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REVIEW OF DISTRACTED DRIVING FACTORS

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ABSTRACT

The purpose of this paper is to provide a comprehensive picture of the impact of driver distraction to road safety. Both internal and external distraction factors are considered, whereas particular focus is put on mobile phone use (internal) and advertising signs (external) related distraction. An exhaustive review of the literature on driver distraction definitions, impacts and accident mechanisms, as well as distraction factors was carried out, concerning both in-vehicle and external factors, as well as road, traffic and individual factors. In-vehicle distraction factors include mobile phone use, navigation / entertainment systems, conversation with passengers, eating or drinking, smoking etc. External distraction factors include advertising signs and labels, traffic signs, landscape, destination or address search, other vehicles, pedestrians or incidents etc. Driver distraction may have an impact to driver attention (hands-off the wheel, eyes-off the road), driver behaviour (vehicle speed, headway, lateral position, driver reaction time) and driver accident risk. As regards the mechanism of distracted driving accident risk, the decrease in speed and the increase in the distance from the central axis, that are observed during distracted driving, might be considered beneficial for road safety. However, they cannot always counter-balance the increased reaction times, which eventually lead to increased accident probability, especially at unexpected incidents. Research results suggest that mobile phone use may be the most important in-vehicle distraction source for drivers. Drivers using their mobile phone while driving present up to 4 times higher accident risk. Measures against driver distraction may include enforcement of traffic rules, driver awareness campaigns, and driver training and education, especially for high-risk groups (e.g. novice drivers, frequent offenders etc.). Technology improvements towards more ergonomic design of in-vehicle devices are rapidly progressing; however the related safety effects are to be validated.

Keywords: Road Safety, Distraction, Inattention, Mobile phone, Advertising signs

INTRODUCTION

Driver distraction constitutes an important factor of increased risk of road accident internationally. The level at which drivers' distraction affects the traffic circulation and the road safety has received increasing emphasis in the international literature. 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., 2011; Johnson et al., 2004; Lesch & Hancock, 2004; Strayer et al., 2003; Neyens & Boyle 2008; Bellinger et al. 2009), 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, 2006; 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.

The purpose of this paper is to provide a comprehensive picture of the impact of driver distraction to road safety. Both internal and external distraction factors are considered, whereas particular focus is put on mobile phone use (in-vehicle) and advertising signs (external) related distraction.

DRIVER DISTRACTION DEFINITION

Driver distraction and driver inattention are two separate yet related aspects of impaired driving; however, they are inconsistently defined in the literature, and the relationship between them is unclear.

Driver inattention can be defined as “insufficient, or no attention, to activities critical for safe driving”. On the other hand, driver distraction can be defined as a “diverted attention” state, i.e. as “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" (Regan, 2008).

Consequently, driver distraction can be distinguished from driver inattention on the basis of the presence or not of a secondary task or a competing activity. In this sense, driver distraction is just one form of attentional failure that can result in inattention.

DISTRACTION ACCIDENT RISK MECHANISM

Driver distraction may have an impact to driver attention (i.e. hands-off the wheel, eyes-off the road), driver behaviour (i.e. vehicle speed, headway, vehicle lateral position, driver reaction time) and driver accident risk.

The key elements affecting the distracted driving accident risk mechanism are the following:

- 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?

More specifically, a decrease in speed and an increase in the distance from the central axis of the road are often observed during distracted driving, and these might be considered beneficial for road safety. However, they cannot always counter-balance the driver's distraction, which leads to increased reaction times, and eventually increased accident probability, especially at unexpected incidents. This complex distracted driving accident risk mechanism is illustrated in Figure 1.

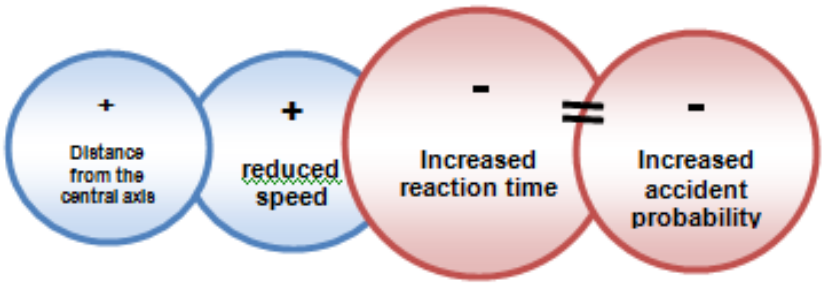

Figure 1 – Distracted driving mechanism

DRIVER DISTRACTION FACTORS

Human factors in total are the basic causes in 65-95% of road accidents (Sabey & Taylor, 1980; Salmon et al., 2011). Driver impairment or distraction factors account totally for 12% of

all road accident contributory factors, while in-vehicle distraction factors account for 2/3 of the total distraction factors (Department for Transport, 2008)

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 1 (Regan et al., 2005).

Table I - 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

Driver 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).

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 2 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 II – 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 3 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 III - 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.

In vehicle distraction

The in-vehicle sources of distraction include the use of mobile phone or navigation / recreation system, the conversation with another passenger, smoking, eating or drinking etc. (Johnson et al., 2004; Stutts et al. 2005; Neyens & Boyle 2008), and their effects are largely examined by means of simulator experiments (Horberry et al. 2006; Bellinger et al. 2009) or naturalistic driving experiments.

Mobile phone use (handheld or hands-free, texting)

As shown in Table I, the highest perceived risk ratings are associated with the use of mobile phones (Patel et al. 2008).Other research results, as well, suggest that mobile phone use may be the most important in-vehicle distraction source for drivers. Although drivers tend to reduce their speed during a mobile phone conversation and 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 (MacEvoy et al, 2005).

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 et al., 2003). Furthermore, Strayer et al. (2003) revealed that when drivers were engaged in a phone conversation using either a hand-held or hands-free phone, they demonstrated similar driving deficits, while Mazzae et al. (2004) suggest drivers tend to overestimate the ease of using hands-free phones while driving.

Another important risk factor concerning the use of mobile phone while driving is texting. An important distinction should be made: 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. 2006). 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. 2008). A recent naturalistic driving experiment suggests that the effects of texting may be significantly underestimated in previous (simulator) experiments (Cooper et al. 2011)

Mobile phone use has been found to interact with several other risk 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).

Other issues affecting the effect of mobile phone use on driver behaviour and safety include the type of conversation and the experience in using mobile phone while driving. 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; Patten et al. 2004). In naturalistic conversation experiments, however, the differences between simple and complex conversation were less striking than in simulator experiments (Rakauskas et al., 2004). Moreover, 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).

In-vehicle driver assistance systems and entertainment systems

In-vehicle route-guidance, navigation systems (e.g., GPS) or other ADAS are designed to assist drivers, but have the potential to distract drivers in several ways. Entering the destination into the navigation system is considered the most distracting component of using in-vehicle navigation systems (Young et al. 2003) while voice activated systems are not proved to be safer in terms of distraction, as they result in increased eye-glances.

Few studies have specifically studied the distracting effects of operating vehicle radios or other entertainment systems. Turning on or simply listening to the radio while driving can distract a driver and degrade driving performance. Research has also suggested that operating a CD player while driving may be equally distracting to dialling a mobile phone.

On the other hand, the effect of other in-vehicle distraction factors has been found to be non negligible. Stutts et al. (2003) report that the frequency of driver distraction from conversation with the passengers is almost equal to the frequency of distraction by the use of mobile phone. Moreover, the results of the 100-car naturalistic driving study revealed that a driver-passenger interaction was observed in 20% of accident, near-misses and incidents recorded (Neale et al., 2005) while Yannis et al. (2011) report that a more demanding conversation is associated with increased accident risk.

Eating, drinking or smoking

Haigney & Westerman (2000) suggest that, while mobile phone use and conversation are mainly distractions induced from additional mental workload, eating or drinking are “manual”

activities that necessarily involve some additional motor workload; consequently, they are expected to significantly affect driving performance.

Around half of all drivers in the USA admit that they are systematically eat or drink while driving at around one third of their trips (NHTSA, 2003). Glaze & Ellis (2003) report that 4.2% of distraction related accidents in the US are due to eating or drinking, whereas respective related results from New Zealand range at around 3% (Gordon, 2005). Stutts et al. (2005) found that eating and drinking increased the hands-off-the-wheel time while driving and contributed to a difficulty in keeping vehicle position on the roadway axis. Their results further suggest that eating and drinking related accidents are almost equal to mobile phone use accidents. On the other hand, simulator experiments (Jenness et al. 2002; Young et al. 2008) have shown little effect of eating or drinking on driver behavior and safety.

Moreover, some studies report a relationship between driver smoking and distraction or accident occurrence. Stutts et al. (2001) report that, on the basis of the CDS - Crashworthiness Data System, around 1% of accidents are due to driver smoking. The 100-car naturalistic driving study associated 2% of distraction or inattention related accidents with smoking (Neale et al. 2005). Gordon (2005) reports that 2.2% of accidents in New Zealand are due to smoking-related distraction. Furthermore, about half of these accidents took place while reaching out for a cigarette, another one fourth while lighting a cigarette and another one fourth while searching for a dropped cigarette (Road Safety Committee, 2006). On the other hand Yannis et al. (2011) found no effect of smoking on accident probability.

External distraction

External (i.e. out-of-vehicle) distractions are a growing cause of concern. A recent study conducted in the United States which examined crash records from the Crashworthiness data system reported external distractions to be a contributing factor in 29.4% of all crashes that were reported between the years 1995 to 1999 (Stutts J. K., 2005; Stutts J. C., 2001). With increasing numbers of cars and pedestrians and the proliferation of shops, vendors, and signs, the driving environment is getting more and more complex. With increasing complexity in the driving environment there is greater potential for external driver distraction. Given this, it is important to know the effects of external distractions on the drivers' ability to drive safely in their presence.

Recent research found younger and experienced drivers to be similarly distracted by external tasks (Milloy and Caird, 2012; Chan, 2010). Specifically, drivers of both age groups were found to be taking equally long glances away from the roadway while performing external tasks 10, 2008) as compared to in-vehicle tasks. Although no measure of the effect of the long glances on drivers' performance was gathered in the Chan (2010) research, the proportion of especially long glances away from the forward roadway on the external distraction was twice what it was inside the vehicle. However, measures of the effect of external distractions were gathered in Miloy and Caird (2012). Specifically, they established that external distractions like billboards and windmills have a negative impact on the drivers' ability to maintain their speed, lane position, following distance and reaction times to sudden

events in a driving simulator. In fact, reaction times are slowed to sudden braking events of a lead vehicle to such an extent that there are actually more crashes when drivers are passing billboards or windmills (external distractions) than when they are in the middle of a control section of highway (one where there are no obvious external distractions) (Milloy and Caird, 2012).

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).

Crundall et al. (2006) found increased influence of advertising signs on the probability of accident, when the sign is placed at the exit of a curve of the road or when it prevents the visibility of drivers in points that can constitute danger, e.g. in corners or turns. At the same time, it is indicated that advertising signs that are placed at the roadway level (e.g. on buses) attract more the attention of drivers. However, this is the only research that examines the influence of the location (i.e. height) of advertising signs on road accidents.

In a simulator experiment (Young, 2008), drivers drove roads with and without advertising signs, and an increased number of accidents, increased proportion of eyes-off-the-road time and inappropriate position on the lane were associated with the presence of advertising signs. In a similar simulator experiment, however, no significant change in driving behaviour or accident occurrence was found between driving on roads with and without advertising signs (Bendak et al., 2009). In this study, drivers also filled in a questionnaire on the perceived distraction from advertising signs, which was found to be higher for drivers >30 years old. Finally, Chattington et al. (2009) found increased duration of eye-glances and increased self-reported mental stress associated with electronic advertising signs.

In general, the accident risk of advertising signs is likely to vary depending on the type, the height, the content, the placement and more generally on the characteristics of the advertising sign. Specifically, the electronic signs, and more generally the signs with intense or reflective colours and movement, that differ a lot from the environment, attract more easily the attention of drivers. For this reason, the design of electronic signs should be similar to the design of conventional signs (Lee et al. 2007). Additionally, advertising signs that resemble traffic signs seem to confuse the driver (SWOV, 2006, Hagenzieker, 1994).

In general, no dedicated studies on other external distractions than advertising signs and billboards are available in the literature. In the 100-Car naturalistic driving study, looking at

external object and not looking at forward roadway were associated with increased odds of crashes / near crashes, as shown in Table IV.

Table IV - Odds ratio for external distraction in the 100-Car naturalistic driving study (Source: NHTSA, 2008)

Type of Secondary Task	Odds Ratio*
Looking at external object	**3.8**
Dialling hand-held phone	**2.8**
Inserting/retrieving CD	2.3
Eating	1.6
Talking/listening on phone	1.3
Talking with passenger, front seat	**0.5**
Cumulative eyes off forward roadway>2 sec in 5 sec prior and 1 sec after event	**2.37**

Note: Only factors in bold are statistically significant

MEASURES AGAINST DRIVER DISTRACTION

Nowadays, the use of a cell phone and the portable nomadic devices while driving are prohibited by road traffic regulations in most European countries (ETSC, 2010), however there are several differences in the related legislations in different countries (see Tables 5 & 6).

Table V – Legislation concerning mobile phone use in Europe (IGES Institut, ITS Leeds, ETSC (2010))

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													

Table VI – Legislation concerning Portable Nomadic Devices in Europe (IGES Institut, ITS Leeds, ETSC (2010))

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
Legislation requires	complete ban																											
	user restriction				x	x	x	x		x	x	x	x			x		x		x	x		x			x	x	x
Manual interaction prohibited if	engine is running																											
	vehicle is moving									x	x	x	x			x							x			x	x	
Prohibited to use	media player function												x			x												x
	other functions						x			x	x																	
Requirements concerning	location of mounting				x	x	x	x			x	x	x			x		x		x	x						x	
	way of fixing						x			x		x						x										

A number of measures against driver distraction have been proposed, mostly aiming to the driver. First, through enforcement of traffic rules on the use of mobile phones, as well as enforcement of the rules concerning the position and characteristics of advertising signs. Second, driver awareness campaigns aim to inform drivers about the risk associated to mobile phone use, and the risk associated to driver distraction in general. Third, driver training and education, with particular emphasis on distracted driving, through traffic education at school, for novice drivers, for frequent offenders etc.

Technology improvements are also aiming to reduce the driver distraction from in-vehicle devices. Steering mounted buttons systems to input information, systems which rely on voice activation for input, and tactile marks on the phone key pad buttons to give each button a distinct feel, may reduce the need for drivers to look away from the road. However, negative impacts on safety of voice-activated systems have been identified, and the potential safety impact of other systems are unknown (Jeanne Breen, 2009). Moreover, blocking phone calls while driving is a rapidly developing technology, but currently not supported by all phone types.

In general, more ergonomic design of the human-machine interface of in-car information systems is required to allow safe use. The current trend of miniaturisation of mobile phones may lead to safety problems.

There are no roadway countermeasures directed specifically at distracted drivers. However, 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. In general, the creation of less demanding road and traffic conditions, through interventions on infrastructure and traffic management are expected to have a positive impact on the frequency and severity of distracted driving accidents.

DISCUSSION

The purpose of this paper is to provide a comprehensive picture of the impact of driver distraction to road safety. Both internal and external distraction factors are considered, whereas particular focus is put on mobile phone use (internal) and advertising signs (external) related distraction. Moreover, the measures against driver distraction are briefly discussed.

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. Drivers using their mobile phone while driving present up to 4 times higher accident risk. Regarding external distraction sources, advertising signs are associated with increased driver distraction but not with accident risk, with the exception of certain specific conditions (e.g. blinking, videos, similar to road signs).

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.
Driver distraction may have an impact to driver attention (hands-off the wheel, eyes-off the road), driver behaviour (vehicle speed, headway, lateral position, driver reaction time) and driver accident risk. Compensatory strategies may fail, especially when unexpected incidents occur. More specifically, the mechanism of distracted driving accident risk is such that, the decrease in speed and the increase in the distance from the central axis, that might be considered beneficial for road safety, cannot always counter-balance the increased reaction times, which eventually lead to increased accident probability, especially at unexpected incidents.

Measures against driver distraction may include enforcement of traffic rules, driver awareness campaigns, and driver training and education, especially for high-risk groups (e.g. novice drivers, frequent offenders etc.). Technology improvements towards more ergonomic design of in-vehicle devices are rapidly progressing; however the related safety effects are to be validated.

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.

Research on remedial measures should concern separately visual, auditory, manual and cognitive distraction. Legislation for compulsory improved human-machine interfaces at both the vehicle and the mobile phone industries should not be delayed. Nevertheless, a particular challenge for the reduction of distraction related accidents is the training of drivers in distracted driving conditions. Distraction may be considered as a typical part of everyday driving, and drivers should learn to manage distraction, by avoiding risky behaviour (texting, handheld phones, distraction overload), interrupt the discussion when there is driving overload (either discussion with passengers or through mobile phone), stop the vehicle if it is necessary to continue the discussion, and learn to use hands-free devices.

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