Accident Analysis and Prevention 122 (2019) 19–24

Contents lists available at ScienceDirect

Accident Analysis and Prevention

journal homepage: www.elsevier.com/locate/aap

Road safety and distraction, results from a responsibility case-control study among a sample of road users interviewed at the emergency room

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ARTICLE INFO

Keywords:
Road safety
Traffic crash responsibility
Attention
Distraction

ABSTRACT

Despite the complexities of the driving task, more and more drivers engage in non-driving secondary tasks that take their hands (manual distraction), their eyes (visual distraction) and/or their mind (cognitive distraction) away from their primary task. Inattention arising from external distractions has received much less consideration beyond the impact of mobile phone use. We aimed to investigate the association between distraction behind the wheel and risk of being responsible for a road traffic crash in a responsibility case-control study. The study population included 1912 drivers injured in a road traffic crash recruited in two rounds of recruitment (from April 2010 to August 2011 and from March 2013 to January 2015) in the adult emergency department of Bordeaux University Hospital (France). Responsibility levels were estimated using a standardized method. Self-reported activities among a pre-established list of potential distractions were combined into four external distraction variables: visual distraction, manual distraction, auditory distraction, and verbal interaction. A significantly increased risk of being responsible for a road traffic crash was associated with the exposure to activities that take drivers' eyes off the road (adjusted odds ratio 2.99, 95% confidence interval 1.42–6.28) and activities that take drivers' hands off the wheel (adjusted odds ratio 2.12, 95% confidence interval 1.20–3.75). No significant associations were found for verbal interaction and listening to the radio and/or singing. This study suggests that beyond the use of mobile phone, particular attention must be paid to activities that involve visual and/or manual distraction.

1. Introduction

Driver inattention and driverdistraction have been identified as major contributors to road crashes (Beanland et al., 2013; Klauer et al., 2006). According to Regan, inattention is defined as "insufficient or no attention to activities critical for safe driving" (Regan et al., 2011). According to the National Highway Traffic Safety Administration, driver inattention contributes to approximately 25% of police-reported crashes. In their review of serious injury crashes in Australia between 2000 and 2011, Beanland et al. found that 57.6% of the 340 crashes showed evidence of driver inattention. Among these inattention-related crashes, 25% resulted from distraction (Beanland et al., 2013). In 2016, a naturalistic study on 3542 drivers aged between 16 and 98 found that distraction was involved in about 68% of the 905 injurious and property damage crash events analyzed (Dingus et al., 2016). In developed countries, a long-term consistent downward trend is observed in the road mortality and morbidity, thanks to a range of factors principally comprising speed limit, seat belt use, road infrastructure and car safety improvements. The share of inattention in the remaining crashes that could not have been prevented by these means is therefore increasing.

Driver distraction is one form of inattention and can be defined as a "diversion of attention away from activities critical for safe driving toward a competing activity" (Regan et al., 2011). Despite the complexities of the driving task, it is not infrequent for drivers to engage themselves in non-driving secondary tasks that take their hands (manual distraction), their eyes (visual distraction) and/or their mind (cognitive distraction) (Klauer et al., 2006; Dingus et al., 2016; Sullman et al., 2015). These distractions have been identified as a major safety concern in road safety mostly due to the increasing use of mobile phones and other electronic devices while driving. They can be inside

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https://doi.org/10.1016/j.aap.2018.09.032
Received 24 May 2018; Received in revised form 7 September 2018; Accepted 28 September 2018
Available online 06 October 2018

(mobile phones, passengers…) or outside the vehicle (looking at billboards or people along the street).

Naturalistic driving studies, which consist in observing everyday driving behaviors with recording systems installed in the subjects' own vehicles, often investigated a large range of secondary activities which made it possible to explore distraction according to their type (e.g. manual, visual…). Among all distractions, visual distraction (e.g. cell dial with handheld phone, reading/writing, cell text) was associated with the highest risk of crash/near crash involvement (Klauer et al., 2006). The same result was found when considering crashes only (Dingus et al., 2016). However, the implementation of naturalistic studies required the recording and exploitation of large amount of driving session data which require high costs and long survey duration. Until a recent study (Dingus et al., 2016), results from naturalistic studies were often limited by the limited number of real crashes observed.

Studies based on driving simulators and epidemiological studies are less expensive and time consuming complementary approaches. While confronted with recall and social desirability biases due to self-reporting, epidemiological studies allow for the assessment of associations among a large sample of drivers who were not previously enrolled and were therefore driving their car with no risk of any behavior that would be induced by participation in a study involving real-time recording. Mobile phones use while driving has been the focus of most of those researches in the recent years (Caird et al., 2014; Haigney et al., 2000; Horrey and Wickens, 2006; Laberge-Nadeau et al., 2003; Matthews et al., 2003; McEvoy et al., 2005; Redelmeier and Tibshirani, 1997; Strayer et al., 2003), and often showed an association with the risk of being involved in a car crash, including when talking on a handheld phone (McEvoy et al., 2005; Redelmeier and Tibshirani, 1997). Until recently, talking on a handheld phone was not identified as a risky behavior in naturalistic driving studies (Klauer et al., 2005; Olson et al., 2009; Hickman and Hanowski, 2012) but this was finally confirmed when assessing real crashes only (Dingus et al., 2016).

To contribute to current research efforts on distracted driving and investigate whether the type of demand (e.g. verbal, manual…) modulates the risk of being responsible for a crash, we implemented a case-control responsibility study among a sample of injured drivers. All vehicle-drivers were included, including truck drivers and two-wheelers.

2. Methods

2.1. Study design and setting

We performed a responsibility case-control study in a population of patients involved in minor injurious road traffic crashes. Its basic principle was to compare the frequency of exposure between drivers responsible for the crash (cases) and drivers not responsible for the crash (controls). The study was conducted at the adult emergency department of the Bordeaux University Hospital (France) attended by urban and rural populations living in an area comprising more than 1.4 million people. Patients were recruited in two rounds from April 2010 to August 2011 and from March 2013 to January 2015. Patients were interviewed by trained research assistants. The interview comprised questions regarding the crash, patient characteristics, and distraction. Informed consent was obtained from all subjects.

2.2. Participants

Patients were eligible for study inclusion if they had been admitted to the emergency department in the previous 72 h for injury sustained in a road traffic crash, were aged 18 years or older, were drivers, and were able to answer the interviewer (Glasgow Coma Score = 15 at the time of interview, as determined by the attending physician).

2.3. Outcome variable: responsibility for the crash

Responsibility levels in the crash were determined by a standardized method adapted from the quantitative Robertson and Drummer crash responsibility instrument (Robertson and Drummer, 1994). The adaptation of the method to the French context has been validated and presented in a previous report (Laumon et al., 2005). The method takes into consideration 6 different mitigating factors considered to reduce driver responsibility: road environment, vehicle-related factors, traffic conditions, type of accident, traffic rule obedience and difficulty of the driving task. Compared with the initial method proposed by Drummer, the adapted method does not use 2 items: witness observations and level of fatigue, which are inconsistently available in crash police reports in France. For each factor, a score is assigned from 1 (not mitigating, i.e. favorable to driving) to 3 or 4 (mitigating, i.e. not favorable to driving). All six scores are subsequently summated into a summary responsibility score. This summary score was then multiplied by 8/6 to be comparable to the 8-factor score proposed by Robertson and Drummer. Higher scores correspond to a lower level of responsibility. The allocation of summary scores was: 8–12, responsible; 13–15, contributory; more than 15, not responsible. Drivers who were judged not responsible (more than 15) served as controls. The others (score $\leq$15) were considered to be cases. The interviewer was blind to the participant responsibility status when using questionnaire sections related to potential distraction because: 1. Responsibility score was computed during the analysis step; 2. Traffic rule obedience was reported after the distraction section.

2.4. Exposures

When interviewed, patients were asked to describe distracting events and activities that occurred just before the crash from a list of potential distracting events and activities including listening to the radio, cell phone use, navigation system use, having a conversation with passengers. We created 4 external distraction variables 1/distractions that take eyes off the road (e.g. dialing, GPS manipulation, looking at something outside the vehicle), 2/distractions that take one or both hands off the wheel (e.g. dialing, applying makeup), 3/distractions that involved verbal interaction (e.g. talking on the phone, talking with passenger, arguing) and 4/listening to the radio and/or singing (Table 1). The classification was made independently by two researchers and, in case of disagreement, they were invited to discuss and explain their choice in the presence of a third researcher until an agreement was reached.

An internal distraction indicator was added as we previously showed the role of mind wandering (i.e. thinking unrelated to the task at hand) (Galéra et al., 2012). Participants were asked to describe their thought content coupled with a numerical scale from 0 to 10 that captures the level of perturbation. A summary variable was created with 3 modalities: 1/no thought or thought unrelated to driving; 2/thought related to driving with a level of perturbation less than or equal to 4; and 3/thought related to driving with a level of perturbation higher than 4 (Galéra et al., 2012). In order to reduce memory bias, participants were given the opportunity to report their thoughts at two time points during the interview.

Potential confounders included the patient's characteristics (age, sex, socioeconomic category), crash characteristics (season, time of day, location…) and self-reported psychotropic medicine use in the preceding week. Patients were also asked how many hours they had slept during the previous 24 h. They were considered as sleep deprived if they reported sleeping less than 6 h on the previous night (Galéra et al., 2012; Farouki et al., 2014). Emotional valence was evaluated with the self-assessment manikin (SAM) tool to characterize the driver's emotional valence state (pleasure-displeasure) just before the crash. Patients were asked to tick the SAM graphic character ranging from a smiling happy figure to a frowning unhappy figure (arrayed in a nine-

Table 1
Distribution of the secondary tasks reported by the participants and type of distraction in which they were classified (n = 1912).

	n (%)	Type of distraction[a]
Phoning	5 (0.26)	H + V
Using hands-free kit	10 (0.50)	V
Texting	0	H
Dialing cellular phone	2 (0.10)	E + H
Reading a text message	0	E + H
Using GPS on a cell phone	2 (0.10)	E + H
Other cell phone use	8 (0.42)	H
Music listening	503 (26.31)	L
Watching TV	0	E
Conversing with passengers	72 (3.77)	V
Listening to passengers	11 (0.57)	V
Reprimanding children	1 (0.05)	V
Arguing with passengers	3 (0.16)	V
Following GPS indication	17 (0.89)	E
Manipulating GPS	3 (0.16)	E + H
Map reading	0	E
Being distracted by an event outside the vehicle	23 (1.20)	N/A
Eating	6 (0.31)	H
Drinking	2 (0.10)	H
Smoking	19 (0.99)	H
Picking up an object	8 (0.42)	E + H
Applying makeup	1 (0.05)	E + H
Reading	1 (0.05)	E + H
Writing	0	E + H
Singing	3 (0.16)	L
Kissing	0	E
Looking somewhere else	9 (0.47)	E
Holding something in the hand	9 (0.47)	H
Other electronic device	4 (0.21)	H
Conversing with other users	3 (0.16)	V
Other distracting activities	9 (0.47)	[b]

[a]E: Distraction where eyes are off the road; H: Distraction where hands are off the wheel; V: Verbal interaction; L: Listening to music or singing.

[b] The other distractions have been recoded manually according to the specification given by the drivers.

Table 2
Sample characteristics of drivers and responsibility for road traffic crash.

	Total participants (N = 1912)	Responsible (n = 896) n (%)	P value
Gender			
Male	1,164	551 (47.3)	0.64
Female	746	345 (46.2)	
Age			
18–24	449	232 (51.7)	0.010
25–34	480	203 (42.3)	
35–44	374	158 (42.2)	
45–54	307	155 (50.5)	
≥55	299	145 (48.5)	
Socioeconomic category			
Worker/farmer	103	49 (47.6)	0.28
Self-employed	105	45 (42.9)	
White collar	963	434 (45.1)	
Middle management	220	100 (45.4)	
Top management and professional occupation	131	63 (48.1)	
Retired/unemployed	137	68 (49.6)	
Student	251	135 (53.8)	
Vehicle type			
Light vehicle	787	331 (42.1)	< 0.001
Commercial vehicle	39	14 (35.9)	
Heavy goods vehicle	25	14 (56.0)	
Bicycle	457	253 (55.4)	
Scooter	197	86 (43.6)	
Motorbike	394	190 (48.2)	
Time of day			
05.00–10.59	887	384 (43.3)	< 0.001
11.00–13.59	404	186 (46.0)	
14.00–19.59	488	244 (50.0)	
20.00–04.59	133	82 (61.6)	
Season			
Spring	548	279 (50.9)	< 0.001
Summer	452	222 (49.1)	
Autumn	581	272 (46.8)	
Winter	331	123 (37.2)	
Location			
≥50,000 inhabitants	1,070	397 (37.1)	0.82
< 50,000 inhabitants	842	499 (59.3)	

point Likert scale), recoded in a dichotomous variable (negative affect *vs* positive or neutral affect). A dichotomous variable was used for alcohol consumption within the six preceding hours.

2.5. Statistical analyses

We used univariable logistic regression analysis to investigate the association between responsibility and exposures and potential confounders or effect modifiers. Significant variables ($P < 0.2$, Chi-square test) were included in the multivariate model. We performed a manual stepwise backward method to select the variable in the final model. Interactions between distraction-related variables kept in the final model were tested. A sensitivity analysis was conducted stratifying by vehicle type (two-wheeler versus four-wheeler). All the analyses were conducted using the SAS software version 9.3.

3. Results

We assessed 2539 patients for eligibility. Of these, 475 were excluded for ineligibility. This resulted in 2064 eligible patients. Of these, 1 was a duplicate, 57 refused to participate and 94 were excluded from the analysis because of insufficient data. Thus, the two periods of inclusion led to the recruitment of 1912 drivers (92.6% of the eligible patients) involved in a road traffic crash between April 2010 and August 2011 or between March 2013 and January 2015. Among them, 851 (44.5%) were four-wheeler drivers, 457 (23.9%) were cyclists, 591 (30.9) were on motorized two-wheelers, and 13 were other road users (e.g. skate, kick scooter). Eight hundred and ninety-six(46.9%) were classified as responsible for the crash. The mean time between the crash and the interview was 4 h 51 min (SD 10 h 58 min).

Among the 1912 participants, 620 (32.4%) reported being engaged in secondary task at the time of the crash (58.5% of the four-wheelers and 11.1% of the two-wheelers). Table 1 shows the distribution of the self-reported activities among the participants. Frequencies according to vehicle type are presented in Supplementary Table 1.

Table 2 presents the participants' characteristics, including gender, age and location of the crash, and a comparison between responsible and non-responsible. Participants were mostly men (60.9%), under the age of 35 (48.6%) and 46% of the crashes occurred in the morning. Responsibility for the crash was significantly associated with age, vehicle type, time of day and season.

Table 3 presents the results of the univariate analyses. The results of the multivariate analysis showed a significant association between responsibility for the crash and negative affect, alcohol consumption, the use of psychotropic drugs and the use of alcohol, after adjustment for sex, age, time of day and season (Table 4). No significant interaction was noted. Distractions that take eyes off the road (OR = 2.99, 95% confidence interval 1.42–6.28) and distractions that take hands off the wheel (OR = 2.12, 95% confidence interval 1.20–3.75) were associated with responsibility for the crash. Drivers who reported mind wandering with highly disrupting/distracting content had a higher risk of being responsible compared with drivers not exposed to mind wandering (OR = 1.90, 95% confidence interval 1.40–2.59). No significant association was found for verbal interaction (e.g. hands-free phone use and conversation with a passenger) and for listening to music or the radio, and singing.

Table 3
Univariate analyses for responsible road traffic crashes.

	Responsible (n = 896) n (%)	Not responsible (n = 1 016) n (%)	OR [95% CI]
Verbal interaction			
Yes	45 (5.0)	47 (4.6)	1.09 (0.72–1.66)
No	851 (95.0)	969 (95.4)	Ref
Listening to music or the radio and singing			
Yes	231 (25.8)	272 (26.8)	0.95 (0.78–1.17)
No	665 (74.2)	744 (73.2)	Ref
Distraction where eyes are off the road			
Yes	31 (3.5)	11 (1.1)	3.27 (1.64–6.55)
No	865 (96.5)	1 005 (98.9)	Ref
Distraction where hands are off the wheel			
Yes	47 (5.3)	21 (2.1)	2.62 (1.56–4.42)
No	849 (94.7)	995 (97.9)	Ref
Mind wandering			
Not reported	413 (46.2)	486 (47.8)	Ref
Little disrupting/distracting content	316 (35.3)	446 (43.9)	0.83 (0.69–1.01)
Highly disrupting/distracting content	166 (18.5)	84 (8.3)	2.33 (1.73–3.12)
Negative affect			
Yes	168 (18.8)	123 (12.1)	1.68 (1.30–2.16)
No	728 (81.2)	893 (87.9)	Ref
Alcohol use			
Yes	94 (10.5)	35 (3.4)	3.29 (2.20–4.90)
No	802 (89.5)	981 (96.6)	Ref
Psychotropic medicine use			
Yes	96 (10.7)	67 (6.6)	1.70 (1.23–2.36)
No	800 (89.3)	949 (93.4)	Ref
Sleep deprivation			
Yes	113 (12.6)	68 (6.7)	2.01 (1.47–2.76)
No	783 (87.4)	948 (93.3)	Ref

A sensitivity analysis stratified by vehicle type showed roughly the same pattern of results (Supplementary Table 2). It should be noted that for two-wheelers, a stronger association was found f distraction where hands are off the wheel.

4. Discussion

This study investigated the association between distraction just before the crash and responsibility. We found that activities that cause drivers to take their hands off the wheel and activities that take the drivers' eyes off the road were significantly associated with a higher risk of being responsible for a crash. These associations remain significant after adjustment for a large range of potential confounders. Mind wandering with highly disturbing content was also associated with crash responsibility.

We conducted a responsibility analysis, which has the advantage of allowing the comparison of cases and controls that share the common characteristic of being drivers. Responsibility levels were calculated

Table 4
Multivariate analysis for responsible road traffic crashes by logistic regression.

	Responsible (n = 885) n (%)	Not responsible (n = 1 011) n (%)	OR [95% CI]
Mind wandering			
Not reported	409 (46.2)	483 (47.8)	Ref
Little disrupting/distracting content	313 (35.4)	444 (43.9)	0.82 [0.67–1.01]
Highly disrupting/distracting content	163 (18.4)	84 (8.3)	1.90 [1.40–2.59]
Distraction where eyes are off the road			
Yes	854 (96.5)	1000 (98.9)	2.99 [1.42–6.28]
No	31 (3.5)	11 (1.1)	Ref
Distraction where hands are off the wheel			
Yes	839 (94.8)	990 (97.9)	2.12 [1.20–3.75]
No	46 (5.2)	21 (2.1)	Ref
Negative affect			
Yes	717 (81.0)	889 (87.9)	1.45 [1.10–1.89]
No	168 (19.0)	122 (12.1)	Ref
Alcohol use			
Yes	92 (10.4)	35 (3.5)	2.27 [1.48–3.49]
No	793 (89.6)	976 (96.5)	Ref
Psychotropic medicine use			
Yes	96 (10.8)	67 (6.6)	1.55 [1.09–2.20]
No	789 (89.2)	944 (93.4)	Ref
Sleep deprivation			
Yes	112 (12.7)	67 (6.6)	1.77 [1.27–2.47]
No	773 (87.3)	944 (93.4)	Ref
Vehicle			
bicycle	251 (28.4)	204 (20.2)	Ref
2 wheels motorized	276 (31.2)	315 (31.1)	0.71 [0.55–0.92]
4 wheels motorized	358 (40.4)	492 (48.7)	0.56 [0.44–0.71]

Adjusted for sex, age, time of the day and season.

independently of alcohol and illicit drug use because of their potential interactions with distractions and interviewer were blind to driver's responsibility status. In a study on the impact of illegal drug consumption, the same method was used to determine responsibility. The comparison to an independent expert evaluation showed high consistency (Laumon et al., 2005). The latter study also confirmed that drivers rated as not responsible for the crash are representative of the general driving population.

Number of studies on distraction are limited to some road users (e.g. light vehicle drivers), population (e.g.: young drivers) or kind of distraction (e.g. mobile phone) which limit the generalizability of the results. We chose to include all eligible drivers regardless of vehicle type, leading to the inclusion of 1910 participants. The sample size made it possible to study several types of distraction and checked potential interaction. However, it also increases sample heterogeneity and consequently impact the precision and validity of the results.

Data on a large range of distractions inside or outside the vehicle and potential confounders (including alcohol consumption, sleep deprivation, and psychotropic medication use) were collected. Information was self-reported retrospectively, which can result in recall and social desirability biases. The memory bias is, however, most likely non-differential between cases and controls. Regarding the desirability bias, it would have resulted in an underestimation of the impact of visual and manual distractions because drivers may have under-reported activities, particularly prohibited activities such as phoning or texting. A French roadside survey conducted in 2011 showed that at any given time, 1.7% of car drivers were holding a mobile phone to their ear and 0.3% were holding a phone but not to their hear while driving (ONISR, 2012), which is higher than the frequencies found in the present study (0.35% of four-wheelers phoning with a hand-held phone). Regarding other activities, frequencies found in this study are similar to those found in a roadside study conducted in UK (Sullman et al., 2015).

It was sometimes difficult to determine if the activity involved one or more forms of distraction. For instance, arguing with a passenger can be a verbal interaction only or a verbal and visual interaction. Because no further details about the activity demand were collected during the interview, we kept only the form of distraction that was unequivocal (verbal interaction in the previous example). This underestimated exposure level may have resulted in underestimation of association level, particularly for the variable "Distraction where eyes are off the road". Another limitation is the large variation in terms of delay between the presentation to hospital and the interview between participants which may have resulted in reporting bias. After stratifying on this delay using the mean time of 4 h as a cut-point, we indeed found differences regarding the proportion of responsible drivers between the two groups but results but there was no change in the final results on the association between types of distraction and responsibility for a crash. Finally, drivers severely injured and consequently unable to answer the questions and drivers whose condition did not require emergency care were not included, which limits the generalizability of the findings.

The strongest association was found for visual distraction. Drivers engaged in a visual secondary task are more likely to fail to react or to delay their response to an unexpected event, such as sudden braking of the car in front or a pedestrian crossing the road. In the literature, visual time sharing was associated with reduced lane keeping (Peng et al., 2013) and delayed response time (Dozza, 2013). Dozza et al. used the 100-car naturalistic driving study and 8-truck naturalistic data and found that eyes-off-road delayed response time by 29% (Dozza, 2013). Our results are also consistent with the results of naturalistic studies in which all activities with visual demands (e.g. reading, looking at external objects, cell dial) were associated with a higher risk of near crash as well as crash (Dingus et al., 2016; Klauer et al., 2005).

Manual distraction was also associated with an increased risk of being responsible for a crash in our study. In the 100-naturalistic study quoted above, no significant association for activities that involved mainly manual distraction (e.g. eating, reaching for an immobile object) was found. However, activities that involved both manual and visual distraction (e.g. reading, dialing) were significantly associated with a higher risk of crash/near crash (Klauer et al., 2005). Moreover, it was based on the use of near crash as surrogate for real crashes which may have underestimated the risk, as the results of a more recent naturalistic study based on real crash only suggests (Dingus et al., 2016). The latter has found a small but increased risk associated with most manual activities including eating and tuning the radio. Manipulation of an object interferes with lateral vehicle control. Moreover, even if drivers see the unexpected event, the time required to reposition their hands on the wheel may delay their response to the event and lead to an accident.

Regarding verbal interaction while driving, no significant association was found. The 100-car naturalistic study found similar results with only the passenger in the adjacent seat associated with a decreased risk of crash/near crash, whereas no association was found for talking to a hand-held device, or to a passenger in a rear seat (Klauer et al., 2006). On the other hand, many studies have shown that both talking on a cell phone and passenger carriage increase the risk of crash (McEvoy et al., 2005; Redelmeier and Tibshirani, 1997; McEvoy et al., 2007), including a naturalistic study based on crash only (Dingus et al., 2016). In our study, only 10 drivers (0.5% of our sample) reported hands-free conversation and none reported hands-on use. This low frequency may be the result of measures to prohibit the use of mobile phones behind the wheel, either because of the effectiveness of these measures or because they encourage drivers to under-report the practice because of the fear of sanctions. The latter could have led to a false-negative result.

Our results for mind wandering while driving confirm the first results we published in 2012, obtained in the same population but restricted to the first period (e.g. from April 2010 to August 2011) (Galéra et al., 2012). Mind wandering is a cognitive distraction which involves a shift of attention away from the driving task toward task-irrelevant thoughts. In 2011, He et al. showed that when engaged in mind wandering, participants tend to focus visual attention narrowly on the road ahead (He et al., 2011). Drivers engaged in mind wandering with highly disturbing content may disengage themselves from the road environment and fail to react to hazard events.

This study suggests that, beyond the use of mobile phone, some other forms of distraction may significantly increase the risk for drivers, primarily by delaying their response to unexpected events. While most countries have instituted laws to ban on cell phone use at the wheel, other distractions while driving are receiving much less attention. For instance, in France, distracted activities other than mobile phone use (e.g. eating, drinking, applying makeup) are not prohibited. However, a law article states that drivers must always be in condition and position to execute all maneuvers without delay but it leaves to police officers' judgment to write a ticket or not. Policies regarding other distracted activities behind the wheel should be clarified to improve prevention campaigns on distracted driving. Drivers' awareness on the impact of distraction while driving should also be raised, especially for distracting tasks with manual and/or visual demand. Finally, although we found no significant increase risk for verbal or listening activities, their detrimental impact on road safety cannot be excluded, in particular among novice drivers who have been shown to be particularly vulnerable to secondary tasks (Klauer et al., 2014).

Conflict of interest

The research was supported by the French National Research Agency (ANR) grant (ANR-09-VTT-04) and the French Fondation Sécurité Routière (FSR) (APR 2011, 2012/MP/02).

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.aap.2018.09.032.

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