European Commission

Thematic Report

Driver Distraction



Mobility and Transport

This document is part of a series of 20 thematic reports on road safety. The purpose is to give road safety practitioners and the general public an overview of the most important research questions and results on the topic in question. The level of detail is intermediate, with more detailed papers or reports suggested for further reading. Each report has a 1-page summary.

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Summary

Driver distraction is a significant risk factor in traffic. Distraction occurs when attention is diverted away from activities needed for safe driving towards a competing activity. Distraction can be visual, auditory, physical and/or cognitive in nature. Common sources are: interaction with passengers, mobile phone/device use, eating, or adjusting in-vehicle systems. Research in the US indicates that car drivers are involved in distracting activities for about half of driving time. The mobile phone is one of the most common sources of driver distraction. The self-declared prevalence of mobile phone use while driving a car in 20 European countries is 48% for the use of hands-free devices, 29% for handheld mobile phone conversations, and 24% for text reading/checking social media. While the latter two activities are illegal, hands-free phoning is generally not. Recent observations of drivers in 15 European countries found that the percentage of drivers using a handheld mobile device varied among countries and ranged from 1.7% to 9.5%. The use of mobile phones while driving is relatively high among younger drivers and relatively low among elderly drivers.

Distraction has negative effects on driving performance. Distracted drivers generally tend to swerve more, have longer reaction times, and more often miss information from the traffic environment. The risks associated with driver distraction depend on the type of distracting activity. Research indicates that activities during which drivers avert their gaze from the road – such as visual-manual tasks including dialling or texting - are riskier than primarily cognitive activities – such as having a phone conversation.

Road-user focused countermeasures include the enforcement of the legal bans on the use of handheld phones (and electronic devices), e.g., with smart cameras, and raising awareness of the risks of distraction in public campaigns and through driver education during licensing.

New vehicle technologies to combat distracted driving are promising but the overall effects are still unknown. Advanced driving assistance systems (ADAS) such as forward collision warning and lane departure warning aim to prevent the consequences of distracted driving. The new EU Regulation makes an advanced driver distraction warning system mandatory for all new vehicles.

In terms of infrastructure, rumble strips can reduce the number of crashes caused by distraction or limit their severity. The placement of potentially highly distracting advertising panels along the side of the road should be avoided.

1. What is the problem?

1.1 Definition

Safe driving requires sufficient awareness of the surroundings, constant monitoring of the road and traffic, and sufficient alertness to be able to react to unexpected events (Kinnear & Stevens, 2018). A widely accepted definition of driver distraction is 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 et al., 2011). The nature of distraction can be visual (e.g., looking at an object outside the car), auditory (e.g., listening to loud music), physical/manual (e.g., dialling), and/or cognitive (e.g., having a conversation). Drivers can be distracted by various sources, for example by manipulating in-vehicle devices, texting, talking with a passenger, looking at a billboard, or eating. Most sources of distraction involve more than one type of distraction. Texting, for example, may cause cognitive, visual, and physical distraction while listening to music may involve cognitive and auditory distraction.

1.2 The impact of distraction on driving

When attention to the driving task becomes inadequate, (driving) performance decreases and, as a result, crashes can occur. The MiRA (Minimum Required Attention) model offers a broad theoretical framework for driver attention and describes the extent to which sufficient information can still be processed to ensure safe driving performance (see e.g., Kircher & Ahlstrom, 2017). According to this model, carrying out another activity will or will not have an impact on traffic safety, depending on the traffic situation. In a driving environment of a limited complexity, sufficient information may still be processed, whereas this will not necessarily be the case in a busy traffic situation (Kircher & Ahlstrom, 2017; Slootmans & Desmet, 2019). A traffic situation and the demands it poses on the driver can however change rapidly. Furthermore, the extent of the negative impact of distraction depends on the type or source of distraction. The timing, intensity, resumability, complexity, duration, frequency, and residual effects of the distracting activity also play a role, together with the traffic context, the type of road user, and personal characteristics such as age and driving experience (Kinnear & Stevens, 2018; SWOV, 2020).

2. How dangerous is driver distraction?

2.1 Proportion of distraction-related crashes

The exact number of road crashes caused by distracted drivers is unknown. Recent estimates of the proportion of distraction-related crashes are scarce. Austrian crash data indicate that distraction and inattention presumably accounted for 29% of injury crashes and 25% of fatal crashes in 2022 (Statisik Austria, 2023). American crash data from 2021 indicate that distraction played a role in 8% of fatal crashes, 14% of injury crashes, and 13% of all police-reported motor vehicle traffic crashes (NHTSA, 2023). Naturalistic driving research suggests, however, that the percentage of crashes related to distraction is higher. In the study of Dingus, 68.3% of 905 crashes (injurious and property damage crashes) involved some type of observable distraction (Dingus et al., 2016).

2.2 Crash risk

Large-scale naturalistic driving research provides the crash risk (odds ratio) of several types of distraction. Table 1 shows the estimated crash risk for different distraction activities based on two analyses of the US SHRP 2 naturalistic driving data (Dingus et al., 2016; 2019). The odds ratios shown in table 1 are calculated based on road crash events (905 in total) in which the participants were involved. An odds ratio above 1 means that an activity is riskier than alert, attentive and sober driving, while an odds ratio below 1 signifies a lower risk. The effect is multiplicative. Specifically, an odds ratio of 2 for “all distractions together” in the table means a 2-fold higher crash risk than alert, attentive and sober driving. The 95% CI (confidence interval) indicates 95% certainty that the odds ratio lies between the first number (1.8 x higher crash risk) and the second number (2.4 x higher crash risk). A percentage driving time of 12.2 for interacting with passengers means that the drivers in the dataset spent on average 12.2% of their driving time being involved in that activity.

The results presented in Table 1 indicate that manual actions with the mobile phone are especially detrimental to road safety. The most recent analysis of the data by Dingus et al., 2019 shows that performing visual-manual tasks, such as hand-held texting, browsing, or dialling increases the crash risk by about 2.5 times. The earlier analysis by Dingus et al., 2016 found a 12-fold increase in crash risk for dialling and a 6-fold increase for texting. A crucial factor is the increased time spent looking away from the road (Klauer et al., 2006).

Table 1. *Crash risk based on naturalistic driving research data (95% confidence interval) and % driving time spent on the activity.*

Activity	Odds ratio (95% CI)	% driving time
Grouped activities		
All activities*[1]	**2.0** (1.8-2.4)	51.9
All primarily cognitive activities[2]	**1.25** (1.01-1.54)	20.0
All hand-held phone activities*[3]	**3.6** (2.9-4.5)	6.40
Visual-manual tasks: hand-held texting, browsing, or dialling	**2.56** (1.68-3.88)	1.8
All activities related to in-vehicle devices*	**2.5** (1.8-3.4)	3.53
Primarily cognitive activities		
Hand-held phoning (talking/listening)	1.27 (0.79-2.04)	2.7
Hands-free phoning (talking/listening)	0.4 (0.10-1.63)	0.9
Talking/singing alone	1.44 (0.99-2.08)	4.2
Interacting with passengers	1.26 (0.98-1.62)	12.2
Activities with in-vehicle devices		
Adjusting radio	1.57 (0.85-2.91)	1.3
Controlling temperature/air conditioning*	**2.3** (1.1-5.0)	0.56
Interacting with vehicle device (other)*	**4.6** (2.9-7.4)	0.83
Mobile phone activities		
Purely holding a phone in the hand	**2.05** (1.13-3.73)	1.1
Reaching for phone*	**4.8** (2.7-8.4)	0.58
Dialling (handheld)*	**12.2** (5.6-26.4)	0.14
Reading/writing text messages (texting)*	**6.1** (4.5-8.2)	1.91
Browsing (e.g., read email, check internet)*	**2.7** (1.5-5.1)	0.73
Other activities		
Reading/writing (also tablet)*	**9.9** (3.6-26.9)	0.09
Reaching for an object (no phone)*	**9.1** (6.5-12.6)	1.08
Prolonged looking at external object*	**7.1** (4.8-10.4)	0.93
Eating*	**1.8** (1.1-2.9)	1.90
Drinking (no alcohol)*	1.8 (1.0-3.3)	1.22
Personal hygiene (e.g., make-up)*	1.4 (0.8-2.5)	1.69
Child in rear seat*	0.5 (0.1-1.9)	0.80

Notes: Odds ratios significantly different from 1 are in ***bold*** *($p \leq 0.05$) (Dingus et al., 2019 and *2016)*

Consequently, the US Department of Transportation states that tasks that involve looking away from the roadway for more than 2 seconds

1. All activities with * + hand-held talking* (OR 2.2; 1.6-3.1) and in-vehicle radio* (OR 1.9; 1.2-3.0) (Dingus et al., 2016).
2. All activities under the subtitle "primarily cognitive activities" (Dingus et al., 2019).
3. All activities with * under the subtitle "mobile phone activities" + hand-held talking (OR 2.2; 1.6-3.1) (Dingus et al., 2016).

at a time, or briefly several times with a total duration of 12 seconds, should not be allowed while driving (NHTSA, 2016).

Purely cognitive tasks, such as holding a hands-free conversation or talking to a passenger, have a low risk (no significant increase in crash risk) based on this analysis. The combination of all mainly cognitive tasks does lead to a significant but limited crash risk increase (odds ratio of 1.25). Interestingly, the low crash risk found in naturalistic driving research for holding a phone conversation is not in line with the results of driving simulator studies. Many of these studies show that have a phone conversation does impair driving behaviour (see section 3.1).

3. What is the impact of distraction?

To measure the impact of distraction on driving performance (e.g., variation in speed, lane position, following distance, total eyes-off-road time, objective and subjective cognitive load), driving simulator experiments or on-road studies are often used. Another method is naturalistic driving research used to observe everyday driving behaviour without experimental control. To do so, drivers and the external conditions are monitored and recorded by means of unobtrusive equipment installed in their cars. This method provides insight into how drivers cope with distraction in real-life conditions and has the general advantage that self-regulatory strategies in dealing with distraction can be identified (i.e., drivers can decide for themselves whether and when to engage in distracting activities).

3.1 Having a phone call

Handheld phone calls involve various actions (such as contact search, dialling, call answering, holding a conversation). These can cause cognitive, auditory, physical and/or visual distraction. There is scientific consensus that handheld phoning has a negative impact on driver behaviour (Caird et al., 2018; Dingus et al., 2016; Simmons et al., 2016; Ziakopoulos et al., 2016a). This includes more time spent looking away from the road, higher reaction and detection times, delayed braking, and a narrowing of the visual field. Especially the visual-manual actions increase crash risk significantly (e.g., dialling: 12x higher risk; see Table 1).

Hands-free telephoning requires less physical and visual actions, but the cognitive distraction is the same as in hand-held phoning (e.g., Strayer et al., 2013). Many studies find negative effects, such as significantly delayed reactions, less attention to traffic signs, other vehicles, and the speedometer (Caird et al., 2018; Desmet &

Diependaele, 2017). Sometimes, on the other hand, there are ambiguous or even positive effects (e.g., increased headway distance, reduction of potentially critical driving situations), though without sufficient verification (e.g., Metz et al., 2015 in: Ziakopoulos et al., 2018). It is therefore concluded that hands-free phoning is 'probably risky' (Ziakopoulos et al., 2018).

Naturalistic driving research found that the mainly cognitive component of phoning (conversing) does not lead to significantly increased crash risk (see Table 1) (Dingus et al., 2019). Thus, the negative effects found in experimental research are not always reflected in naturalistic driving research, where drivers' natural driving behaviour is observed. Experimental research often does not account for the fact that drivers in real-world can choose when they use their mobile phone, (Singh & Kathuria, 2021; Wijayaratna et al., 2019). It has been found that drivers adjust their driving behaviour to compensate for the negative effects of the phone use, for example, they drive more slowly, keep greater distance or decide to have a phone conversation in less demanding traffic context (e.g. more on motorways, at standstill) (Christoph et al., 2019; Oviedo-Trespalacios et al., 2018).

Having a phone conversation, however, does increase the crash risk for young drivers (Guo et al., 2016). Moreover, starting a hands-free conversation often still requires visual-manual actions (Fitch et al., 2013).

3.2 Interacting with mobile devices

Mobile phones are also often used to send messages, surf, navigate, etc. Manipulating mobile phone or other mobile technological devices leads to a high degree of visual-manual distraction. This has clear negative effects on driving performance: longer and more frequent glances from the road, slower reaction and detection times, speed reduction and more variation in lane position and following distance. Visual-manual distraction leads to significantly increased crash risk (see Table 1: e.g., texting: 6.1 x higher risk) (Caird et al., 2014; Dingus et al., 2016, 2019; Ziakopoulos et al., 2017). Manual operation of a phone in the hand or in a holder has - in terms of visual behaviour - the same negative effects on driving (Doumen et al., 2019). However. texting on a smartwatch while driving leads to more visual distraction than a smartphone (Brodeur et al., 2020).

3.3 Talking to passengers

Talking to passengers can have negative effects on road safety, such as slower reactions and increased injury severity (Consiglio et al., 2003; Donmez & Liu, 2015; in: Theofilatos et al., 2018). Naturalistic driving research found no increase in crash risk for interaction with passengers (see Table 1). However, the role of passenger age (teenagers and children) deserves special attention. Naturalistic driving research shows that young drivers (16-29 years old) often interact with passengers. For this age group interaction with passengers was found to increase the crash risk (Guo et al., 2016). Interestingly, the increase in crash risk during a conversation on the phone is greater. This may be because the passenger can see the traffic situation and can adjust the complexity and pace of the conversation accordingly (Gaspar et al., 2014).

3.4 Interacting with built-in systems

Experimental studies show that interaction with built-in infotainment technology can have moderate to strong adverse effects on workload, visual behaviour and driving performance. A naturalistic driving study found indications of self-regulation to cope with this task (e.g., longer system interactions when the vehicle is stationary) (Perez et al., 2015). Effects differ strongly though, according to the actual task (e.g., navigation set-up, music search), the interaction mode (e.g., buttons, touchscreen, voice control), and system (brand).

Older drivers in general, experience more adverse effects (Cooper et al., 2019) than the younger ones. Naturalistic driving research also shows that interaction with vehicle systems leads to significantly increased crash risk (x2.5, see Table 1) (Dingus et al., 2016).

Possible ways of reducing visual-manual distraction are the use of voice control and head-up displays (Vlakveld, 2018). However, these solutions have still some drawbacks, particularly in terms of cognitive distraction. To start with, although the negative effects of voice-controlled systems seem to be smaller than for operating an infotainment touch system, a voice-controlled system will take more time to complete a task (Strayer et al., 2017). Furthermore, research indicates that voice-based interactions can have negative effects on driving behaviour (Simmons et al., 2017): the cognitive load remains, and poorly executed voice systems can still give rise to negative effects on visual behaviour (e.g., long glances away from the road for confirmation/status checking) (Cooper et al., 2014). Finally, the negative effects of cognitive distraction can persist for a relatively long time after the interaction with a system (e.g., up to 20 seconds as found in Strayer et al., 2017).

To reduce or prevent distracted driving, infotainment systems in cars can make it impossible to perform certain tasks while driving (e.g., typing a destination into the navigation system) (Vlakveld, 2018).

3.5 Roadside advertising

Roadside advertising billboards can cause drivers to behave less safely. Possible effects include looking away from the road more often, slower reaction to sudden braking of the car in front and to road signs, shorter following distance, and less fixed lane position (Vlakveld & Helman, 2018). In particular, signs with moving images, emotional charge or in the central visual field are more difficult to ignore. The moment a sign switches to another advertisement is the most distracting. Naturalistic driving research shows that looking at an external object for a prolonged period (e.g., advertising billboards) strongly increases crash risk (x7.1) (see Table 1) (Dingus et al., 2016). However, studies specifically into the effect of billboards on crash risk show inconclusive results. From the two studies with a strong research design, one found an increased crash risks near static digital billboard (Gitelman et al., 2012) and the other not (Izadpanah et al., 2014).

3.6 Other distraction sources

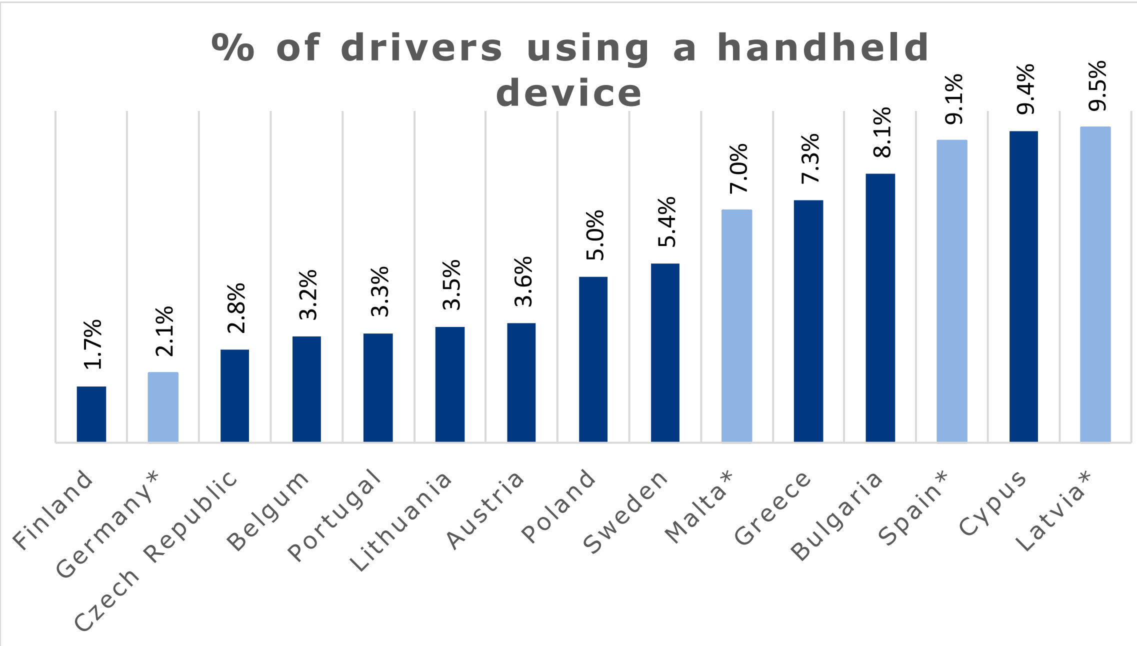
Eating and drinking while driving can also affect driving performance, leading to greater deviations in lane position and longer reaction times (Irwin et al., 2015). Naturalistic driving research indicates that eating is associated with a limited but significant increase in crash risk (odds ration of 1.8, see Table 1). Drinking does not appear to significantly increase risk (see Table 1). The effect of listening to music while driving is unclear as it can have both negative and positive effects (Ziakopoulos et al., 2016b). Naturalistic driving research shows that reaching for an object (no phone) is associated with a significant increase in crash risk (odds ratio of 9.1, see Table 1). Furthermore, observable emotions such as anger, sadness, crying, and emotional stress increase crash risk 9.8 times compared to alert/sober driving (Dingus et al., 2016).

4. What is the prevalence of distraction in traffic?

Large scale naturalistic driving research in the USA shows that car drivers are engaged in observable distraction activities for about half of driving time. Primarily cognitive activities take up 20% of driving time (Dingus et al., 2016; 2019, see Table 1: column 3). The top three comprise: interaction with passengers (12.2%), all hand-held phone activities (6.4%), and operation of vehicle systems (3.5%).

Another method used to estimate the presence of distraction in traffic is via direct observation of drivers and their engagement in secondary tasks, usually mobile phone related. The European Baseline project provides recent figures for the handheld mobile device use while driving in several European countries (Boets, 2023), see Figure 1.

Figure 1. *Percentage of drivers using handheld mobile device. (Boets, 2023)*



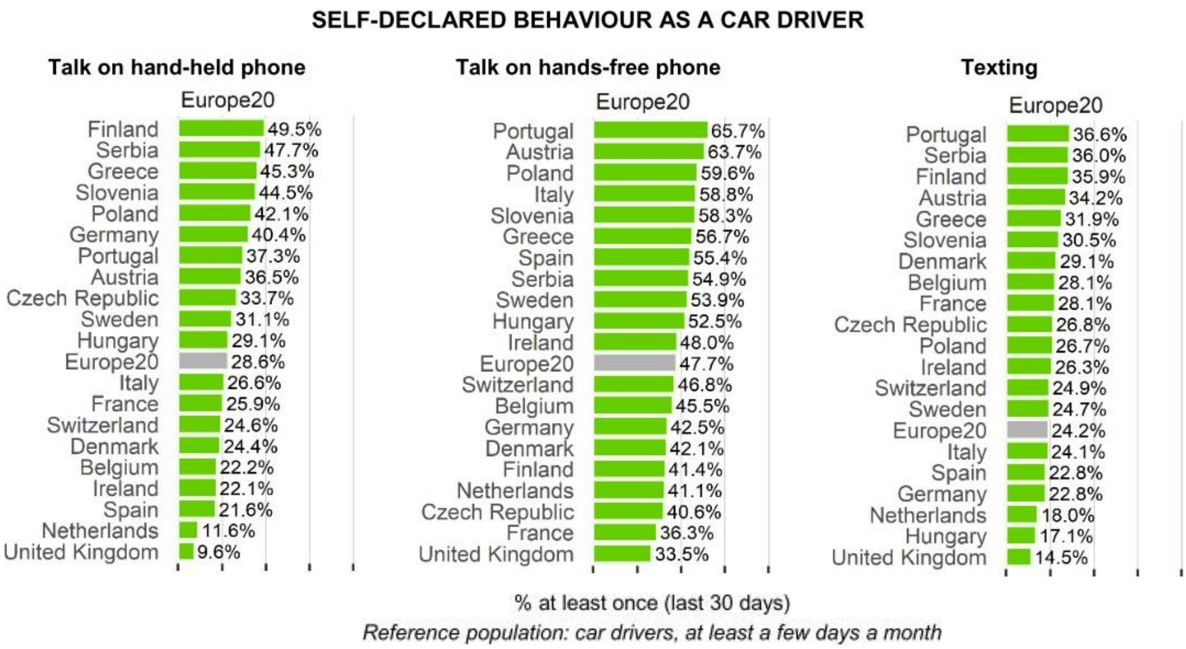
*Malta, Latvia: no motorways in road network. *Latvia: week + weekend days. *Germany: only passenger cars. * Spain: broader KPI: % having in the hand or operating with the hand a mobile phone or other electronic devices, whether mobile or on-board. * Spain: 4 road types with expressways. *Austria, Greece, Cyprus: % not using a handheld mobile phone. *Finland, Lithuania: analysis of camera images; other MS: roadside observations by trained observers.

The data in Baseline are generally collected according to common methodology and are aggregated for three vehicle types (passenger cars, light goods vehicles and buses/coaches), on three road types (urban roads, rural roads, motorways) and during weekdays. A few countries deviated to some extent from the common methodology:

these are indicated with the lighter colour and an asterisk in Figure 1. As can be seen, overall, less than 10% of the drivers use a handheld mobile device while driving; the percentages range between 1.7% in Finland and 9.5% in Latvia.

Finally, surveys can also provide information on how often drivers are distracted. Recent self-reported figures on distraction while driving in Europe come from the ESRA-project (E-Survey of Road users' Attitudes) (Pires et al., 2019), see Figure 2. On average 47.7% of European drivers reported talking on a hands-free mobile phone, 28.6% talking on hand-held mobile phone, and 24.2% reading text messages/checking social media (texting) at least once while driving in the past 30 days. Self-reported prevalence shows substantial variety among countries (see Figure 2). The percentages generally increase with lower age and decrease with higher age, especially for texting (18-24: 43% vs. 65+: 7.7%) and are higher for male than for female drivers (for texting 26.6% and 21.6% respectively).

Figure 2*. Self-reported mobile phone use while driving. (Pires et al., 2019)*

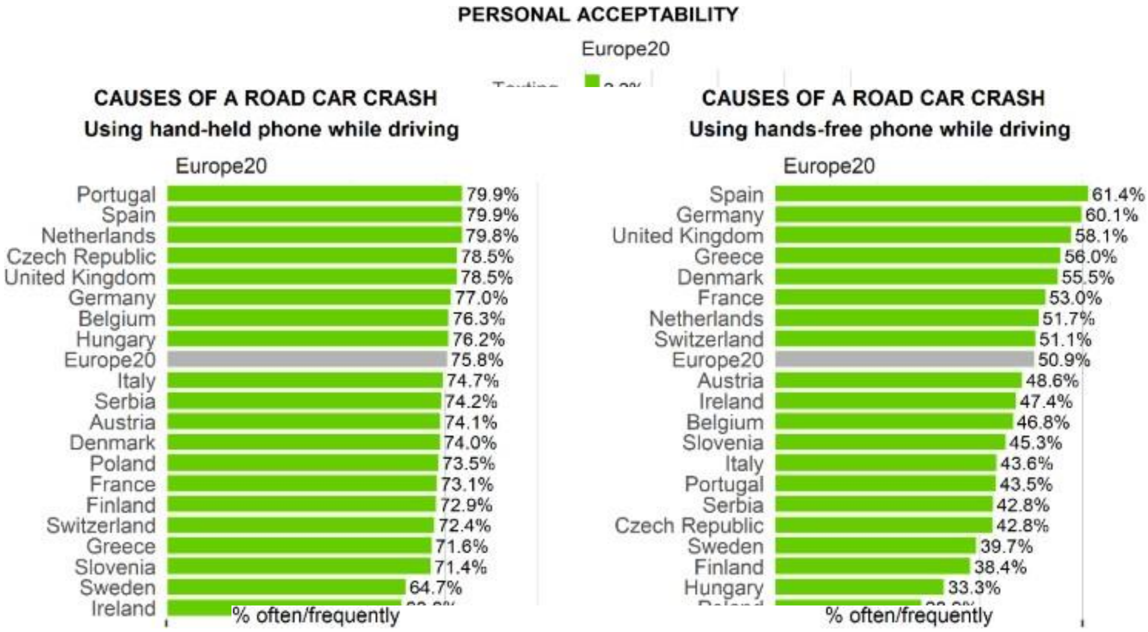


5. Why do road users drive while distracted?

Factors contributing to distracted driving, especially among young drivers, include risk-taking willingness, attitudes, social norms and influences (e.g., observed behaviour of parents and peers), and perceived behavioural control (e.g., confidence in own ability to engage) (e.g., Carter et al., 2014; Gauld et al., 2017). The international ESRA survey provides information on opinions concerning distracted driving, specifically the mobile phone use (Pires et al., 2019 - see Figure 3). The vast majority of road users in Europe seem to acknowledge the danger of hand-held phone use while driving. Only a small proportion of road users consider this acceptable (European mean: 2.2% for texting and 3.5% for hand-held phoning) and 65 - 80% consider using a hand-held phone while driving to (very) often be the cause of a road crash.

A higher percentage of respondents consider it personally acceptable to talk on a hands-free mobile phone (which is also a legal activity) and consider it less risky than hand-held phoning. Also, a recent Swiss survey (Achermann, Stürmer & Meier, 2023) showed that drivers may underestimate the dangers associated with using hands-free devices while driving: 73% of drivers in Switzerland stated that they used hands-free devices to make phone calls while driving and only 25% of drivers considered this practice to be dangerous.

Figure 3. *Driver opinions about distracted driving. (Pires et al., 2019)*



In general, the EU ESRA data show that women, in comparison to men, consider using the phone while driving riskier and less acceptable and they use it less often in traffic. Furthermore, with increasing age, risk perception increases, and acceptability and self-declared behaviours decrease (Pires et al., 2019). The factors that most increase the likelihood of talking on a hand-held mobile phone and texting while driving are personal acceptability and trust in being able to use the mobile phone while driving.

6. Which rules and legislation exist to combat distracted driving?

All European countries prohibit hand-held mobile phone use while driving a motor vehicle. In some countries, it is also prohibited for cyclists (e.g., Denmark, Germany, the Netherlands, and Austria) (Stelling-Kończak et al., 2020). In 2019, in the Netherlands, the original reference to mobile phones in the legislation was extended to a ban on holding "all mobile electronic devices that can be used for communication” (including mobile phone, tablet computer, media player) (Ministerie van Infrastructuur en Waterstaat, 2019). These devices may only be used if they are fixed in a holder. In some countries, the ban only applies to vehicles in movement (e.g., the Netherlands), in other countries it also applies to vehicles standing still in a traffic jam or in front of a red light (e.g., Belgium, Germany). Hands-free use of the mobile phone is generally permitted for drivers in Europe (European Union, 2023). In some countries there are some additional rules though (e.g., in France this is only allowed through a car kit, not via headphones/earbuds). In the US, many states ban all forms of phone interaction (including hands-free use) for school bus drivers and young drivers (Governors Highway Safety Association, 2021).

7. Countermeasures

7.1 Road user

Increasing enforcement and the subjective chance of being caught for hand-held mobile phone use while driving can stimulate reduction of this risky behaviour (Vlakveld, 2018). Almost 80% of European respondents in the ESRA survey agreed that traffic rules are not sufficiently monitored for phone use while driving (Pires et al., 2019). The use of smart cameras to conduct checks, as in Australia and the Netherlands, could lead to more and better enforcement of the ban on hand-held phone/device use (Stelling-Kończak et al., 2020).

A main aim of public campaigns is raising awareness about the dangers of distraction in traffic (Kaiser & Aigner-Breuss, 2017; Vlakveld, 2018). To increase impact, public campaigns should be conducted regularly, and accompanied with target group-specific messages. In the case of the prohibited distracting activities, public campaigns should be linked to increased enforcement (Delhomme et al., 2010). Special attention should be given to young drivers who generally use their phones more often than older drivers (see e.g., Kint, van der & Mons, C. (2021). Raising awareness should also be included in driver education and continuing training for professional drivers (European Commission, 2018). Drivers should also be aware that built-in information and entertainment systems can be a source of distraction. Harms et al. (2017) drew up specific guidelines for users of such systems. The impact of awareness-raising strategies can be limited, however. Research shows that many drivers use the mobile phone while driving even though they are aware of the risks (Pires et al., 2019).

General training programmes for combatting distraction and learning to deal with it as safely as possible can lead to behavioural change. However, there is a risk that drivers will perform more distracting tasks while driving because they feel able to do so after the training (Vlakveld, 2018). Encouraging companies to implement a safety policy on distracted driving can also contribute to road safety (Vlakveld, 2018). One study showed that drivers in trucking companies with a clear safety culture report less use of the phone while driving (Huang et al., 2013). Organisational safety culture was determined by the shared perception of the drivers of the safety climate. The authors concluded that "safety climate can be a strong indicator of safe driving behaviour and objective safety outcomes in the trucking industry." Drivers can also activate apps on their mobile phone which aim at reducing mobile phone use while driving, but these appear to be easy to circumvent (Vlakveld, 2018).

7.2 Road infrastructure

7.2.1 Reducing the prevalence of distracted driving

One countermeasure against distraction by roadside advertising is to avoid placing of billboards that are potentially highly distracting (mainly luminous, digital ones) along the road (Vlakveld, 2018). The European CEDR project ADVERTS (https://www.cedr-adverts.eu/) provides recommendations to road administrations for minimising distraction from roadside advertising (van Schagen et al., 2018; Weekley & Helman, 2019).

7.2.2 Mitigating consequences of distracted driving

To prevent running off the road due to distraction, longitudinal rumble strips can be implemented to warn drivers, with sound and vibration. Rumble strips are considered a cost-effective countermeasure with an estimated reduction of single vehicle crashes by 25%, with a 95% probability that the actual reduction is between 5 and 41% (Elvik et al., 2009).

7.3 Vehicles

Advanced Driver Assistance Systems (ADAS), which support the driver in performing primary driving tasks, can be used to prevent distraction of its consequences.

7.3.1 Types of systems and their effectiveness

ADAS can contribute to reduction in the number of distraction-related crashes, by warning about danger (e.g., lane departure warning, forward collision warning) or by intervening (e.g., lane keeping assist, advanced/autonomous emergency braking). Such systems assist in limiting the consequences of distracted driving by preventing running off the road or driving into a vehicle in front. Little crash data is available to allow the evaluation of the effectiveness of these systems (Vlakveld, 2019). Nevertheless, a recent analysis of US crash data did find that forward collision warning reduces the number of front-to-rear injury crashes by 20%. For this analysis, a comparison of the same type of vehicles with and without this system was made (IHHS/IIHS, 2019). The combination of forward collision warning and autonomous emergency braking seems to be highly effective (Vlakveld, 2019). With the new EU Regulation on motor vehicle type approval (European Commission, 2022) several safety features became mandatory for new passenger cars and light commercial vehicles/vans from 2022, including lane keeping assist and advanced emergency braking.

There are also automatic systems specifically developed to detect driver distraction. These systems infer distracted driving from observations of certain driver behaviours. For instance, for attentive drivers steering wheel control inputs tend to have small amplitudes and high frequencies. In contrast inattentive drivers show large amplitude and low frequency inputs, resembling major corrections necessary when a driver has veered off-course. Other methods infer distraction by monitoring gaze direction using camera systems, and issuing warnings when a driver does not monitor relevant parts of their visual field for longer than a certain threshold time-limit. There are also systems detecting mobile phone use (Vlakveld, 2019). An overview of systems can be found in MEDIATOR Deliverable 4.3 (Ahlström et al., 2023). Logging of issued warnings in a vehicle 'black box' to be retrieved in case of a crash, may have a deterrent effect on drivers by raising awareness of culpability.

Distraction monitoring systems are continuously evolving, and their accuracy, in particular, requires further improvement (Vlakveld, 2019). Also, the effect on crash involvement requires further investigation. An accurate system can increase road safety, especially if the driver tries to avoid the warnings. Based on the new EU General Safety Regulation on type approval requirements for motor vehicles, advanced driver distraction warning system will be mandatory from mid-2024 for new types of vehicles and from mid-2026 for all new vehicles (passenger cars and light commercial vehicles/vans) (European Commission, 2023).

7.3.2 Downsides of ADAS

Drawbacks of ADAS that inform and/or warn drivers are that they can distract the driver when continuous information about the broad driving context is given or when the human machine interface leads to increased workload (Bates et al., 2021). One study also showed that too many perceived unnecessary alerts of distraction can lead to a "cry wolf" effect, resulting in drivers ignoring the alarms (Cabrall et al., 2020). It is therefore recommended that prerequisites for HMI design are better followed and that accuracy of ADAS is further improved (Tsapi et al., 2020). In the Netherlands specific human factor guidelines for the development of traffic information services in cars have been drawn up (Kroon et al., 2019).

Another possible drawback is that ADAS and (partly) automated driving can increase the likelihood of drivers' performing more distracting tasks because they feel 'protected' while driving (Vlakveld, 2018). One driving simulator study showed that drivers were occupied with non-traffic-related activities more often when driving was partly automated, and even more frequently when driving was highly automated (Carsten et al., 2012). In the situation of increasing vehicle automation, distraction can lead to delays in taking back control and in emergency reactions. These effects, together with the feeling of confidence in the systems, may increase in line with increasing automation (Cunningham & Regan, 2018). This underlines the importance of driver awareness of the limitations and possible deficiencies of in-vehicle systems (Hungund et al., 2021). However, driver awareness alone may not be enough to prevent crashes while using highly reliable (but not perfect) automation. In the study of Viktor et al. (2018) reminders and explicit instructions on system limitations and supervision responsibilities did not prevent 28% of drivers from crashing, even though the drivers had their eyes on the conflict object (car or bag). Training in taking over manual control in automatic cars can be effective (Payre et al., 2017). Tsapi et al. (2020) provide a number of policy recommendations for maximizing the road safety benefits of ADAS.

8. Further reading

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