover, a couple of studies report that external distraction factors are less than 30% of the total distraction factors (Stutts et al. 2001; Kircher, 2007). Other studies specify that external distraction factors account for less than 10% of all distraction factors (Sagberg, 2001; MacEvoy et al. 2007).

It is noted that a recent exhaustive research conducted in the Great Britain, in which the effect of more than 70 road accident contributory factors was examined, driver distraction was found to be a contributory factor in only 3% of all accidents. Out of this 3%, in-vehicle distraction sources accounted for 2%, whereas external distraction sources accounted for only 1% of all accident contributory factors (Department for Transport, 2008).

The distraction caused by interacting with in-vehicle devices while driving appears to impair the driver's ability to maintain speed, control and lateral position on the road, to a more important degree compared to external distractions.

Moreover, a study carried out by Patel et al. (2008) examined perceived qualitative characteristics of 14 driver distractions. Survey participants were asked to complete a questionnaire in which ranked a list of distractions according to certain criteria. Table 3 shows the mean perceived risk ratings of each of the 14 driver distractions. The highest perceived risk ratings were associated with the use of mobile phones, followed by 'looking at a map or book' and 'grooming'. The lowest perceived risk ratings were associated with 'listening to music', 'talking to passengers' and 'looking at road signs'. It is noted that advertising signs and

landscape have a non negligible perceived risk level as external distraction sources.

Table 3: Perceived risk associated with driver distractions.
(Source: Patel et al., 2008)

Driver Distraction Hazard	Risk rating	Lower limit	Upper limit
Listening to music	3.3	1.2	4.8
Talking to passengers	3.8	2.0	5.0
Looking for/at road signs	4.2	3.0	6.0
Satellite navigator use	4.6	3.0	6.0
Hands-free kit use	4.7	3.0	6.0
Looking at Landscape	5.2	3.0	7.0
Adjusting device	5.3	4.0	7.0
Smoking	5.3	3.0	7.0
Looking at advertising sign	5.7	4.0	8.0
Eating or drinking	6.3	5.3	8.0
Looking for object	7.4	6.0	9.0
Grooming/make-up	8.5	8.0	10.0
Looking at a map or book	8.5	8.0	10.0
Mobile phone use	8.6	8.0	10.0

More analytical results on the actual relative importance of different distraction factors was sought in the reports of the 100-Car naturalistic driving study carried out in the USA. Table 4 shows results on the odds ratio (i.e. increased risk) of engaging in various secondary distracting tasks over “just driving” (statistically significant results are in bold). A significant odds ratio indicates an important increase in risk associated with that activity.

Table 4. *Odds ratio for secondary tasks in the 100-Car study (Source: NHTSA, 2008)*

Type of Secondary Task	Odds Ratio
Reaching for a moving object	8.82
Insect in vehicle	6.37
Reading	3.38
Applying makeup	3.13
Dialling hand-held device	2.79
Inserting/retrieving CD	2.25
Eating	1.57
Reaching for non-moving object	1.38
Talking/listening to a handle-held device	1.29
Drinking from open container	1.03
Other personal hygiene	0.70
Adjusting the radio	0.50
Passenger in adjacent seat	0.50
Passenger in rear seat	0.39
Child in rear seat	0.33

These results suggest that 'reaching for a moving object' is associated with the highest risk, increased by more than eight times compared to just driving, followed by 'reading' and 'applying make-up', increasing risk by more than 3 times. Subsequently, the use of mobile phone is associated with 2.8 times increased accident risk.

The use of mobile phone while driving has raised strong concerns about the impact of on road safety and several research actions are under way (NHTSA, 2006; McEvoy et al. 2007). Early research results showed that cell phone communication is a quite demanding cognitive and operational task, which may compromise decision making while driving (McKnight and McKnight 1993). Recent studies confirm that mobile phone use while driving may significantly affect driver's behaviour and safety. Drivers tend to reduce their speed during a mobile phone conversation (Strayer & Drews, 2004; Yannis et al. 2010a). Although reduced speed is generally associated with lower accident risk, drivers using their mobile phone while driving present up to 4 times higher accident risk (MacEvoy et al. 2005; Redelmeier & Tabshirani, 1997), most probably as a result of increased workload and delayed reaction time (Caird et al. 2008).

Nowadays, the use of a cell phone while driving is prohibited by road traffic regulations in most European countries, because it is blamed for increased risk of provoking or failing to avoid a road accident. In this context, in the next section, the results of existing studies on the effect of mobile phone use on road safety in Greece are presented.

4. In-vehicle distraction: the effect of mobile phone use in Greece

The research results presented above suggest that mobile phone use may be the most important in-vehicle distraction source for drivers. In Greece there are three researches carried out in the National Technical University of Athens, related on the impact of mobile phone use on traffic characteristics. The first one concerns a basic naturalistic driving experiment (Yannis et al. 2010a), the second one concerns a roadside survey (Yannis et al 2010b) and the third one concerns a simulator experiment (Roumpas, 2010).

4.1. A basic naturalistic driving experiment

In this experiment, the effects of mobile phone use while driving on traffic speed and headways were examined, with particular focus on young drivers. A basic naturalistic driving experiment was carried out, in which drivers' speeds and headways were measured while using or not a mobile phone. The experiment concerned 37 participants and took place within a selected University Campus area.

Linear and loglinear regression methods were used to investigate the effects of mobile phone use and several other young driver characteristics, such as gender, driving experience and annual distance travelled, on vehicle speeds and headways. The modelling results presented in Table 5 concern the statistically significant parameter estimates of the models (β), their t-tests (t), their elasticities (e), the normalization (e*) of the elasticities to the lowest value, and the R^2

coefficient. The results show that mobile phone use leads to statistically significant reduction of traffic speeds of young drivers.

Table 5: Modelling driver speed in relation to mobile phone use in Greece (naturalistic driving experiment) - Parameter estimates and elasticities

Variable	Total average speed (V_t)			
	β	t-test	Elasticities	
			e	e^*
Mobile phone use	-0.047	-3.909	0.017	2.46
Gender	-0.032	-2.671	0.007	1.00
Annual distance	0.020	1.861	0.008	1.12
Average headways	-0.033	-5.123	0.069	10.33
R^2	0.609			

Note: A t-test value higher than 1.96 indicates a statistically significant effect at 95% confidence level.

Furthermore, it was found that male and female drivers reduce their speed similarly when using a mobile phone while driving. Moreover, male drivers using their mobile phone drive at lower speeds than female drivers not using their mobile phones. Variables sensitivity analysis revealed that, among all explanatory variables, the effect of mobile phone use on speed was the most important one.

4.2. A roadside survey

The objective of this research was the analysis of the impact of cell phone use on vehicle traffic speed and headways. In the experiment carried out, traffic data were recorded on a four-lane urban arterial segment, in which more than 3,000 vehicles were captured by means of a video camera and a speed gun.

Linear regression models were developed for the analysis of the effect of cell phone use and other variables on traffic speed and time / space headways. The modelling results presented in Table 6 concern the statistically significant parameter estimates of the models (β), their elasticities (e) and the normalization (e*) of the elasticities to the lowest value, as well as the t-tests (t) for parameter estimates and the models fit (R^2).

The results confirm that mobile phone use decreases driver speed. It was also found that vehicle speed is increased for young drivers (aged 18-25 years), male drivers and taxi drivers, and decreased for older drivers (>55 years) and for drivers using their cell phone while driving.

Vehicle headspaces, estimated as the product of vehicle speed and time headways, were found to be decreased for drivers using their cell phone, young drivers and older drivers. Moreover, headspaces increased with the difference in speed and in headway of the vehicle ahead.

Table 6: Modelling driver speed in relation to mobile phone use in Greece (roadside survey) - Parameter estimates and elasticities

	Vehicle speed (V)				Headspace (Hs)			
Variable	**β**	**t-test**	**e**	**e***	**β**	**t-test**	**e**	**e***
Taxi	0.692	1.914	0.00154	1.13	-	-	-	-
Gender	-0.688	-2.537	0.00318	2.34	-	-	-	-
Age 18-25	0.441	1.642	0.00228	1.68	-	-	-	-
Age 25-55	-	-	-	-	7.299		0.14733	1.63
Age >55	-1.503	-3.828	0.00297	2.18	-	-	-	-
Cell phone use	-0.726	-1.849	0.00136	1.00	-28.824		0.09023	1.00
Speed difference dv	-	-	-	-	7.134		0.87752	9.73
Headways difference dHw	-	-	-	-	7.174		128.655	14.26
R^2	0.45				0.47			

Note: A t-test value higher than 1.96 indicates a statistically significant effect at 95% confidence level.

Overall, the distraction caused by mobile phone use is reflected in the reduced speeds and space headways for all drivers. The reduction is more pronounced when the speed and headway difference between successive vehicles was not significant in the first place, as is the case for vehicle platoons.

4.3. A simulator experiment

This research aims to investigate the interrelation between mobile phone use, driver speed and accident probability. For that purpose, a driving simulator experiment was carried out, in which 30 young drivers aged between 18 and 30 years old drove in different driving scenarios, covering urban and interurban areas, good or rainy weather conditions and with or without the occurrence of an incident (Roumpas, 2010).

Linear regression methods were used to analyse the influence of mobile phone use as well as various other parameters on the mean speed of drivers. Binary logistic regression methods were used to analyse the combined influence of mobile phone, driver speed and other parameters on the probability of an accident. The modelling results in terms of statistically significant parameter estimates (β), their t-tests (t) and elasticities (e) are presented in Table 7. Moreover, models fit is presented by means of the R^2 coefficient for the linear regression model and by means of the likelihood ratio test for the logistic regression model.

It appears that mobile phone use leads to statistically significant decrease of the mean speed but simultaneously it leads to an increase of accident probability, suggesting that the speed reduction when using a mobile phone is not sufficient to counter-balance the overall increased risk of doing so while driving, especially when an unexpected incident occurs.

It was also found that drivers did not present a statistically significant different mean speed in rainy conditions; however, they had a higher probability of being

involved in an accident. It was finally revealed that the effect of mobile phone use in case of speed increase and adverse weather conditions makes accident avoidance in case of an unexpected incident almost impossible.

Table 7: Modelling driver speed and accident probability in relation to mobile phone use in Greece (simulator experiment) - Parameter estimates and elasticities

Variables	Driver speed			Accident probability		
	β	t-test	e	β	t-test	e
Mobile phone use	-0.071	-7.47	-0.023	-	-	-
Urban area	-0.107	-10.90	-0.034	-	-	-
Mean distance from the right border	-	-	-	3.134	1.58	1.028
% of the route the 4th gear was used	0.097	5.32	0.022	-	-	-
% of the route the 2nd gear was used	-	-	-	2.761	3.41	0.469
Mean motor revolutions	$7.91*10^{-5}$	10.36	0.147	-	-	-
Annual mileage	$3.75*10^{-6}$	4.90	0.022	-	-	-
2nd drive in rainy conditions	-0.032	-3.24	-0.011	-	-	-
change in speed while using mobile phone	-	-	-	-0,138	5.66	-0.318
Rain	-	-	-	1.798	5.49	1.796
occurrence of an incident while using mobile phone	-	-	-	3.295	12.84	8.986
occurrence of an incident while not using mobile phone	-	-	-	2.100	5.33	2.971
Never using mobile phone while driving	-	-	-	1.726	4.35	1.481
1st drive	-	-	-	-1.567	4.86	-0.590
R^2	0.655			-		
Likelihood Ratio Test	-			72.62		
Degrees of freedom	-			7		

Note: A t-test value higher than 1.96 indicates a statistically significant effect at 95% confidence level. A likelihood ratio test equal to 72.62 with 7 degrees of freedom leads to accepting the model at 95% confidence level.

5. External distraction: the effect of advertising signs in Greece

According to the international literature, external driver distraction sources are a minor proportion of road accident causes. However, the particular case of advertising signs is often associated with increased accident risk and several studies examine the effect of roadside advertising on driver attention, behaviour and safety. In most countries, specific rules exist as per the size, location and type of roadside advertisements.

Although most studies are in concordance with one another as regards the fact that advertising signs do attract the attention of the majority of drivers, for a non negligible proportion of their driving time (Wallace, 2003; Regan et al. 2005), their contribution to road accident occurrence is low when compared to other distraction sources or other human factors. In particular, the potential risk

associated with advertising signs may depend on their type, their height, their content and other characteristics (Chattington et al. 2009; Crundall et al. 2006).

Within this context, a recent research in Greece aims to investigate the effect of advertising signs on road safety. More specifically, it examines whether the placement leads to significant increase of road accidents, and whether the removal of advertising signs may lead to any significant reduction of road accidents.

On that purpose, a 'before-and-after' statistical analysis was carried out in eight different road axes within the greater Athens area to investigate the correlation between advertising signs and road accidents. The specific roads were chosen as there was placement or removal of advertising signs during the last decade. A before-and-after statistical analysis with control groups was applied, in which special attention was given not only to the identification of the appropriate control groups, e.g. neighbouring or not road axes with very similar geometric and traffic characteristics, but also that the sample size of all cases examined was statistically significant. Before and after periods vary from 2.5 to 6 years depending on the date of the placement / removal of the advertising signs and the availability of the road accident data.

From the statistical analysis of the road axes selected it was found that no statistical correlation between road accidents and advertising signs can be proved in none of the eight cases examined. More specifically, the global safety effects of placing / removing and their confidence intervals are presented in Table 8. These were estimated on the basis of the odds-ratio method for a number of treatment and control sites (Yannis et al. 2005). It can be seen that the estimated safety effects are non significant, given that their confidence intervals, estimated at 95% confidence level, are too large and thus not acceptable.

Table 8: Before-and-after analysis of the effect of advertising signs in Greece

	Advertising signs	
	Placement	Removal
Accidents 'Before' in the treatment sites	258	1334
Accidents 'After' in the treatment sites	223	1307
Accidents 'Before' in the control sites	527	1331
Accidents 'After' in the control sites	523	1452
weighted mean effect	1.125	1.052
safety effect	**-12.5%**	**-5.2%**
lower limit	-34.9%	-15.1%
upper limit	6.1%	3.8%

This finding can be explained by the fact that in the road axes selected drivers are overloaded by a lot of information (traffic signs, directions signs, several advertising labels of the shops on the road, pedestrians and other vehicle traffic, etc.) so that the additional information load from the advertising signs may not worsen their concentration on driving. These findings coincide with results from international literature using such statistical analyses. To conclude, advertisings

signs as drivers' distraction factors do not seem to have statistically significant impact on road accidents in general. However further investigation is needed to extract specific conclusions for more specific cases (e.g. junctions, sign positioning, etc.).

6. Discussion

This paper aims to provide a comprehensive picture of the impact of driver distraction on road safety in Greece and internationally. Driver distraction is a safety problem that can increase accident risk due to the degradation in driving performance during multitasking, including slower reaction time and narrowed visual scanning. Moreover, as more in-vehicle systems, such as wireless communication, entertainment and driver assistance systems, become more widespread, the occurrence of distraction related crashes is likely to escalate.

A review of international literature and a synthesis of the results were carried out, concerning both in-vehicle distraction sources (e.g. mobile phone use, reading, adjusting the radio) and external distraction sources (e.g. advertising signs, destination search, pedestrian or cyclist). A comparative assessment of distraction sources with other contributory factors was carried out. Overall, distraction related road accidents appear to be a minor yet non negligible proportion of road accidents, whereas in-vehicle distraction sources appear to have a far more significant effect than external ones. Existing research also largely focuses on in-vehicle distraction sources, namely the use of mobile phones while driving. As regards external distraction, most studies examine the effect of advertising signs on road safety.

Within this context at international level, the results of analyses concerning basic in-vehicle and external driver distraction factors in Greece were presented. More specifically, the results of three studies on the effect of mobile phone use on road safety in Greece were presented and discussed. In these studies, the effect of mobile phone use on driver speed and headways was examined by means of different methods, including a naturalistic driving experiment, a roadside survey and a simulator experiment. All studies are in accordance with the international literature and reveal a significant effect of mobile phone use on driver speed (i.e. speed reduction). However, the simulator experiment allowed to conclude that this speed reduction can not counterbalance the reduced headways and reaction times, and therefore mobile phone use increases accident probability.

Furthermore, the results of a 'before-and-after' study on the effect of advertising signs on road safety in Greece were presented. Both the placement or removal of advertising signs were examined, and the results suggest that the effect of advertising signs on road safety is non significant, at least for the particular locations that have been investigated.

These results highlight the need for measures for the improvement of driver's behaviour due to distraction, especially as regards the use of mobile phones. Measures against driver distraction include enforcement of traffic rules, concerning the use of mobile phones, or other hand-held in-vehicle devices, as well as the appropriate placement of road signs, advertisements etc.. They also include driver information campaigns e.g. concerning the risk associated to mobile phone use and driver distraction in general.

The next steps of the research on driver distraction could focus on several open issues starting from establishing the most ergonomic way to design in-vehicle devices to minimize distraction. Furthermore, future research should focus on mobile phone use, in terms of both the isolation of their impact from the various distraction factors and the analysis of their combined impact with other distraction factors. In addition, it would be important to achieve a common international definition of driver distraction. Finally, the cross-validation of driver distraction results from experiments (e.g. driving simulator, naturalistic driving) and statistical analyses (before-after, comparison of sections) should be carried out.

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