

# **Relative crash involvement risk associated with different sources of driver distraction**

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## **ABSTRACT**

A sample of crash-involved drivers (n=4307) filled in a web-based questionnaire about distractions during the crash. For each potential distraction factor the drivers indicated whether or not they were distracted by that specific factor at the time of the crash. Relative crash risk was estimated by using quasi-induced exposure. The most frequent distractions were ‘talking with passenger(s)’ and ‘attending to children in backseat’. The distractions with the highest relative risk were ‘billboards outside’, ‘searching for addresses’, and ‘moving object inside car’ followed by ‘talking with passenger(s)’, ‘attending to children in backseat’, ‘adjusting music player’, and ‘radio tuning’.

## INTRODUCTION

Driver distraction has been found to be a contributing factor in 8 to 25 percent of road accidents [1, 2]. With the proliferation of potential in-vehicle distraction factors such as mobile phones and electronic route guidance systems, as well as various electronic entertainment systems, research on driver distraction and related driving behavior has become popular within the field of traffic safety in the last twenty years. However, whereas a vast amount of research on driving *behavior* has been published in this field, research on the *risk* associated with various distraction factors is sparse in the scientific literature, with the exception of mobile phone related distraction [3-6]. In the present study, relative risk of various in-vehicle distractions (excluding mobile phone use) and external distractions are estimated.

### Distraction defined and categorized

Driver distraction can be defined as what happens when a driver's attention is diverted away from the driving task by an object, activity, event, or other person, to such a degree that the driver no longer is capable of performing the driving task in a safe manner [7]. Thus, driver distraction involves a secondary object, event, or activity in addition to the primary task of driving. This object, event, or activity may be in-vehicle, e.g., using a mobile phone, or external, such as looking at a billboard outside. Further, four distinctive types of distractions have been identified: Visual distraction, auditory distraction, biomechanical (physical) distraction, and cognitive distraction [8]. Whereas it is quite intuitive that visual (e.g., looking at a map instead of at the road) and physical distractions (e.g., eating a sandwich leaving only one hand at the steering wheel) can affect driving behavior, the effects of auditory and cognitive distractions are more subtle.

In addition to discern between these four types of distraction, it has been proposed that driver distraction can be categorized into 13 different objects, activities etc. [1]: 1) eating or drinking, 2) outside person, object or event, 3) adjusting radio, cassette, or CD, 4) other occupant in vehicle, 5) moving object in vehicle, 6) smoking related, 7) talking or listening on mobile phone, 8) dialing (mobile phone), 9) using device brought into vehicle, 10) using integral in-vehicle device, 11) adjusting climate controls, 12) other distractions, and 13) unknown distraction. While research on mobile phone use and driving behavior has dominated the scientific field of driver distractions, research on some of the other distraction factors listed above is relatively sparse. In the present study, we will examine visual and physical distracters, both in-vehicle and external to vehicle, and their potential contribution to accident involvement risk.

### Driver distraction research

When it comes to research on driver distraction factors in general (i.e., not mobile phones exclusively), three different types of studies can be identified: 1) studies

investigating distraction factors and their potential *effects on driving behavior*, 2) crash studies describing the *prevalence* of various distraction factors in *crashes*, and 3) *crash risk studies* investigating the risk associated with various distractions. Studies belonging to the first category are typically experiments conducted in a simulator setting or on a test track [9-15]. In addition to strictly controlled experiments conducted in simulators or driving tracks, naturalistic driving studies have gained interest, as these allow for investigation of driving behavior and attention while avoiding the artificial experimental setting associated with simulator studies [16]. In general, both simulator studies and naturalistic driving studies have found various distractions to have an effect on both driving behavior and subjective workload.

The second type of studies is often based on large crash databases. Results show that one or more distractions contribute to between 8 and 25 percent of crashes [1, 17]. Whereas such studies are important with regard to knowing the extent of contribution of various distractions to accidents, it is not possible to say anything about the risk associated with the distraction in question. This is due to the fact that in pure crash studies, one lacks information about the exposure to the risk factor, i.e., how often the drivers are exposed to the distraction in question.

Research on distraction related accident risk is sparse relative to the other two types of studies. Most accident risk studies on distractions have focused on mobile phone use, and the results show an increased accident risk related to such use [4-6, 18]. As for other distractions than mobile phone use, research have found increased accident risk associated with having passengers in the car – especially among novice drivers [18, 19]. In addition, Lam [20] found in-vehicle distractions to be significantly associated with accident risk whereas outside vehicle (external) distractions were not.

Getting good exposure data on the various distraction factors is probably the main obstacle for conducting research on actual accident risk. One method that has been applied in order to estimate accident risk when lacking information about drivers' exposure to the risks hazards in question is quasi-induced exposure (see method section). Although disputed, applying this method in order to estimate accident risk associated with driver distractions can contribute to knowledge about what distraction factors are associated with accident involvement risk.

The main objective of the present study was to use quasi-induced exposure in order to estimate relative risk related to various driver distractions. Moreover, accident risk was measured both as crude relative risk ratios (i.e., relative risk was estimated for each distraction factor separately), as well as odds ratios in a multiple logistic regression (i.e., the odds ratio when controlling for other variables).

## **METHODS**

### **Participants, procedure, and measures**

A sample of 33,103 drivers was drawn from a crash database hosted by a Norwegian insurance company (Gjensidige). Of these, 6111 drivers responded to an online questionnaire about various driving conditions and risk factors related to a car accident that the respondent in question had been involved in. The low response rate (i.e., 18 %) can probably be explained by several factors: First, response rates in random sample surveys in Norway are at present low (approximately 20-30 %) and one likely explanation may be the “overload” of invitations to participate in marketing and research surveys. Second, the population in the present project was quite special in that it only consisted of accident involved drivers. Moreover, these were contacted by the insurance company and asked about various risk factors related to an accident they had reported to the same insurance company. Although respondents were assured anonymity as well as informed about the true purpose of the project, the questions may have been perceived as sensitive and respondents may have been unwilling to answer. Finally, we experienced some trouble with the web-solution, and we cannot rule out the possibility that respondents who were not able to access the web-page the first time they tried omitted to answer altogether. It is worth noting, though, that this potential explanation would “hit” randomly, and no systemic bias would appear because of this limitation.

As online surveys tend to generate an underrepresentation of elderly respondents, an optional paper version of the questionnaire was offered to respondents who were unable to access or use the internet. 466 persons chose this option, of which only 8 % were under the age of 50, whereas 50 % were older than 72 years.

Because of the low response rate, we conducted analyses to examine potential responder bias. The results from these analyses showed that the following driver groups were under-represented in our study sample compared to the gross sample (i.e., those who received invitation letters): a) males (61 % vs. 64 %), b) young drivers (Mean age in study sample=48 vs. Mean age in gross sample=47) and c) at-fault drivers (54 % vs. 62 %). Although these differences between the study sample and the gross sample were statistically significant, it is important to note that they are rather small.

For the purpose of the present study, only multiple-vehicle accidents were included, leaving a sample of 4307 respondents.

Each invitation letter referred to a specific accident that the respondent in question had been involved in during the year of 2006. Respondents were instructed to think about that specific accident when answering the questions. The questionnaire included measures of the following questions that are of relevance in the present study: a) the presence of various driver distraction factors; conversation with passenger, children in the backseat, bug/insect inside the car, smoking, eating/drinking, billboard along the road, searching for addresses/street name, map reading, adjusting CD/iPod etc, tuning the radio, moving object inside

the car, and adjustment of in-car equipment, b) culpability of the accident, c) type of accident, and d) background factors (gender, age, education, annual driving distance). A note on the measure of culpability is called for as this variable is of particular importance in the analyses that was applied in order to estimate relative risk; respondents were asked to indicate who was the responsible part in the accident according to the insurance company (*I myself/The other party/ Shared responsibility*). Following this question, respondents had the opportunity to give their own version of what happened and who they themselves believed to be the responsible part in a free text field.

### **Quasi-induced exposure**

When lacking information about the prevalence of a risk factor in traffic, one way to estimate relative risk is by means of so called “quasi-induced exposure” [21, 22]. This method presumes that the prevalence of the risk factor in question (for instance a distraction factor) is the same among not-at-fault drivers in multiple-vehicle accidents as in the driver population in general. Thus, the main idea is that at-fault and not-at-fault drivers come from different populations and that not-at-fault drivers are a random sample of the total driving population and resemble the population on relevant variables [22]. Increased accident risk is indicated when the percentage of drivers with the risk factor present among at-fault drivers is higher than the percentage with the same risk factor present among not-at-fault drivers.

Quasi-induced exposure has been criticized for the assumption of the randomness of not-at-fault drivers, that is, that not-at-fault drivers are representative of the total population. However, in an elegant study by Chandraratna & Stamatiadis [22], this assumption is tested by comparing not-at-fault drivers from the first two vehicles in a multiple vehicle accident (involving two or more vehicles) with not-at-fault drivers from multiple-vehicle accidents with more than two vehicles excluding the first two drivers. The reasoning is that the latter group of not-at-fault drivers is “more” not-at-fault than the former group. The results of the study showed that the null hypothesis of similarity of the two groups could not be rejected, i.e., that the drivers of the two not-at-fault groups came from same populations. Thus, the authors conclude that quasi-induced exposure is a valid method when culpability of the accident can be assigned with certainty [22].

A possible objection against this conclusion, however, could be that although the two groups of not-at-fault drivers belong to the same driver population, they may both be different from the general driver population, e.g. regarding crash avoidance skills.

The mentioned possible limitations of the quasi-induced exposure approach should be kept in mind when interpreting the results of the present study.

## RESULTS

Fifteen percent of the drivers at fault in the accident reported that one or several distraction factors were present during the crash. If “other distraction” (which was a response option in the questionnaire) is included, this estimate rises to 30 percent. However, free-text specifications provided by respondents revealed that many of the “other distraction” responses were not distractions and should therefore not be counted. The true percentage of distraction is therefore likely to be somewhere between 15 and 30 percent among not-at-fault drivers.

Conversation with other passenger(s) was the most frequent distraction and was present in 8.1 percent of crashes among not at-fault drivers, followed by attending to children in the back seat (Table 1).

When looking at the whole sample, a significant difference between men and women was found for being distracted by attending to children, with a higher percentage of women being distracted by this factor than men (2.7 versus 1.7, chi-square=4.84,  $p<0.05$ ). Significant differences between men and women were not found for any of the other distraction factors.

### Relative risk

Crude relative risk ratios (for accident involvement) were estimated using quasi-induced exposure. The following formula was used for computing relative risk (RR)

$$RR = \frac{a / n_a}{b / n_b}$$

a = number of at-fault drivers with risk factor present

$n_a$  = number of at-fault drivers

b = number of not-at-fault drivers with risk factor present

$n_b$  = number of at not-at-fault drivers

Upper and lower limits of 95% confidence intervals (CI) were computed using the following formula:

$$Se(RR) = \sqrt{\frac{1}{a} + \frac{1}{b} - \frac{1}{n_a} - \frac{1}{n_b}}$$

95% CI:  $(RR * e(-1,96 * Se(RR)), (RR * e(1,96 * Se(RR)))$

As can be seen in the right-hand side in Table I, eight of the twelve distraction factors investigated turned out significant. “Looking at a billboard outside the vehicle” had the highest relative risk ratio (16.95), followed by “searching for addresses/street name” (15.54). “radio tuning” (9.89), “adjusting iPod/CD etc.” (6.50), “attending to children in the back seat” (5.65), “conversing with passenger(s)” (5.22), and “adjusting in-car equipment” (3.39). Note that most of the confidence intervals are very large, among them the confidence intervals for “billboard outside” and “searching for address/street name”.

Table I. Logistic regression with culpability as the dependent variable. Percentage of drivers being distracted by each distraction factor, relative risk and 95 % confidence interval.

Logistic regression			Percentage of drivers being distracted by each factor			
Variables	Exp.	Sig. level	At-fault drivers n=1785	Not-at-fault drivers n=2522	RR	95 % CI
Gender (1=women. 2=men)	0.95	ns				
Age (25-40 compared to 18-24)	0.69	.001				
Education (high compared to low)	1.03	ns				
Years with drivers' license	1.00	ns				
Km driven per year (x 10 000)	0.98	ns				
<b>Talking with passenger</b>	<b>4.85</b>	<b>.001</b>	8.07	1.55	<b>5.22</b>	3.68-7.39
<b>Attending to children in back seat</b>	<b>4.68</b>	<b>.001</b>	3.81	0.67	<b>5.65</b>	3.33-9.58
Bug/insect inside car	5.20	ns	0.22	0.08	2.83	0.52-15.41
Smoking	0.73	ns	0.39	0.20	1.98	0.63-6.22
Eating/drinking	2.90	ns	0.28	0.04	7.06	0.83-60.42
<b>Billboard outside</b>	<b>15.32</b>	<b>.01</b>	0.67	0.04	<b>16.95</b>	2.19-130.28
<b>Searching for address/street name</b>	<b>12.10</b>	<b>.001</b>	1.23	0.08	<b>15.54</b>	3.66-66.01
Map reading	0.00	ns	0.06	0.04	1.41	0.09-22.57
<b>Adjusting iPod/CD etc.</b>	<b>5.50</b>	<b>.001</b>	1.29	0.20	<b>6.50</b>	2.48-17.06
<b>Radio tuning</b>	<b>6.67</b>	<b>0.05</b>	0.78	0.08	<b>9.89</b>	2.25-43.46
Moving object inside car	(2E+009)	ns	0.62	0.04	<b>15.54</b>	2.01-120.28
Adjusting in-car equipment	3.04	ns	0.67	0.20	<b>3.39</b>	1.20-9.61

Note! 389 missing in the logistic regression analysis

In order to control for potential confounding variables, a logistic regression analysis with “culpability” as the dependent variable was conducted. Independent

variables were all distraction factors, as well as gender, age (groups: 18-24, 25-40, 41-64, 65+), education (low, medium, high), years with drivers' license, and annual driven kilometres (/10 000). As the results in the left hand side in table II indicate, age is the only background variable that is significantly associated with risk; drivers who are between 25 and 40 years old have a significantly lower accident involvement risk than drivers aged 18 to 24 (OR=3.69,  $p<.001$ ). Of the distraction factors, "radio tuning", "moving object inside vehicle", and "adjusting in-car equipment" turned insignificant when controlling for confounding variables. "Looking at billboards outside the vehicle" and "searching for addresses/street names" were still the distraction factors associated with highest accident risk, although somewhat smaller than indicated by the crude estimates.

## DISCUSSION

The present study was an attempt at estimating relative accident risk involvement by using quasi-induced exposure. The results indicate that various distraction factors are associated with increased accident risk, and that relative risks are surprisingly high. However, the field of estimating driver distraction related accident risk is relatively small and unexplored, and the present study should be considered as an explorative study only.

8 percent of all drivers in the sample reported that they were distracted by one or several factors during the crash, whereas 15 percent of at-fault drivers were distracted. Conversing with passenger(s) and attending to children in the back seat were the most frequently reported distractions.

Of the eight distraction factors that turned out to be significantly related to accident involvement risk, four factors were in-car activities, and two factors were outside-car related. Moreover, of the two outside-car distractions, one can be categorized as external "object" (i.e., looking at billboard outside vehicle)<sup>1</sup>, whereas the other is more properly defined as an activity (i.e., searching for addresses/street names). Further on, the two outside distractions are clearly visual. As for the in-car activities, radio tuning, adjusting iPod/CD etc., and adjusting in-car equipment can be both visual and physical, as can attending to children in the back seat, and moving object inside vehicle (for instance if the driver was searching for the object). Finally, conversing with passenger(s) can be both cognitive and auditory, but also visual if the drivers for instance were looking at the person he or she was conversing with.

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<sup>1</sup> We chose to categorize this as an "object" even though it includes "looking at" which of course is an activity.



## **Outside-vehicle distractions**

As for external or outside-vehicle distractions, previous results are inconclusive. In a study on accident risk for various in-car and outside-car distractions, Lam [20] found that outside vehicle distractions did not increase accident risk. Moreover, the results in his study showed an insignificant tendency towards decreased accident risk. However, Lam's [20] data were based on police records of crashes, and one explanation for those results may be that the police does not identify outside-vehicle objects as distractions to the same extent as in-vehicle objects or activities. In this respect, the results of the present study are more valid as the drivers themselves indicated whether or not they were distracted by the factor in question.

Young et al. (in press) found in a simulator experiment that advertising boards alongside the road had adverse effects on behavior measured as lateral control and mental workload (measured with NASA-TLX [11, 23]), which may in turn increase accident risk. Moreover, 65 percent of the participants in a survey regarding roadside memorials agreed that such memorials "may distract drivers" and 46 percent agreed that "they are a safety hazard" [24]. Thus, it also seems like drivers perceive external factors to distract drivers. It should be noted though, that an on-road experiment showed that red-light violations decreased at an intersection when a "mock roadside memorial" was introduced. This can probably be explained by drivers' increased perceived risk as the information a memorial gives is that it has been a fatality at the section in question. However, this would not apply to billboards and other potential external distractions as investigated in the present study.

## **In-vehicle distractions**

As for in-vehicle distractions, the increased accident risk indicated by the present results support previous findings. Lam [20] found increased accident risk for in-vehicle distractions (excluding mobile phones) for all age groups except for drivers 40 to 49 years old. Moreover, in a study comparing mobile phone use and driving with passengers, Mc Evoy et al. [18] found increased risk for driving with passengers, although the risk was even higher for mobile phone use. Effects on behavior have also been found for handling an MP3 player in a simulator study, with increases in perception response time and collisions [9]. The sample in Chisholm's [9] study consisted of only young drivers (18 to 22 years old), whereas all ages were included in our study. Breaking down the results in our study showed, however, that of the 30 persons reporting to be distracted by adjusting iPod/CD etc. before the accident, 19 (63 %) were between 18 and 24.

## **Limitations**

The main assumption of quasi-induced exposure is that not-at-fault drivers represent the general driving population, and hence that the prevalence of a driver or car-related factor is the same among not-at-fault drivers and the general driving

population. At-fault drivers, on the other hand, are believed to come from a different population. The method has been criticized both for the randomness and representativeness of not-at-fault drivers, and for the possibility of misidentification of responsibility in the accident [25]. Even though the critique has been refuted [22], it is constantly emphasized in the literature that responsibility in the accident should be identified with certainty. As we only have self-report measures of responsibility, we cannot rule out misidentification of culpability. However, we believe respondents have no incentive to misinform us with regard to culpability as we ask about the responsible driver *according to the insurance company*. With regard to the identification of culpability from the insurance company, we have no possibility to investigate the validity.

When it comes to measuring the presence of the distraction factors, we only asked about the presence of one or several of a list of factors that distracted the driver before the accident in question. Thus, the exposure to the distraction factors as measured by the prevalence among not-at-fault drivers is not a measure of the *mere presence* of a potential distraction factor. Rather, it is a measure of how often drivers *are distracted* by the factor in question.

## **Conclusions and future research**

Even though the results from this study indicate that looking at billboards and searching for addresses/street names are the distractions associated with highest accident risk, it is also important to look at the prevalence of the risk factor. These two factors were reported to have been distracting the drivers in only 0.3 percent of all crashes (i.e., in the whole sample) each. This means that, as measured by the rate to which billboards *distract* drivers, this is not a large risk factor from a population perspective. However, we can assume that far more than 0.3 percent of drivers were exposed in some sense to billboards before or during the accident. As we did not ask about the mere presence of the risk factor, but the presence of a risk factor that did *distract* them before the accident, we cannot conclude about the risk for driving in the presence of a billboard.

When considering the prevalence of the risk factors in addition to the relative accident involvement, talking with passenger(s) and attending to children in the back seat are the distraction factors that perhaps are most likely to have the highest overall risk – i.e., these two distraction factors are both associated with high accident risk and are frequent distractions, generating high exposure.

Knowledge about the prevalence and the relative risk associated with the various distractions may be important for estimating the potential accident-reducing effect of countermeasures. One example of such countermeasure is restriction to drive with passengers under a certain age for novice drivers.

Future research should aim towards developing better methods for estimating the prevalence of various distraction factors in the driving population. Large naturalistic driving studies are promising in this respect, allowing for investigation

of a) the prevalence of various in-vehicle distraction factors, b) various behavior measures, as well as c) accidents and near-accidents.

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