Communication Technologies and Road Safety

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Distracted driving and mobile phone use: overview of impacts and countermeasures

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Background

- Driver distraction constitutes an important factor of increased risk of road accident worldwide.
- 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.
- Distraction sources may be considered as a typical 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 further investigation of their influence on the attention of drivers, on traffic flow and on road safety very essential.

Objectives and Structure

Objectives

- To provide a comprehensive picture of the impact of driver distraction regarding mobile phone use on road safety

- To propose specific countermeasures

Structure

- Review of international literature on the effect of mobile phone while driving
- Presentation of recent research findings from NTUA experiments
- Proposals for measures to address mobile phone use while driving

Inattention and distraction - Definitions

driver inattention

- "insufficient, or no attention, to activities critical for safe driving"

driver distraction (diverted attention)

- "The diversion of attention away from activities critical for safe driving toward a competing activity, which may result in insufficient or no attention to activities critical for safe driving."

Driver distraction is just one form of attentional failure that can result in inattention.

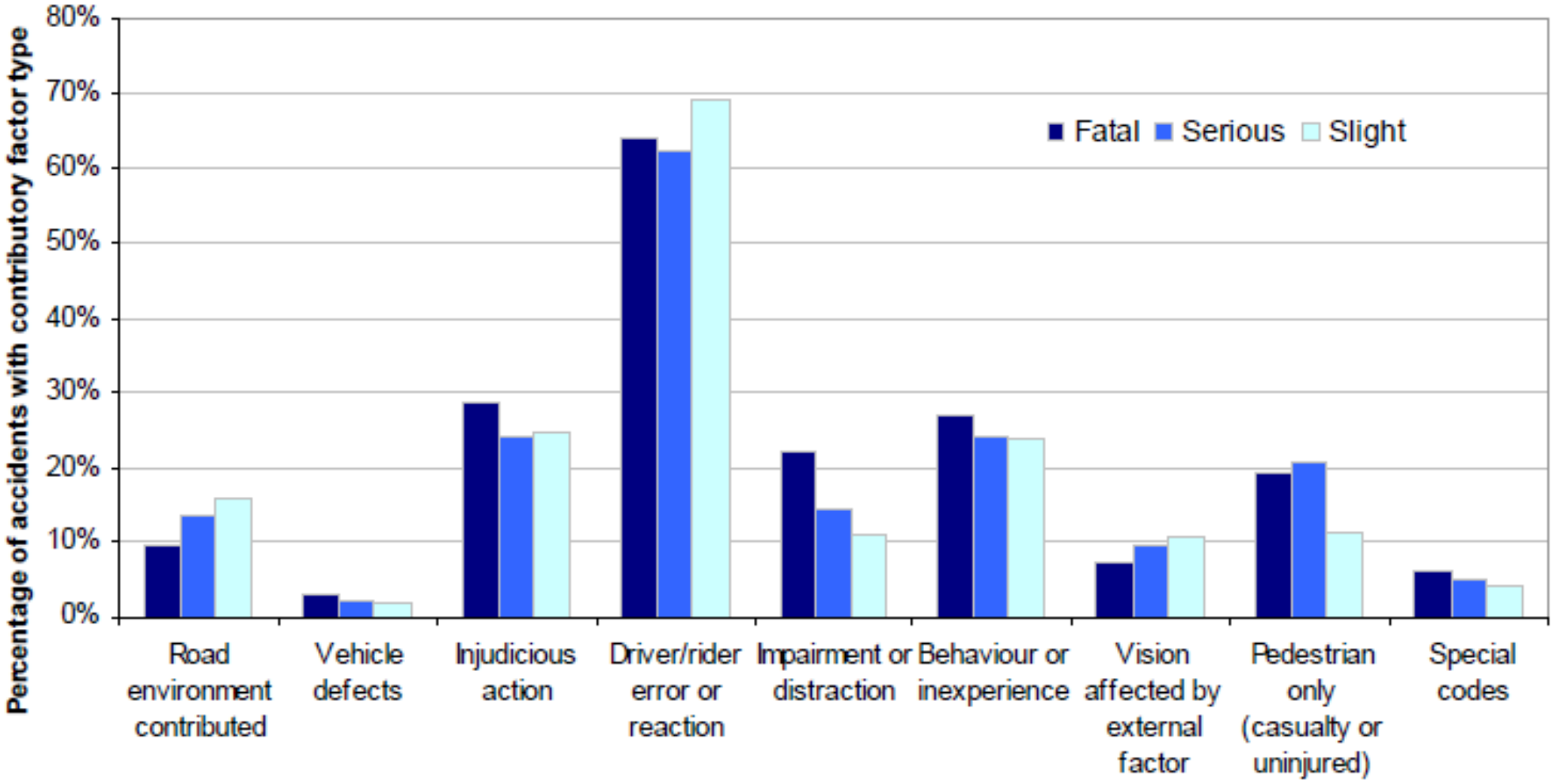
Road Accident Contributory Factors – Human Factors

- Human factors are the basic causes of road accident in 65-95% of road accidents.

- Human factors include a large number of specific factors that may be considered as accident causes, including:
  - 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.).

Road Accident Contributory Factors

Source: GB 2008, Department for Transport



Impairment or distraction factors
account totally for 12% of all contributory factors

Road Accident Contributory Factors related to Impairment or Distraction

Source: GB 2008, Department for Transport

Road accident contributory factors*	Fatal accidents (%)	Total accidents (%)
Road environment	9	16
Vehicle defects	3	2
Injudicious action	29	25
Driver/rider error or distraction	64	68
Impairment or distraction	22	12
Alcohol	11	5
Drugs	3	1
Fatigue	3	1
Illness or disability	5	1
Mobile phone use	1	0
In-vehicle distraction	3	2
External distraction	2	1
Behaviour or inexperience	27	24
Vision affected	7	10
Pedestrian accident	19	13

** The sum of percentages may exceed 1 due to multiple contributory factors per accident*

Internal distraction factors account for 2/3 of the total distraction factors

Driver Distraction Factors

Source: Regan et al., 2005

In-vehicle	External
Passengers	Traffic control
Communication devices	Other vehicle
Entertainment system	Looking for destination / location
Vehicle systems	Pedestrian / Bicyclist
Eating / drinking	Accident / incident outside the vehicle
Smoking	Police / Fire brigade / Ambulance
Animal / insect in the vehicle	Landscape / Buildings
Coughing / sneezing	Animal
Driver stress	Advertising sign
Daydreaming	Road signs and markings
	Sun / vehicle lights

Driver Distraction Impacts

Driver distraction may have an impact to:

- Driver attention
  - Hands-off the wheel
  - Eyes-off the road

- Driver behaviour
  - vehicle speed
  - headway
  - vehicle lateral position
  - driver reaction time

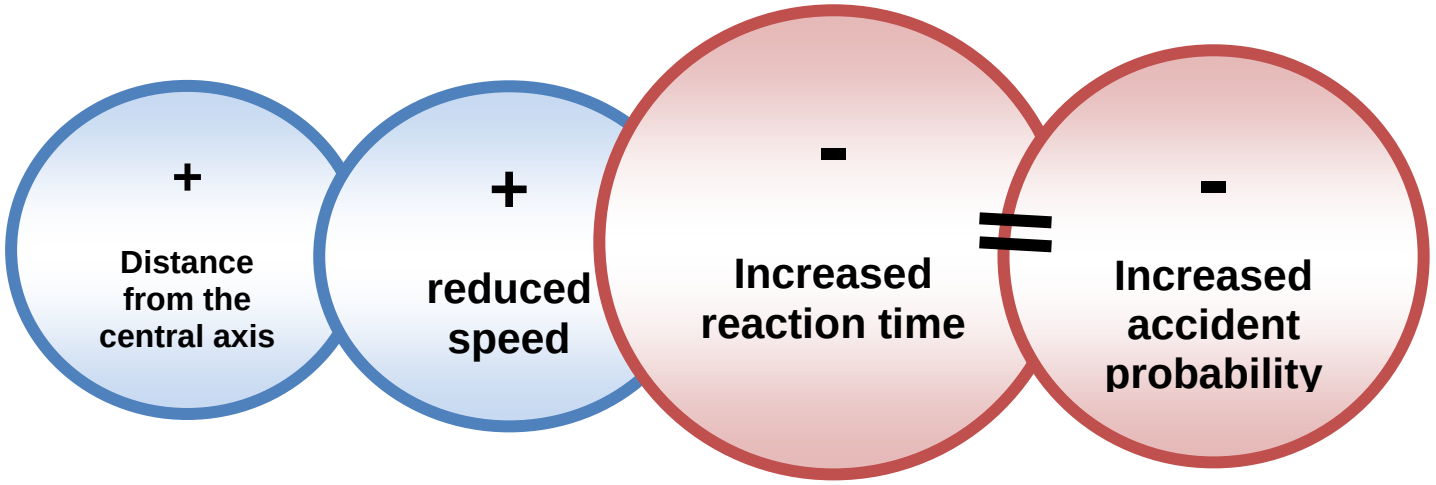
- Driver accident risk

Distraction accident risk – Key elements

- Attentional demands: The amount of resources required to perform the distraction task.
- Exposure: How often and when drivers engage in the task. Driver strategies (if any) to compensate for distraction.
- Risk compensation: can the additional mental or motor workload be counterbalanced by adjusting driving behaviour?

Distraction accident risk – Mechanism

- The decrease in speed and the increase in the distance from the central axis, during distracted driving might be considered beneficial for road safety.
- However, they cannot always counter-balance the driver's distraction
- This leads to increased reaction times, and eventually increased accident probability, especially at unexpected incidents.



In-vehicle distraction – Mobile phone use

- Earlier and recent studies agree that mobile phone use while driving may significantly affect driver's behaviour and safety.
- Research results suggest that mobile phone use may be the most important in-vehicle distraction source for drivers.
- Drivers tend to reduce their speed during a mobile phone conversation.
- 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, most probably as a result of increased workload and delayed reaction time.

In-vehicle distraction – Mobile phone use – handheld vs. hands-free

- Although the physical distraction associated with handling the phone can present a significant safety hazard, the cognitive distraction associated with being engaged in a conversation can also have a considerable effect on driving.

- Many studies have found that conversing on a hands-free phone while driving is no safer than using a hand-held phone
  (Haigney et al., 2000; Matthews et al. 2003; Redelmeier & Tibshirani, 1997; Strayer, Drews, Albert & Johnston, 2003).

- When drivers were engaged in a phone conversation using either a hand-held or hands-free phone, they demonstrated similar driving deficits
  (Strayer et al. 2003).

- Drivers tend to overestimate the ease of using hands-free phones while driving.
  (Mazzae et al. 2004.)

In-vehicle distraction - Mobile phone use: texting

- Important distinction: texting is amenable to resumption after selective disengagement, while conversation may be more difficult to interrupt and resume, once initiated.

- The question of whether drivers actually modulate texting engagement is not well addressed in the literature.

- Results indicated that drivers were particularly impaired when sending text messages and less so when receiving *(Hosking et al. 2009).*

- When texting, participants express greater following variability, greater lateral variability, reduced response time to the lead vehicle, and increase in collision frequency.
  (Drews et al. 2009)

- A recent naturalistic driving experiment suggests that the effects of texting may be significantly underestimated in previous (simulator) experiments.
  (Cooper et al. 2011)

In-vehicle distraction – Mobile phone and other factors

- Driving environment: Impairment due to mobile phone use may increase in more complex road environments (e.g. urban areas, unfamiliar environment), more traffic density, adverse weather conditions.
  (Cooper & Zheng, 2002; Strayer et al. 2003)

- Driver age: Research has consistently found that older people have a decreased ability to share attention between two concurrent tasks while driving than younger drivers.

- Driving experience: Young novice drivers may also be relatively more vulnerable to the effects of distraction than experienced drivers.
  (Young & Regan, 2007).

In-vehicle distraction - Mobile phone use - Other issues

- Complex conversation (e.g. recalling information, solving arithmetical problems, emotional conversation) is associated with more impaired driving, due to higher cognitive demands.
  (McKnight and McKnight, 1993; Pattel et al. 2005)

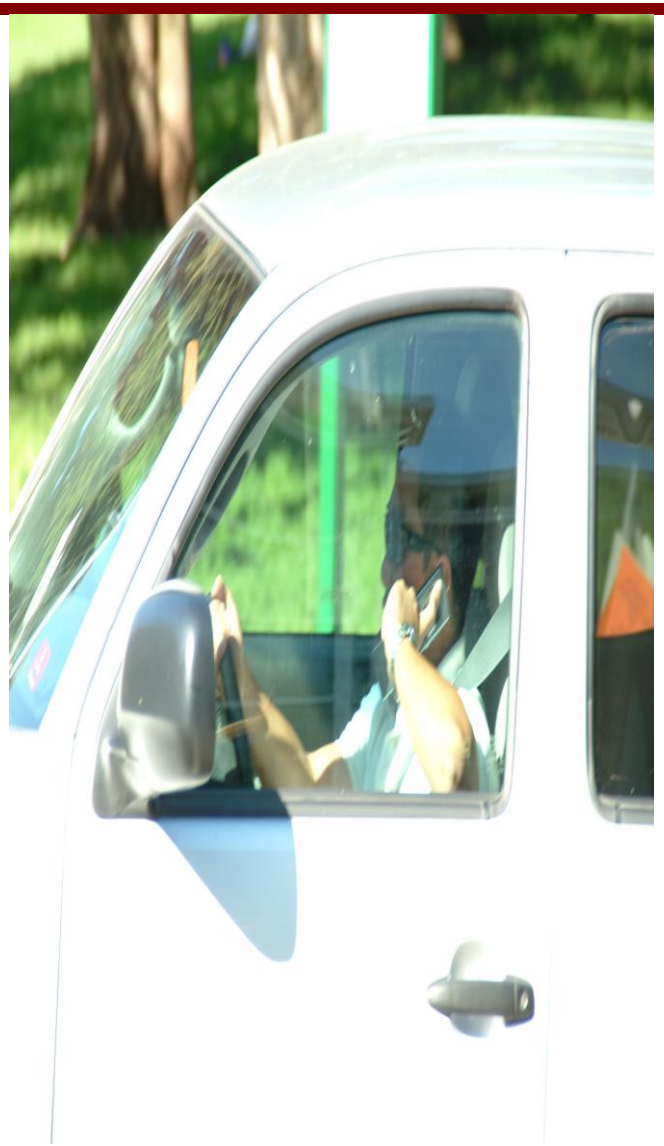
- In naturalistic conversation experiments, however, the differences between simple and complex conversation were less striking than in simulator experiments.
  (Rakauskas et al., 2004)

- Repeated experience may lead to learning effects. Over the course of repeated sessions, the negative effects of the phone tasks on driving performance may diminish.
  (Shinar et al. 2005)

Results of related research in Greece

- 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:

  - in-vehicle observations
  - a roadside survey
  - a simulator experiment.

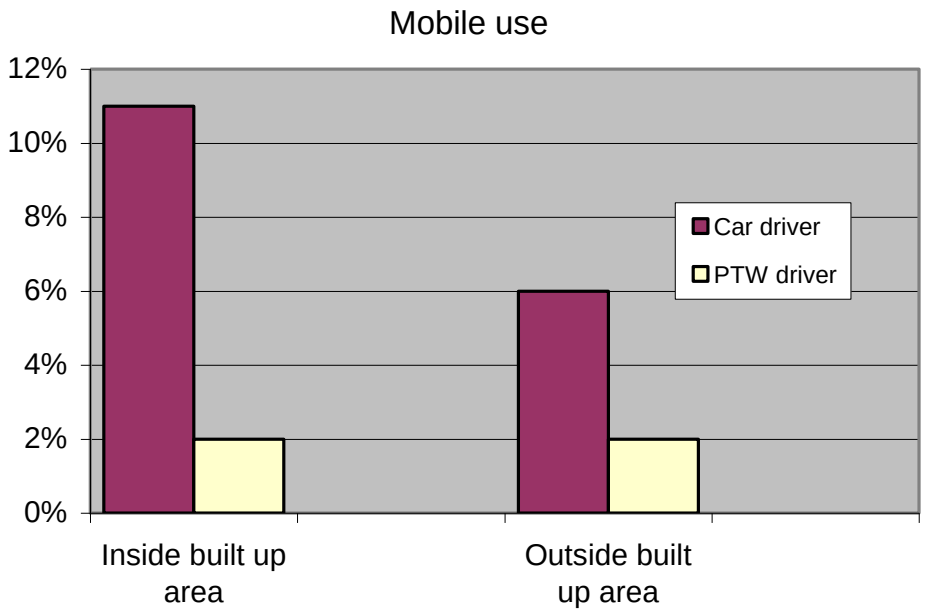


Mobile phone use in Greece

	Male			Female			Total
	16-24	25-54	>55	16-24	25-54	>55	
Car driver	15%	9%	4%	16%	12%	1%	9%
PTW driver	4%	2%	2%	12%	3%	0%	2%

	Inside built up area	Outside built up area
Car driver	11%	6%
PTW driver	2%	2%

	Large	Small	Total
Car driver	9%	10%	9%
PTW driver	2%	3%	2%



- 9% of car drivers in Greece use their mobile phone while driving
- Mobile phone use rate is increased for young car drivers (16 - 24)
- Mobile phone use rate is increased inside built-up area
- PTW riders present very low mobile phone use rates, except for young females (12%)

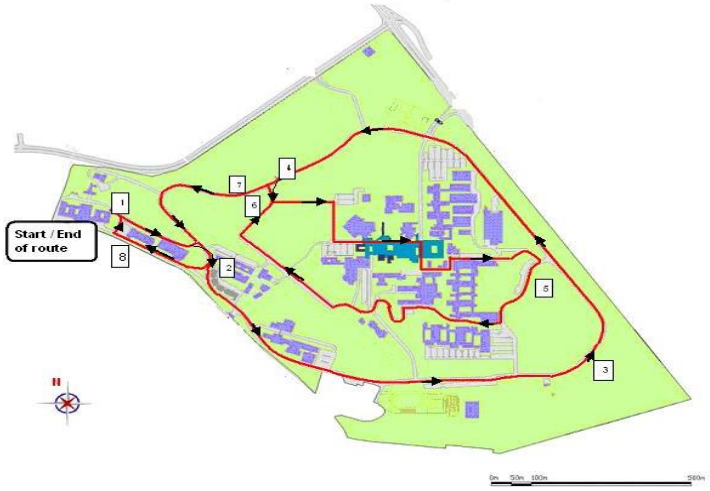
Mobile phone use, driver speed and headways

In-Vehicle observations, NTUA, 2007

- Effects of mobile phone use while driving on traffic speed and headways, focused on young drivers.

- Experiment with 37 participants took place in NTUA Campus area, under either free flow or interrupted flow conditions.

Field survey area and routes



- Separate models were developed for average free flow, interrupted flow, as well as for total average speed.

Mobile phone use, driver speed and headways

In-Vehicle observations, NTUA, 2007

Best fitting models for vehicle speed

Variable	Total average speed (V_t)			Free flow average speed (V_f)			Interrupted flow average speed (V_i)		
	β_i	Relative effect		β_i	Relative effect		β_i	Relative effect	
		e_i	e_i^*		e_i	e_i^*		e_i	e_i^*
Mobile phone use	-0.047	0.017	2.46	-0.049	0.017	3.12	-0.063	0.023	1.97
Gender	-0.032	0.007	1.00	-0.028	0.005	1.00	-0.050	0.012	1.00
Driving experience	-	-	-	0.030	0.010	1.79	-	-	-
Annual distance	0.020	0.008	1.12	+0.032	0.012	2.15	-	-	-
Average headways	-0.033	0.069	10.33	-0.023	0.047	8.81	-0.026	0.059	5.08

- Mobile phone use leads to statistically significant reduction of traffic speeds
  - Total average speed, Vt: ↓ 15,6% ± 0,1%
  - Free flow average speed, Vf: ↓ 14,3% ± 0,6%
  - Interrupted flow average speed, Vd: ↓ 16,4% ± 1,0%

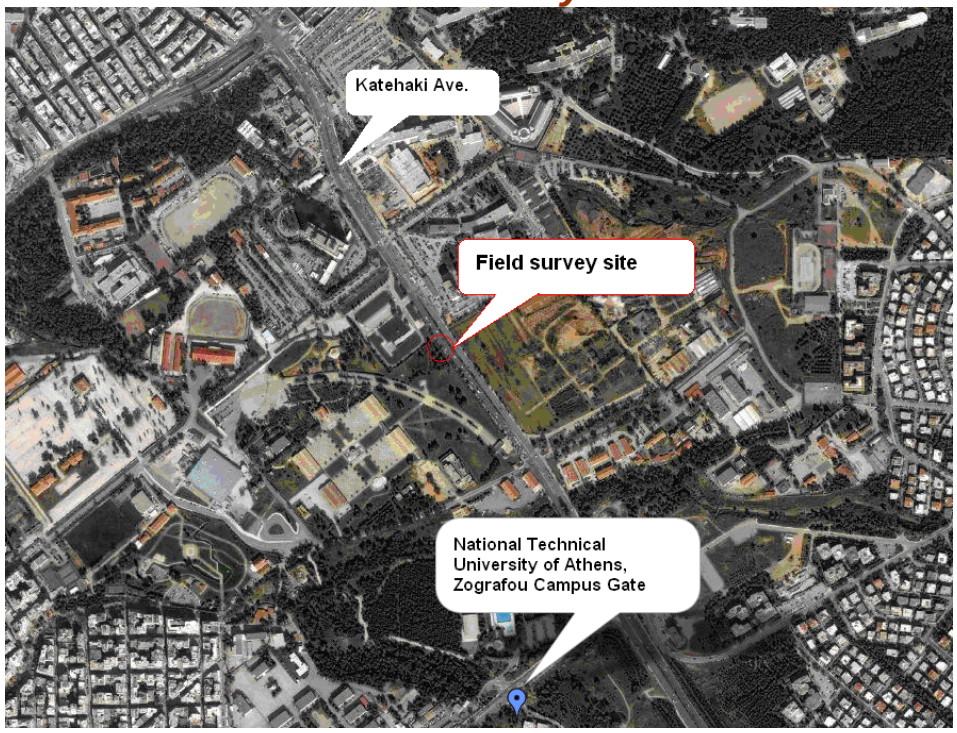
- Experienced drivers (annual distance travelled exceeds 10,000 per year) drive faster while talking on mobile phone.

Mobile phone use, driver speed and headways

Roadside observations, NTUA, 2008

- Impact of mobile phone use on vehicle traffic speed and headways.
- Field survey in real traffic conditions, Katehaki ave., in which 3.048 vehicles were captured by means of a video camera and a speed gun.

Field survey site



- 2 linear regression model models were developed for vehicle speed and headspace.

Mobile phone use, driver speed and headways

Best fitting models for vehicle speeds and headspaces

Variable	Vehicle Speed (V)			Headspace (Hs)		
	β	e	e*	β	E	e*
Taxi	0.692	0.00154	1.13	-	-	-
Gender	-0.688	0.00318	2.34	-	-	-
Age 18-25	0.441	0.00228	1.68	-	-	-
Age 25-55	-	-	-	7.299	0.14733	1.63
Age >55	-1.503	0.00297	2.18	-	-	-
Cell phone use	-0.726	0.00136	1.00	-28.824	0.09023	1.00
dSpeed / dHeadways	-	-	-	7.134	0.87752	9.73
dHeadways	-	-	-	7.174	128.655	14.26

The use of mobile phone is a significant additional determinant of vehicle speeds and headspaces, although other driver and traffic characteristics are the main determinants.

Moreover mobile phone use:

- brings a slight decrease of vehicle speed
- leads to a reduction of vehicle headspaces

Mobile phone use, driver speed and accident probability

Driving Simulator Experiment, NTUA, 2010

- Investigation of the interrelation between mobile phone use, driver speed and accident probability.

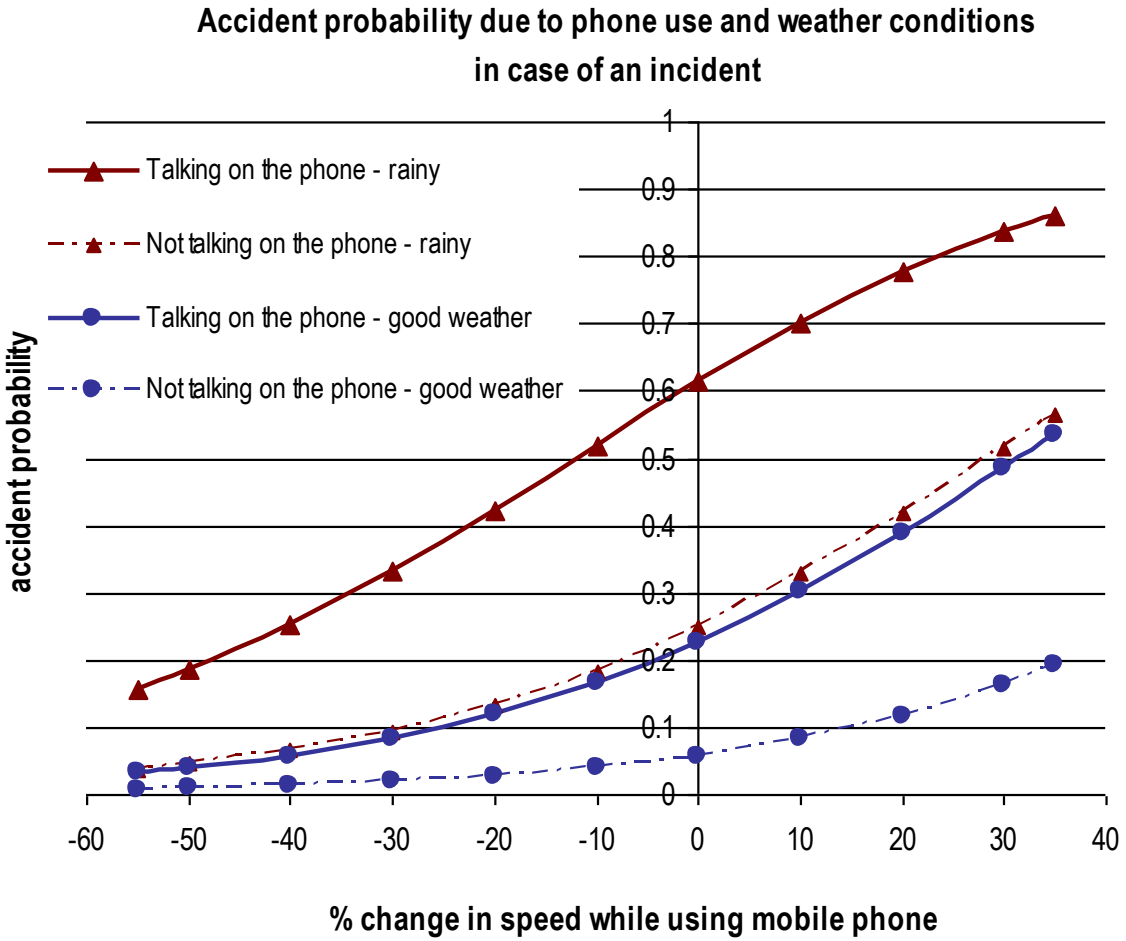
- The research focuses on the behaviour of 30 young drivers aged between 18 and 30 years old.

- A driving simulator experiment took place, in which participants drove in:
  - ✓ different driving scenarios
  - ✓ urban / interurban areas
  - ✓ good / rainy weather conditions
  - ✓ with / without the occurrence of an incident

- 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.

Mobile phone use, driver speed and accident probability

Driving Simulator Experiment, NTUA, 2010



Mobile phone use leads to:

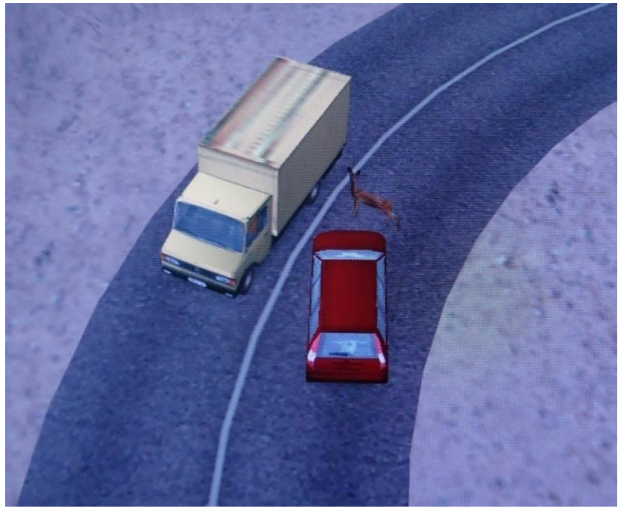
- Significant decrease of mean speed in urban and interurban environment
- Increase of accident probability

Mobile phone – Simple vs. complex conversation

Driving Simulator Experiment, NTUA, 2010

Participants: 48 drivers aged between 19 and 27 years, out of which 29 were males and 19 were females.
The experiment included 3 simulated drives in a rural road environment during good weather conditions.

- Simple mobile phone conversation: basic questions on driver's characteristics (age, name, job, hobbies, news etc.)
- Complex mobile phone conversation: questions requiring some concentration, as well as some logical and mathematical reasoning
- Listening to music



Simple and complex mobile phone conversations were associated with reduced speeds.

Listening to music was associated with increased speeds

Only complex mobile phone conversation was associated with reduced reaction times and increased accident risk at unexpected incidents.

Driver Distraction factors - Summary

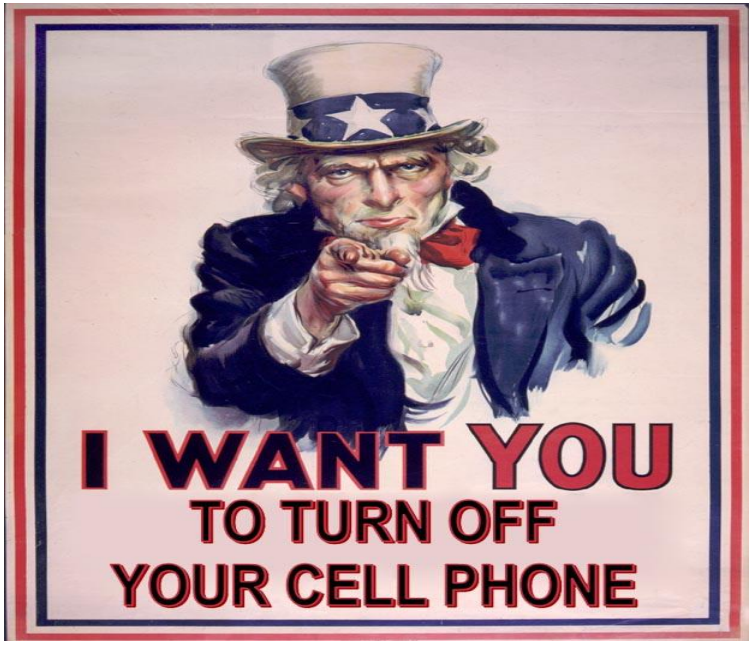
- The distraction caused by interacting with in-vehicle devices while driving seems to impair drivers on the road more than external distractions.
- Mobile phone use (handheld or hands-free) and complex conversation (at mobile phone or with passengers) appear to be the most critical in-vehicle distraction factors.
- The complexity of the secondary task being performed and of the driving environment, as well as driver characteristics (age and driving experience) can all influence the potential for non-driving tasks to distract drivers.
- Distraction factors may affect driver behaviour (speed, lateral position, headways) and safety (reaction time, accident probability).
- Compensatory strategies may fail, especially when unexpected incidents occur.

Measures against driver distraction - Driver

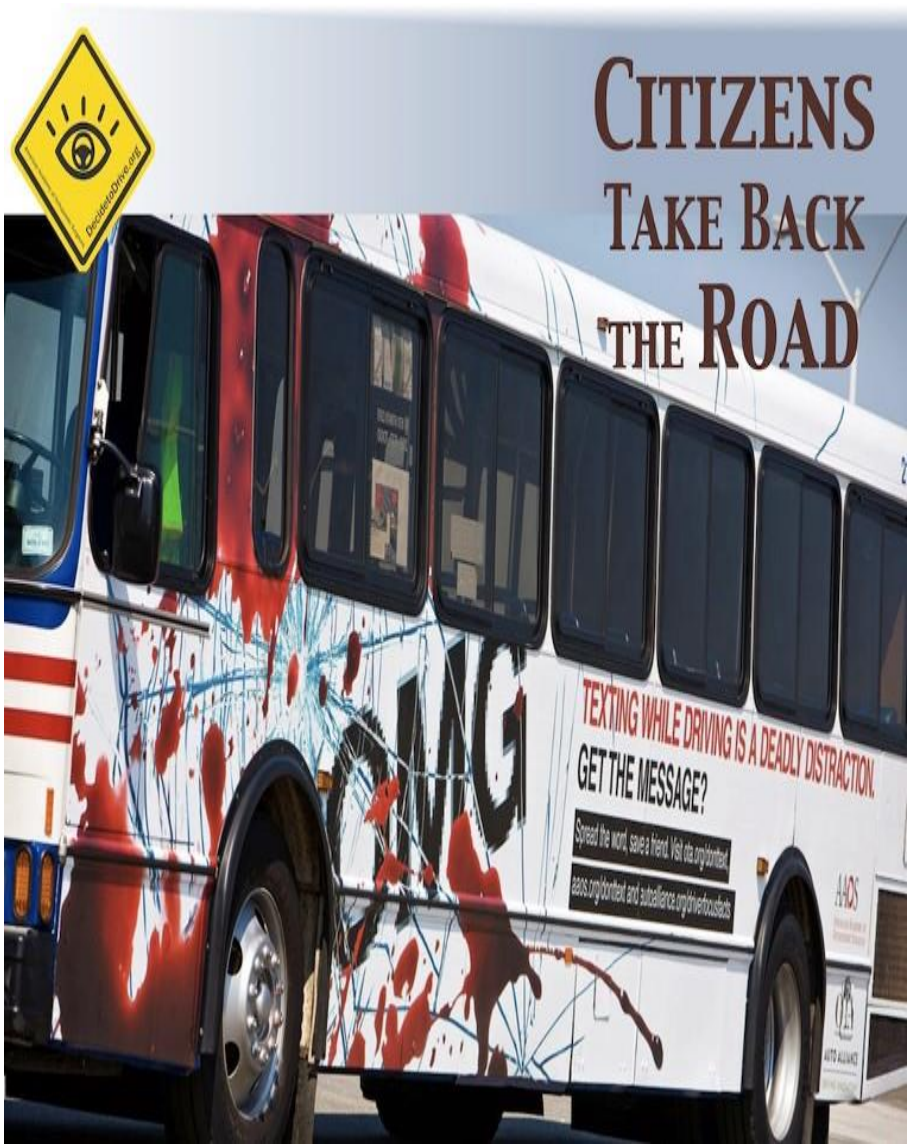
- Enforcement of traffic rules
  - not use of mobile phones
  - position and characteristics of signs

- Driver awareness campaigns
  - risk associated to mobile phone use
  - risk associated to driver distraction in general

- Driver training and education
  - traffic education at school
  - for novice drivers
  - for all drivers
  - re-integration courses of frequent offenders



Measures against driver distraction - Driver



Measures against driver distraction - Legislation

IGES Institut, ITS Leeds, ETSC (2010)

Mobile Phone Use

Country		AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	UK	CH	IS
Legislation requires	Complete ban																													
	use of hands free equipment	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X
Hand-held phone is prohibited if	engine is running		X				X	X			X			X	X		X											X		X
	vehicle is moving	X		X	X	X			X	X		X	X			X		X	X	X	X	X	X	X		X	X		X	
Requirement to use	headset/Blue tooth	X	X	X	X	X	X	X	X			X	X	X	X		X		X		X	X	X	X			X	X	X	X
	additionally fixed phone									X						X		X		X						X				
Hands-free required when using	phone function	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X
	other function		X	X		X	X	X		X		X	X			X	X				X	X	X			X	X	X	X	
Forbidden to use	texting function				X		X			X			X			X		X	X					X			X			X	
	all functions that involve continous handling											X					X	X						X			X				
	head phones										X																				
Requirements concerning	location of mounting																													
	way of fixing									X							X													

Measures against driver distraction - Technology

- Steering mounted buttons systems to input information;
- Systems which rely on voice activation for input.
- Tactile marks on the phone key pad buttons to give each button a distinct feel, reducing the need for drivers to look away from the road;

- Negative impacts on safety of voice-activated systems have been identified, and the potential safety impact of other systems are unknown.
  (Jeanne Breen, 2009)

- Blocking phone calls while driving is a rapidly developing technology, but currently not supported by all phone types.

Measures against driver distraction - Roadway

There are no roadway countermeasures directed specifically at distracted drivers.

Many effective roadway design and operation practices that improve traffic safety in general, such as edge line and centreline rumble strips, can warn distracted drivers or can mitigate the consequences of distracted driving.

- Creation of less demanding traffic conditions
  - interventions on infrastructure
  - interventions on traffic management

Future research - Open Issues

- identify functions behind distraction activities
- focus on mobile phones use
- separate impact from the various distraction factors
- examine the combined effect of all distraction factors
- **link distraction-associated driver behaviour with accident risk**
- cross validation through experiments (driving simulator, naturalistic driving) and epidemiological studies
- ergonomic design of devices to minimise distraction
- develop universally agreed definition of driver distraction

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