KFV
Kuratorium für Verkehrssicherheit
BRSI

# KFV - Sicher Leben #7

## The impact of distraction on driving behaviour in urban traffic.

### Results of a simulator-based study

KFV (Kuratorium für Verkehrssicherheit)

# KFV - Sicher Leben
# #7

## The impact of distraction on driving behaviour in urban traffic.

### Results of a simulator-based study

KFV - Sicher Leben. Band #7. The impact of distraction on driving behaviour in urban traffic.
Results of a simulator-based study. Vienna, 2017

**Media owner and publisher**
KFV (Austrian Road Safety Board)

**Authors**
Monika Pilgerstorfer (KFV)
Sofie Boets (BRSI)



Kuratorium für Verkehrssicherheit

# CONTENT

# 1 ABSTRACT

Distraction in traffic is a growing problem. In Austria, distraction, together with inattention, is responsible for one third of all injury accidents.[1] On an international level, it is estimated that distraction contributes to 5% to 25% of all traffic accidents.[2] For this reason, the Austrian Road Safety Board (KFV) has dealt extensively with the topic of distraction while driving. Surveys, expert assessments and Naturalistic Driving Observations have been used to identify the main sources of distraction (in terms of frequency, duration, use of cognitive, visual, auditive and manual resources) for Austrian car drivers. These were identified as: (1) phoning, (2) texting, and (3) eating and drinking.

The aim of the current study was to evaluate the effect of these sources of distraction on the driving behaviour and safety of experienced drivers using a repeated measures design. Six experimental conditions were included in three simulator tracks: (1) reading and writing text messages; (2) talking on the phone (hand-held as well as hands-free); (3) eating and drinking. Each experimental condition was composed of two track sections that included the respective distraction task. The effects were analysed with regard to driver related characteristics (two age groups and gender) and unexpected incidents while driving (e.g. a pedestrian suddenly crossing the road). In total, 63 participants completed all four tracks (three experimental and one control) in the StiSim3 driving simulator. The order of the conditions was counterbalanced between the subjects to reduce order effects due to fatigue or learning. Simulator driving and self-reported data were gathered for all subjects, as well as eye-tracking data for part of the sample. Six (generalized) mixed linear models were developed to estimate the effects of different side activities on each dependent variable, while also taking into account random effects (heterogeneity across subjects). The six dependent variables were: mean speed, standard deviation of lateral position (SDLP), hazard detection time, reaction time to the hazard, hazard collision and general collision probability.

The results obtained by applying (generalized) mixed linear models indicate that, compared with the other distraction sources, reading and writing text messages had the most detrimental effects on the simulated driving (i.e. lower mean driving speed, increased reaction time and standard deviation of lateral position), while hands-free phoning did not influence driving. The eye-tracking results are also in line with this finding: the percentage of gaze at relevant screen areas for reading and writing text messages was lower than the control condition. Interactions were found with age and especially with gender, suggesting that females, and to some extent middle-aged drivers, are more likely to self-regulate than males and young drivers when distracted while driving. Finally, the perceived effects of the different sources of distraction during the experiment were largely in line with actual driving performance.

1 Verkehrsunfallstatistik 2013, 2014, 2015; Statistik Austria.

2 DaCoTA (2012). *Driver distraction.* Deliverable 4.8 of the EC FP7 project DaCoTA; SWOV (2013) *SWOV- Fact sheet. Distraction in traffic*. Leidschendam, the Netherlands, Institute for Road Safety Research.

# 2 INTRODUCTION

## 2.1 Background

Distraction on the roads is a familiar yet increasing area of concern for road safety. In Austria, distraction together with inattention is the main cause of one third of all injury related traffic accidents.[3] In 2014, a total of 111 road users died in Austria because they or someone else were (was) inattentive or distracted while driving. In 2015, this figure rose to 123 such fatalities. On an international level, it is estimated that distraction plays a role in 5% to 25% of all traffic accidents.[4]

International studies indicate that drivers are distracted for about 25% to 30% of their driving time: they have conversations with passengers, listen to music (and therefore operate devices) and often eat or drink while driving.[5]

A recent analysis of Naturalistic Driving[6] data for 905 crash events that resulted in injuries to people and/or damage to property showed that distraction is detrimental to driver safety. The use rates and risk of accident are especially high for hand-held electronic devices. A closer look at road accidents that resulted in injuries and/or damage to property reveals that distraction was a factor in 68.3% of all cases. Overall, the risk of accident due to distraction while driving was two times higher than in cases when the driver was not distracted. Researchers conclude that sources of distraction which require drivers to take their eyes off the road ahead have the highest risk.[7]

A previous analysis of the distracting effects of mobile phones showed that although talking on the phone seems to have no effect on crash risk, visual-manual phone tasks such as dialling or texting significantly increase crash and near-crash risk. Furthermore, drivers distracted by such activities look away from the road for a long time and distance. On average, drivers take their eyes off the road for 23.3 seconds while texting, 7.8 seconds while dialling without a hands-free system, and between 0.5 and 2.5 seconds when starting a hands-free call.[8] When it comes to the duration of distracting activities in relation to total driving time, the following activities distract drivers longest: talking to passengers (15.32%), eating and drinking (3.16%), and the use of mobile devices (1.3%).[9]

Based on findings in corresponding literature and previous KFV projects[10], the topic of distraction in traffic was further examined by KFV in 2015. In an extensive phone survey, 1,000 road users, including 657 car drivers, were asked about the frequency of their side activities while driving. The respon-

3 Statistics Austria: Road traffic accidents.

4 DaCoTA (2012). Driver distraction. Deliverable 4.8 of the EC FP7 project DaCoTA; SWOV (2013) SWOV- Fact sheet. Distraction in traffic. Leidschendam, the Netherlands, Institute for Road Safety Research.

5 SWOV (2013) SWOV- Fact sheet. Distraction in traffic. Leidschendam, the Netherlands, Institute for Road Safety Research; Klauer S.G., Dingus T.A., Neale V.L., Sudweeks J., Ramsey D., The impact of driver inattention on near-crash/crash risk: An analysis using the 100-car naturalistic driving study data. Washington DC: NHTSA; 2006. (Technical Report).

6 In naturalistic driving observations, the behaviour of road users is observed unobtrusively in a natural setting for a long period of time (SWOV, 2012).

7 Dingus, T.A., Guo, F., Lee S., Antin, J.F., Perez, M., Buchanan-King, M., & Hankey, J. (2016). Driver crash risk factors and prevalence evaluation using naturalistic driving data. PNAS Early Edition, 113(10), 2636-2641

8 Fitch G.M, Soccolich S.A, Guo F., McClafferty J., Fang Y, Olson R.L., Perez M.A., Hanowski R-J.,. Hankey J.M. Dingus T.A.(2013). The impact of handheld and hands-free cell phone use on driving performance and safety critical event risk. DOT HS 811 757. USA: National Highway Traffic Safety Administration.

9 http://www.rospa.com/road-safety/advice/drivers/distraction/fact-sheet/

10 Cf. Kühnelt-Leddihn, A., Bauer, R., Schuster, M., Braun, E., Hofer, M. (2013) Get Smart. Smartphone Verwendung und Verkehrssicherheit bei jugendlichen FußgängerInnen und RadfahrerInnen [Smartphone use by young pedestrians and cyclists and road safety], https://www.bmvit.gv.at/verkehr/strasse/publikationen/sicherheit/vsf/downloads/26_endbericht_getsmart.pdf; Nitsche, P., Aichinger, C., Aigner-Breuss, E., Hahn, M., Kaiser, S., Rußwurm, K., Stütz, R. (2014) FAST. Fahrverhaltensstudien zur Ablenkungsbewertung von Straßeninfrastruktur [Driving Behaviour Studies on the Impact of Road Infrastructure on Driver Distraction] (2014), http://www.bmvit.gv.at/verkehr/strasse/sicherheit/fonds/vsf/downloads/33_fast.pdf ; Aleksa, M., Aichinger, C., Hahn, M., Harnisch, M., Kaiser, S., Nitsche, P., Rußwurm, K., Winkelbauer, M. (2014) ORTUNG. Objektive Beurteilung von Navigationssystemen mit Empfehlungen für den Gesetzesgeber [Objective assessment of navigation systems with recommendations for policy makers], https://www.bmvit.gv.at/service/publikationen/verkehr/strasse/verkehrssicherheit/vsf/downloads/37_ortung.pdf

ses indicated that the most common distractors in Austrian traffic are: conversation with passengers, followed by daydreaming or becoming lost in thoughts, drinking and eating. Another common side activity are phone calls - About one third of the responding car drivers use a mobile phone to make a call while driving at least occasionally. Of these phone calls, 18.5% are made without hands-free equipment. Around half of the car drivers answer their mobile phones while driving at least occasionally, 32.6% of them using a hand-held device.

The reading and writing of text messages are a further cause of risks. Forty percent of the survey participants Forty percent state that they check for incoming messages, text actively or read text messages – 5% even do so “frequently”. An extrapolation of the responses to a previous survey,[11] which focused on phone use while driving, showed that about 73 million text messages are sent from Austrian cars every year. If we assume that drivers do not look at the road for five seconds per text message, at an average speed of 50 km/h Austrian cars would circumnavigate the globe 128 times (5.1 million kilometres) every year while being driven blind.

In addition to the visual distraction, such activities also take up cognitive and motoric resources. It can likewise be assumed that this kind of side activity will continue to grow. To identify specifics for novice drivers, 256 participants in the second phase of driver training[12] (mostly young adults aged up to 22 years) were also surveyed using questionnaires which focused on the frequencies of various side activities during driving. The results showed a rise in communication via text messages during driving among young drivers.

The subjective information was complemented by a video analysis of Naturalistic Driving Observations,[13] in which driving behaviour is observed unobtrusively in a natural setting by video cameras and measuring devices. This analysis revealed that distracting activities could be observed in around half of the video sequences examined. The most frequent side activities were conversations (10%), most of them presumably hands-free phone calls (a few may have been conversations with passengers or soliloquys) and hand-held phone calls (2%).

A KFV expert panel assessed the internal resources used in the most common side activities while driving. In doing so, they assessed the extent to which the attention required for participating in traffic is hindered by visual, auditive, motoric, and/or cognitive demands and ranked the side activities according to their need for action(s). The following three side activities used the most internal resources: phoning, texting, and eating/drinking.

## 2.2 Research questions

The aim of the current study was to evaluate the effect of the top three distracting activities on the driving behaviour and safety of experienced drivers in Austria using a repeated measures design. The specific research questions were as follows:

1. **What is the impact of reading text messages, writing text messages, phoning with a hand-held device, phoning with hands-free equipment, eating, and drinking on**

- five key aspects of driving behaviour and road safety (speed, standard deviation of lateral position, detection and reaction time to sudden critical events, crashes), and on
- the perceived mental load of car drivers?

11 Representative survey (1,000 Austrian drivers, 17+ years), conducted by Marketmind on behalf of KFV, 2014.
12 A post-licence measure in Austria; All learner drivers must complete a safe driving course, psychological group discussion and two feedback drives within a year of obtaining their licence.
13 Data were used from Pommer, A., Donabauer, M., Winkelbauer, M., Schneider, F., Robatsch, K. (2016). KFV- Sicher Leben. Band #1. 100-Car Study Österreich [100-Car Study Austria]. Vienna.

2. **Which differences can be observed in gaze behaviour between different driving conditions (no distraction and distracting activities)?**
   Although this is a well-researched topic, the aim was also to add to the existing literature by including interactions with age and gender as well as subjective data. The study is an extended replication of a Belgian study on the effects of texting (reading and writing) on the driving behaviour of young drivers.[14]

### 2.3 Framework and setting

The project was carried out by the Belgian Road Safety Institute (BRSI) for and with KFV. BRSI was responsible for the set-up, field work, and analysis of questionnaires and simulator data. KFV provided support in the development of the design and scope, the recruitment of subjects, and the fieldwork in Vienna. The eye-tracking data analysis was also conducted by KFV. The project was carried out between June and December 2015.

14 Boets, S., Ross, V., Van Belle, G., Vanroelen, G. & Jongen, E. (2015) Effects of texting on driving behaviour of young drivers in urban traffic. Results of a simulator-based study. Road Safety and Simulation Conference, Orlando, USA (Oct. 6-8 2015).

# 3
# METHODOLOGY

## 3.1 Participants

The recruitment of participants was outsourced to a survey services provider. The aim was to obtain a study sample of 60 participants distributed equally over four groups by age (20-34 years and 35-49 years) and gender, and an additional sample of participants aged 50+ years (only included in the descriptive analysis). Participation was voluntary. The initial inclusion criteria were:

- has a class B driving licence[15] and is medically fit to drive
- has driven a car for a minimum of 10,000 km in the last 12 months
- Samsung Galaxy smartphone user
- does not suffer from migraines or epilepsy, does not wear reading glasses, has no food allergies

Some of the initial criteria had to be lowered or omitted to reach the required sample size (>5,000 km driven in last 12 months; not all participants were Samsung Galaxy smartphone users, but all were experienced in the use of this device; some participants wore reading glasses). Participants were asked to bring their unlocked/charged smartphone, earplugs (if available, otherwise these were provided by KFV), and glasses with them on the day of the experiment. The participants each received 50 euros as compensation for their participation. A total of 78 people were invited to participate. Since eight of these did not show up, and seven had to be excluded (five did not meet the inclusion criteria and two had to stop due to simulator sickness), the final study sample consisted of 63 participants.

| Socio-demographics | Full sample N=63 | | 20-34 N=25 | | 35-49 N=31 | | 50+ N=7 | | Female N=34 | | Male N=29 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | % | N | % | N | % | N | % | N | % | N | % |
| **Gender** | | | | | | | | | | | | |
| Female | 34 | 54 | 12 | 48 | 19 | 61 | 3 | 43 | | | | |
| Male | 29 | 46 | 13 | 52 | 12 | 39 | 4 | 57 | | | | |
| **Age** | | | | | | | | | | | | |
| 20-34 years | 25 | 40 | | | | | | | 12 | 35 | 13 | 45 |
| 35-49 years | 31 | 49 | | | | | | | 19 | 56 | 12 | 41 |
| 50+ years | 7 | 11 | | | | | | | 3 | 9 | 4 | 14 |
| **Education** | | | | | | | | | | | | |
| Lower *(incl. apprenticeship, vocational college and Matura)* | 43 | 68 | 14 | 56 | 21 | 68 | 7 | 100 | 25 | 74 | 17 | 59 |
| Higher | 23 | 37 | 11 | 44 | 10 | 32 | 0 | 0 | 9 | 26 | 12 | 41 |

**Table 1:** *Sample socio-demographics (N=63)* *% within group; Significance levels: ** $p \leq 0.01$ ; * $p \leq 0.05$ (excl. 50+, Chi-square)*

Table 1 provides an overview of the socio-demographic characteristics of the final sample. There were 12 female and 13 male participants in the 20-34 years age category and 19 females and 12 males in

15 The Class B driving licence is in use in the Member States of the European Economic Area (European Union, Iceland, Liechtenstein and Norway) and in Switzerland. It is the most common driving licence and allows the holder to drive a car with passengers. More specifically, a Class B licence holder is permitted to drive motor vehicles with a maximum authorised mass not exceeding 3,500 kg and which are designed and constructed for the carriage of no more than eight passengers in addition to the driver; motor vehicles in this category may be combined with a trailer with a maximum authorised mass which does not exceed 750 kg.

the 35-49 years age group. The 50+ years group consisted of 3 female and 4 male participants. There were no significant differences in the level of education among the (gender or age) groups. The mean age was 37.4 years (SD 10.4; range: 21-63).

Further comparisons based on gender and age category (20-34 vs. 35-49 years) indicated that the subgroups matched on different relevant driving and smartphone related variables, such as reported frequency of car driving, kilometres driven in the last 12 months, months of owning a smartphone, and perceived ease of texting. The frequency of texting did however differ.

There were no significant age or gender differences in the reported frequency of car driving (Figure 1). Most participants were frequent car drivers (driving a car at least 4 days per week).

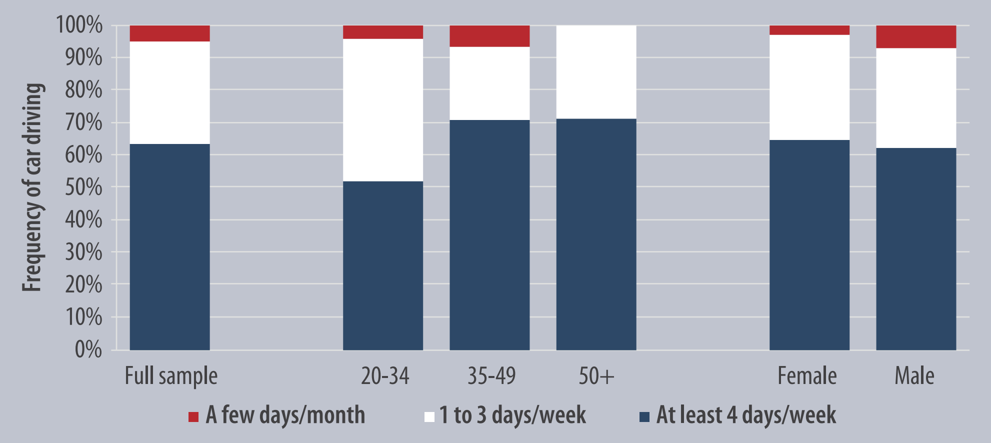



**Figure 1:** *Frequency of car driving* Significance levels: ** p ≤ 0.01 ; * p ≤ 0.05 Chi-square, U-test)

With regard to the number of kilometres driven in the last 12 months, male participants reported slightly higher figures (mean: 18,018 km) than females (mean: 14,800 km), but this difference is not significant (trend) (see Figure 2).

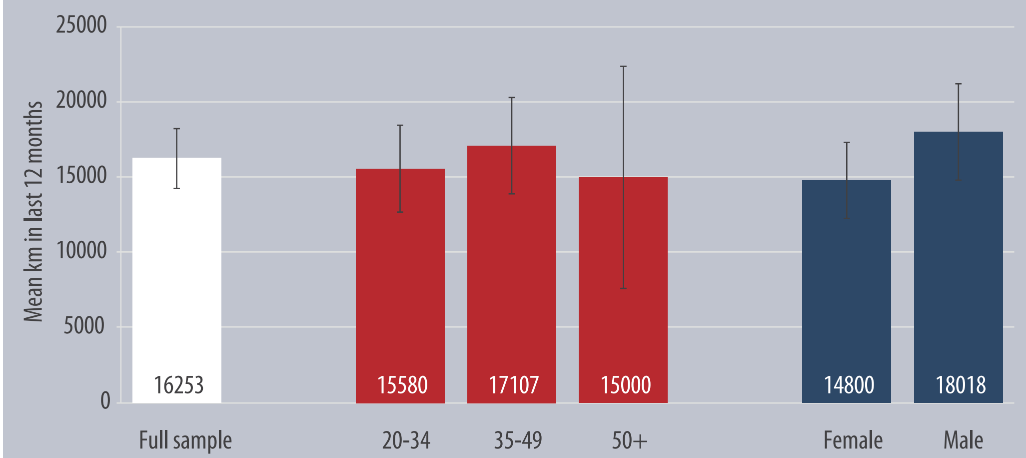



**Figure 2:** *Mean driving distance in last 12 months* Significance levels: ** p ≤ 0.01 ; * p ≤ 0.05 (Chi-square, U-test)

Young and middle-aged participants (excl. 50+) differed slightly (trend) (see Figure 3) in their length of ownership of a smartphone. The gender related difference was not significant.

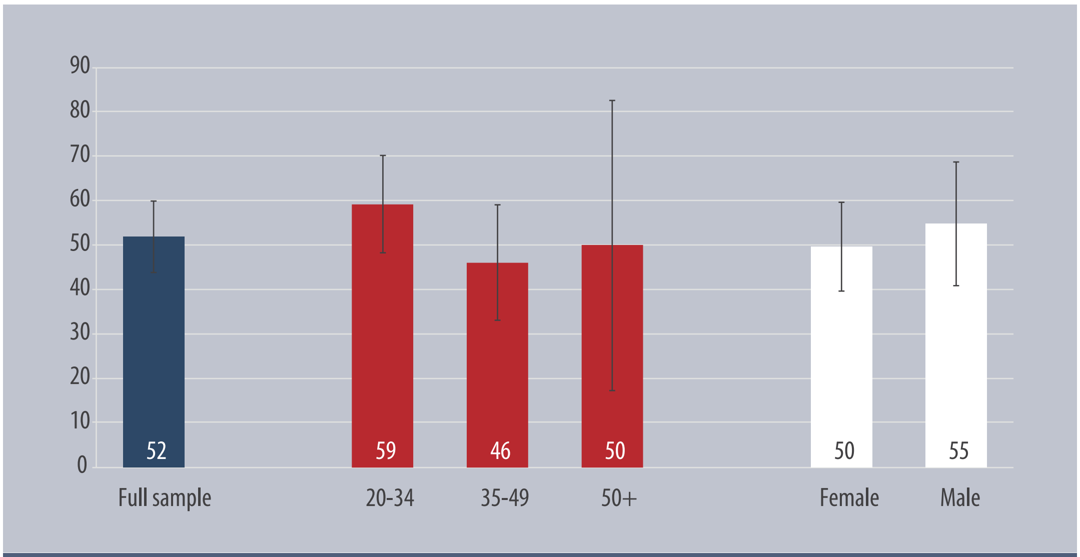



**Figure 3:** *Mean duration of ownership of a smartphone in months* **Significance levels: ** p ≤ 0.01 ; * p ≤ 0.05 (U-test)**

Figure 4 shows that the group of 20-34-year-old participants differed significantly (p ≤ 0.05) from the 35-49-year-old participants in the number of text messages sent (20-34 years: 31; 35-49 years: 13) and received (20-34 years: 31; 35-49 years: 13) on an average day. No significant difference was observed here with regard to gender.

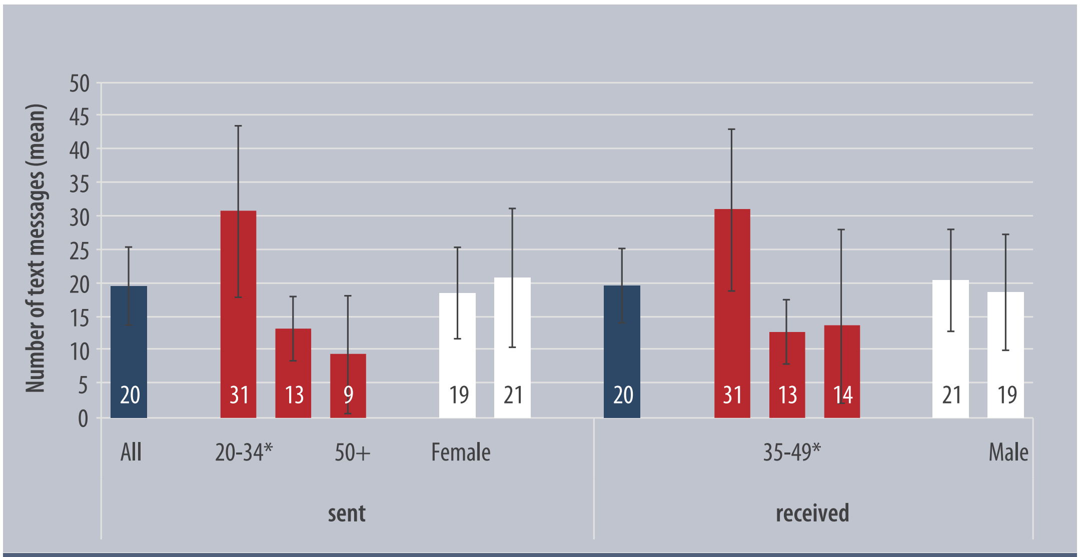



**Figure 4:** *Mean number of text messages sent by day* **Significance levels: ** p ≤ 0.01 ; * p ≤ 0.05 (U-test)**

A question was included on the perceived ease of texting on a scale from 0 (very easy) to 10 (very difficult). In general, the participants seemed to find texting quite easy (see Figure 5). No significant differences were observed here from either a gender perspective or between the 20-34-year-old and 35-49-year-old participant groups.

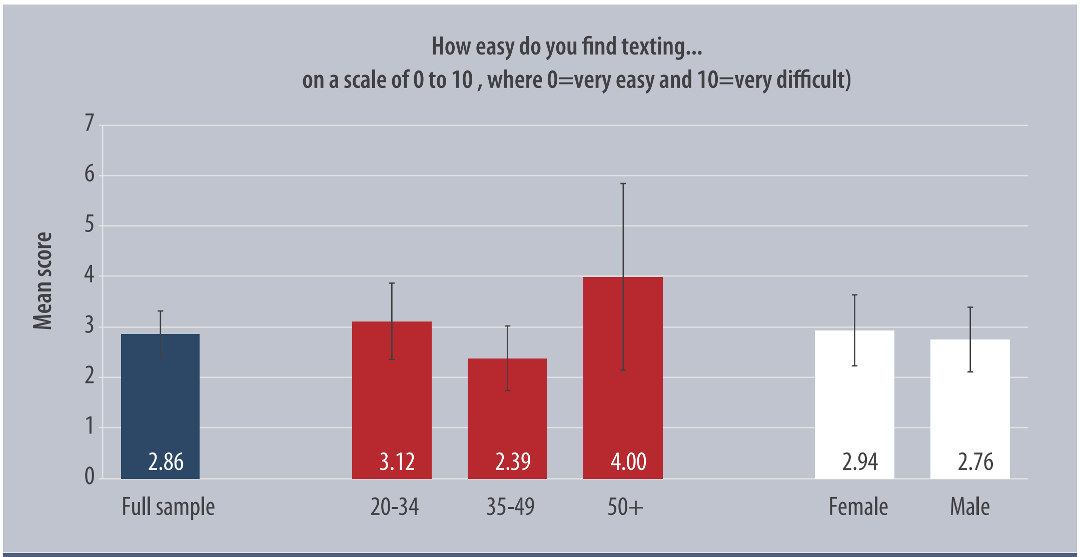



**Figure 5:** *Ease of texting* Significance levels: ** p ≤ 0.01 ; * p ≤ 0.05 (U-test)

A small majority (60%) of participants indicated that they use hands-free equipment in their car while driving (Figure 6). This percentage does not differ significantly between males (61%) and females (59%) and between age groups (20-34 years: 68%; 35-49 years: 57%). For the participants in the 50+ age group, this figure lies at 43%.

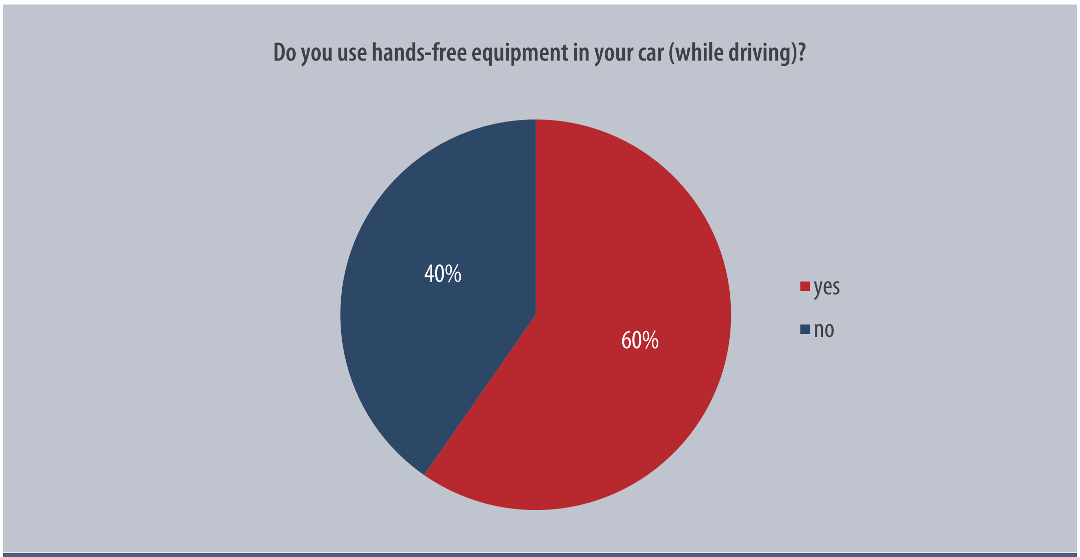



**Figure 6:** *Use of hands-free devices*

The most-frequently mentioned systems in use were:

- Tethered headset with in-ear earplugs (37%)
- Bluetooth operated via steering wheel (27%)
- Bluetooth operated via voice control (19%)
- Tethered microphone and headset (17%)

## 3.2 Materials

### 3.2.1 BRSI driving simulator

The simulator used for this study consisted of a fixed-base set-up including a car seat, steering wheel, pedals, and automatic gear shift. The software used was STISIM3. The driving scenario was visualized up to a visual field of 120° using three LCD television screens. The simulation was displayed as the driver's view from inside the car (first-person perspective) and provided the participant with a view of the surroundings through the front and side windows as if in a real car. The surrounding environment was displayed on three simulated mirrors on the main screens (rear-view mirror on the middle screen and two side mirrors on the left and right screens). Dashboard information was displayed on the middle screen (speedometer, tachometer).

**Figure 7:** *Driving simulator, source: BRSI*

### 3.2.2 Simulated test tracks & secondary tasks

Two familiarization tracks and four test tracks were developed by the University of Hasselt in Belgium (Transportation Research Institute). The four test tracks each had a length of 5 km (8-10 minutes) with the same traffic characteristics: two-lane urban road, 50 km/h speed limit (road signs), no red lights, moderate traffic intensity, non-intrusive road users (cars, pedestrians), light road curves from left to right, daylight, and fair weather (Figure 8).


**Figure 8:** *Snapshot of the drivers' view of the scenario, source: BRSI*

There were three tracks which involved secondary tasks (experimental tracks) and one control track in which no additional task was required. The three experimental tracks were: (1) texting – reading and writing text messages, (2) phoning – talking on the phone (using hand-held and hands-free devices), and (3) eating and drinking. Each track consisted of four sections. In total, each participant thus drove through 16 sections: 12 involving a secondary task and four control sections.

(1) Texting track: two text reading and two text writing sections. In the reading tasks, participants were asked to read a real-time standard message (128 characters) ending with a request to send a message back. For the texting tasks, they were asked to answer the received message (giving five examples of vacation destinations or types of vegetables/fruits).

(2) Phoning track: two hand-held and two hands-free phoning sections, with naturalistic conversations with standard questions in a fixed order ("Name five examples of car brands, zoo animals, etc.).

(3) Eating/drinking track: one continuous eating task running over two sections and one continuous drinking task running over two sections (opening and continuously eating/drinking a sandwich or a bottle of water).

Details of the operationalization of tasks as well as the messages and questions can be found in the Appendix.

The order of the sections was fixed in the texting track and counterbalanced between participants in the phoning and eating/drinking tracks (see Figure 8 for an overview of the experimental set-up).

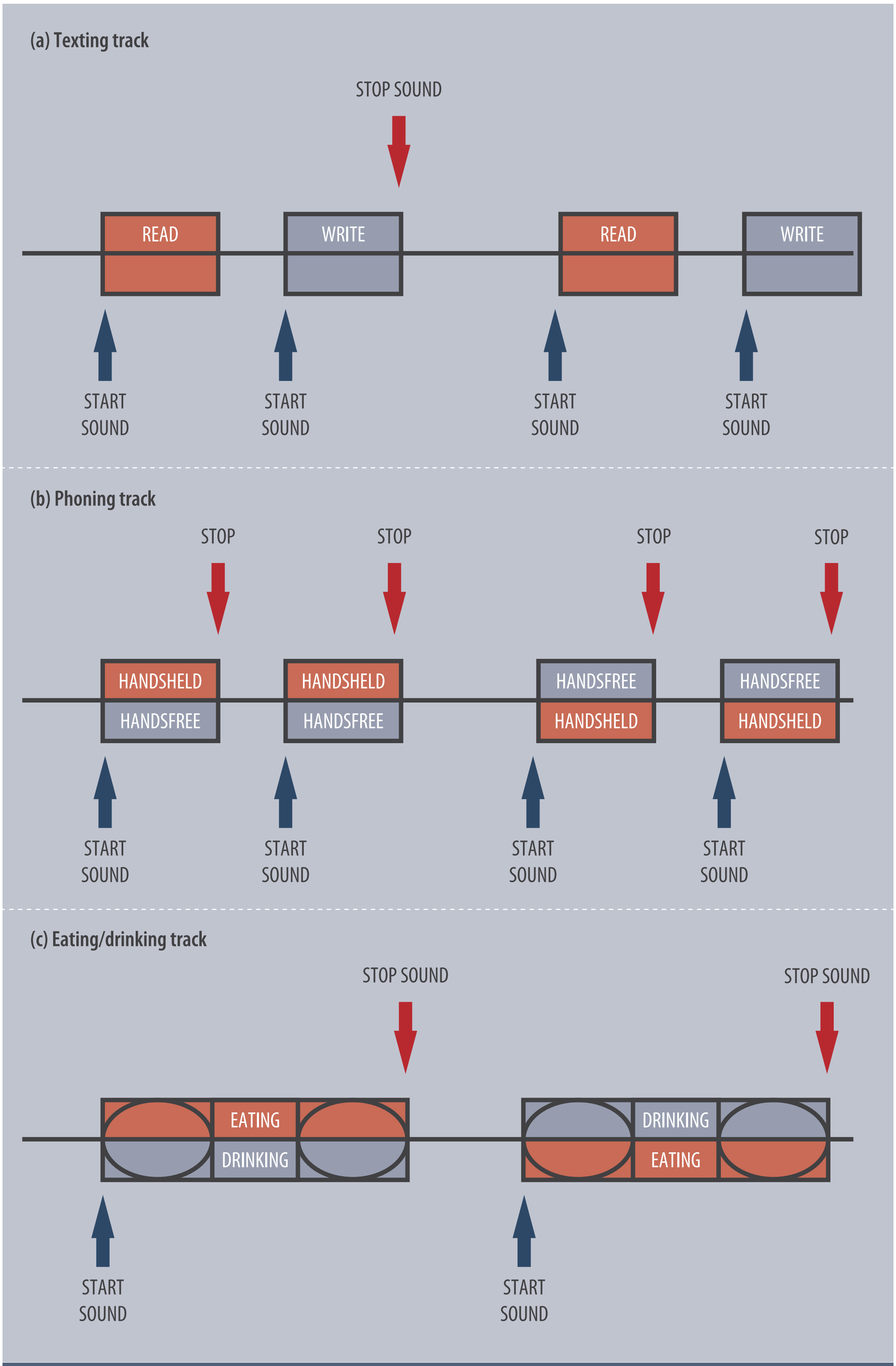



**Figure 9:** *Outline of the four task sections in the experimental tracks used in the final analysis: the blocks in subfigures a) and b), and the circles in the blocks in subfigure c). The blocks refer to the time windows of each experimental task, with start and stop sounds to initiate and end (if not finished before) the task. The different tasks above and below the centre line in b) and c) indicate the counterbalanced order between participants.av*

The start and end point of each section was identical in the four scenarios. In order to reduce order effects, the environmental characteristics differed within each section. In the tracks with secondary tasks, the onset and end of the tasks was announced by a start and stop sound programmed in the scenario.

In each section, one critical event (CE) was programmed (16 in total) which required braking and/or a complete stop depending on the driver's speed. The CE was always a pedestrian suddenly crossing the road (no pedestrian crossing) from behind parked cars on the right (Figures 10 and 11). The use of identical hazards allowed comparisons across all conditions.


**Figure 10:** *Critical event, source: BRSI*

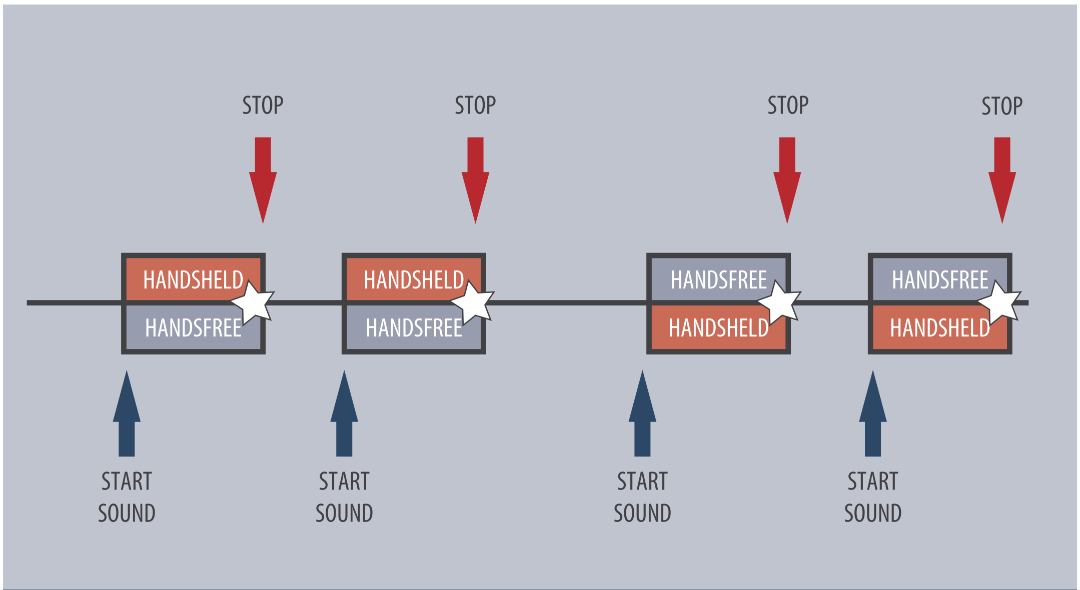



**Figure 11:** *Schematic outline of the programmed critical events in the texting scenario (stars represent critical events)*

A detailed description of the four tracks can be found in the Appendix.

The effects of different types of distractions were evaluated for five key parameters. The definitions of these dependent variables were derived from previous research investigating the effects of distraction on driving behaviour (e.g. Cuenen et al. 2015, Engström et al. 2005, McKeever et al. 2013). The following variables were extracted for the 16 study sections:

- **Mean speed: mean driving speed in meters per second (m/s)**
- **SDLP: standard deviation of lateral position in meters (m), which can be considered as an index of road-tracking precision (Ramaekers, 2003)**
- **Hazard perception:**
  **Detection time (DT): time between the first unexpected move in the critical event and the release of the accelerator (throttle release) in seconds**
  **Reaction time (RT): time between the first unexpected move in the critical event and the pushing of the brake pedal in seconds**
- **Collisions: moment when the surface of the driver's vehicle overlaps with the surface of any other object. A differentiation was made between a 'collision with critical event' and an 'other collision'.**

### 3.2.3 Eye-tracking

The BRSI FaceLAB automotive desktop system was used to track the driver's gaze in a non-intrusive manner during the simulated track drives. This device allows the tracking of eye-movements up to 90° horizontally (i.e. middle simulator screen) and head movements up to 180°. FaceLAB uses a set of cameras as a passive measuring device (see Figure 12). These cameras were placed on a platform behind the simulator's steering wheel and did not hinder the participants' view of the middle screen. The distance between the participants' faces and the cameras ranged from 80 cm to 1 metre. Using the EyeWorks Premier Analysis Software, real-time data integration with the STISIM simulator was applied. With EyeWorks, each test track drive is captured on video, including a visual overlay of the gaze-tracking on the track scenario on the simulator's middle screen.


**Figure 12:** *FaceLAB cameras, source: BRSI*

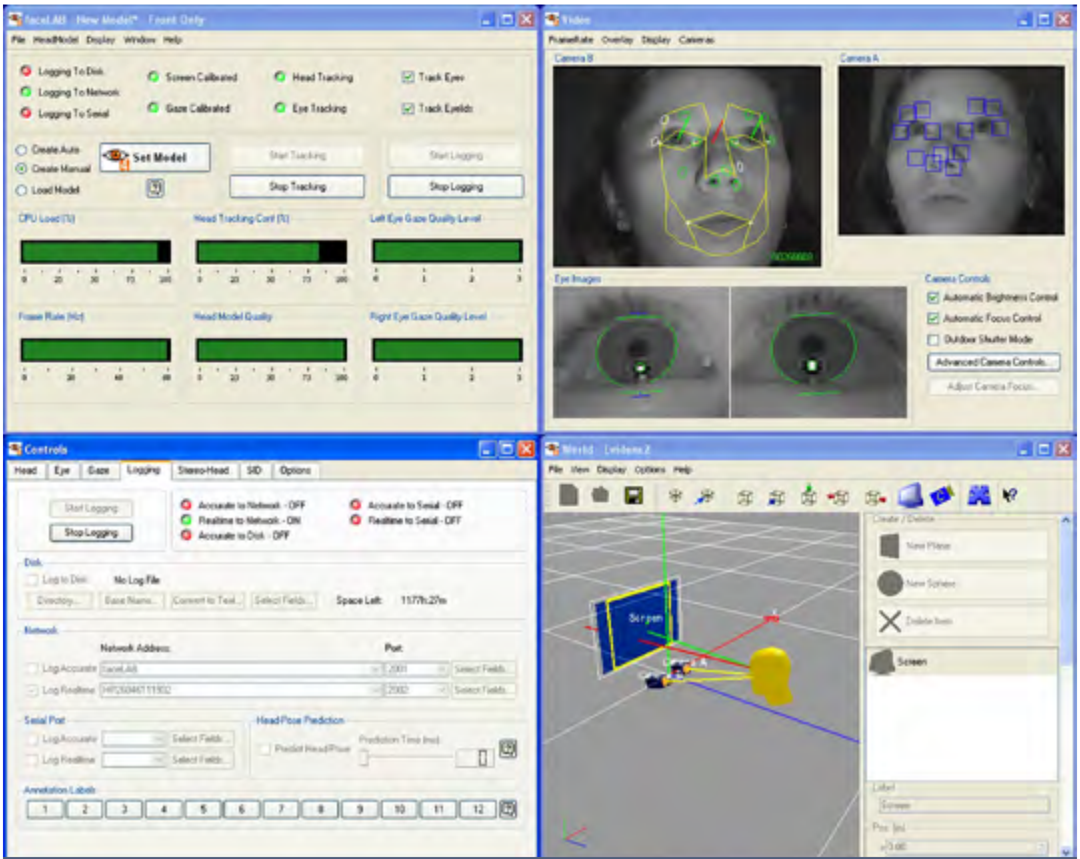



**Figure 13:** *FaceLAB software, source: BRSI*

### 3.2.4 Questionnaires

A number of different questionnaires were developed, namely a pre- and post-questionnaire to be completed by each participant before and after the experiment as well as three post-ride questionnaires to be completed after each experimental track in order to assess how the drive and tasks were experienced (copies of all questionnaires are provided in the Appendix).

- Pre-questionnaire: socio-demographic and car driving variables, smartphone use, self-reported distraction behaviour while driving, perceived impact of distractions on attention to traffic, opinion on a total ban of mobile phone use while driving, reasons for engaging in distracting activities while driving, and presence of symptoms related to simulator sickness.
- Post-questionnaire to assess the impact of participation on the perceived effect of distractions while driving, opinion on the total ban of mobile phone use while driving, reasons for engaging in distracting activities, and the simulator sickness symptoms.
- Post-ride questionnaires to obtain assessments from participants directly after they had driven the test tracks with distraction tasks. These included items like perceived required effort, self-evaluation of driving behaviour, and perceived effects of the distraction tasks.

## 3.3 Study design and analysis

This study took the form of a laboratory experiment with a repeated measures (within subjects) design with one control and six experimental conditions. The order of the conditions was counterbalanced between participants to reduce fatigue or learning effects. In addition to within-subject comparisons of experimental and control conditions, the recruited sample also allowed between-group comparisons for two age (20-34 and 35-49 years) and gender groups. Driving and self-reported data were gathered for all participants along with eye-tracking data for part of the sample.

The effects of different types of distraction were evaluated for five key parameters. The definitions of these dependent variables were derived from previous research investigating the effects of distraction on driving behaviour.[16] A Matlab© compiler (Release 2015a, Mathworks) was used to extract the five dependent driving variables:

- **Mean speed:** Mean of the digitally recorded driver speed with an interval of 30 milliseconds (ms) within the defined analysis section = within each critical section from start sound until just before the onset of the CE (m/s).
- **SDLP:** Standard deviation of the continuously recorded (meter (m); each 30ms) lateral lane position, referenced in relation to the centre of the driver's vehicle with respect to the centre dividing line on the roadway, within the critical analysis section for SDLP.

The relevant sections for mean speed and SDLP begin at the start sound (i.e. task onset) and continue until just before the onset of the critical event. Free segments without traffic lights, road hazards, or other events are required as these influence the speed and SDLP. In the event of a crash before the CE, the speed value is invalid.

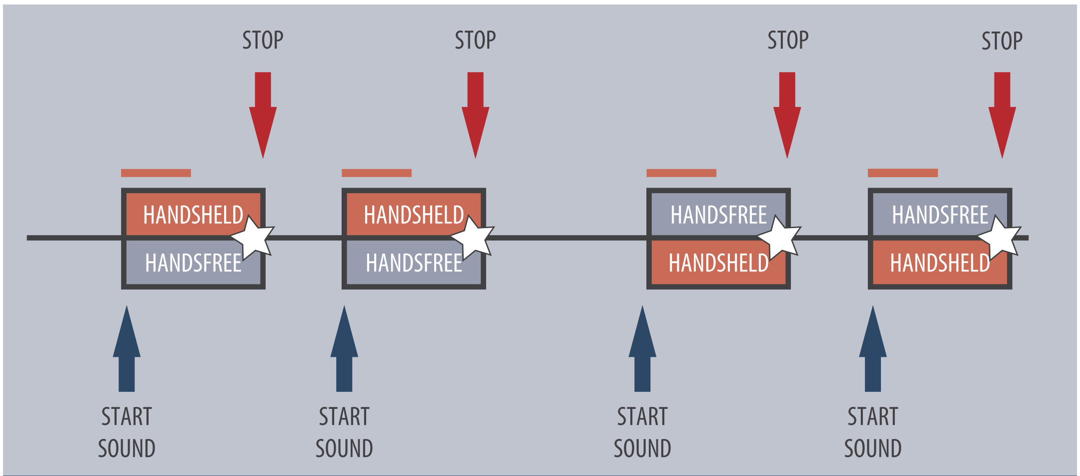



**Figure 14:** *Relevant sections for mean speed and SDLP in texting scenario* *Defined section for measuring mean speed and SDLP: ▬; Star = critical event*

- **Detection time and reaction time to critical events:** Time difference between the onset of the CE (t0 = speed CE >0m/s = pedestrian starts to move) and a 10% throttle or accelerator release (DT) and a 10% brake pedal press (RT) relative to hazard onset (t0). This 10% criterion is used to avoid accidental releases/presses.
  A further basic assumption for DT and RT was that both are only determined within the 'CE time window' from the exact hazard onset until hazard end (i.e. when the subject has successfully passed the hazard). DT and RT calculations are ignored (missing values) in the event of a crash with the CE and/or overtaking. If the 10% criterion cannot be met at the CE onset, it is considered a missing value. This could be the case, for example, if the accelerator was already released more than 90% or the brake pedal was already pressed more than 90% at the time of the hazard onset. In such cases, a 10% change could no longer be achieved.

- **Collision with CE:** (0/1) crashes with the CE only

- **Collision section:** (0/1) all possible crashes within the entire section, including those with the CE

The following subtasks of the distraction tasks were included as valid task handling (data included in the analysis):

16 e.g. Cuenen et al. 2015, Engström et al. 2005, McKeever et al. 2013

- Reading/writing: pick up phone from seat, open text messenger, read/write, send back, lay phone back down on passenger seat
- Hand-held phoning: pick up phone from seat, initiate call, listen and talk, lay phone back down on passenger seat when call is ended
- Hands-free phoning: initiate phone call by clicking the earplug OR via the phone, listen and talk, lay phone back down on passenger seat when call is ended
- Eating: pick up food from seat, unwrap, continuously eat, lay food back down on seat at stop sound
- Drinking: pick up bottle from seat, open, drink, lay bottle back down on seat at stop sound or before (if finished)

The validity of secondary tasks was assessed using the qualitative information on the observation grid that was filled out independently by at least two observers. The research team made prior decisions on inclusion and exclusion criteria for the tasks. Driving data was excluded, for instance, when no task was done (e.g. participant did not want to eat/had an allergy, connection problem prevented the call being received, call was erroneously rejected, etc.) or in the event that it was not handled properly (e.g. difficulty in reading/writing a text message without reading glasses, participant waited a long time before starting task, etc.). Outlier data was excluded from the analysis (continuous values >2 SD from sample mean or 'extreme' values). For the self-reported data, several (additional) variables were recoded and computed (e.g. questionnaire rating scale answers transformed into dichotomous variables; composite score of self-reported distraction behaviour while driving, etc.).

The analysis began with a **descriptive analysis** of the entire sample, followed by analyses for age group and gender: tables and figures for self-reported data, and boxplots and scatterplots for driving data (median; upper/lower quartile; min/max; outliers) (see Chapter 4). The 50+ age group (N=7) was always excluded in the analysis of driving data.

For the **in-depth analysis** of self-reported data, the Chi-square test, Mann-Whitney U-test, Friedman tow-way analysis of variance by ranks, and Wilcoxon signed rank test (SPSS) were used for the following evaluations:

- General comparisons of different conditions (post-ride questionnaire and parts of pre-questionnaire)
- Self-reported data by age category and gender (pre-questionnaire)
- Comparisons of pre- and post-questionnaires (impact evaluation).

For analyses based on age categories, the participants in the 50+ age group were excluded. Comparisons based on gender were executed on the full sample (N=63) as well as on the sample excluding the 50+ age group (N=56). The results always refer correctly to the source sample.

For the N=56 sample (50+ age group excluded), mathematical models were developed for the six dependent driving variables using R software for statistical computing and graphics (R Core Team, 2015). These models included age category (2), gender, number of kilometres driven in the last 12 months, a composite score of self-reported distraction behaviour while driving, and task order in the experiment. Linear Mixed Models (LMM) were made for continuous driving variables and Generalized Linear Mixed Models (GLMM) for collisions (binomial). The purpose of such a model is to estimate the effects of different independent variables on the dependent variable, while taking into account random effects (heterogeneity across individuals). The six dependent variables are: mean speed, standard deviation of lateral position (SDLP), detection time for the critical event (DT to CE), reaction time to the critical event (RT to CE), collision with the critical event (crash CE), and collision within the section (crash section). The independent variables are: the different distraction tasks (and their interactions with age category and with gender), age category (2), gender, kilometres driven in the last 12 months, self-report composite, and task order (to capture order related bias, e.g. through boredom, fatigue or learning).

The self-report composite is the calculated mean of the responses to a question in the pre-questionnaire regarding the six secondary tasks in the experiment. The question was “In the last 12 months, how often did you do the following while driving a car?”. The behaviours were: answer a phone call (hand-held), answer a phone call (hands-free), read a text message or e-mail on a smartphone, write/send a text message/e-mail on a smartphone, eat wrapped food (e.g. sandwich, chocolate bar), and drink from a bottle/can. Participants could answer on a scale from 1 to 5, where 1 = “never” and 5 = “(almost) always”. The composite thus gives a score of reported frequency of involvement in distraction activities while driving.

### 3.4 Eye-tracking analysis

For the purpose of analysing relevant eye-movements and gaze, the screen was divided into several “areas of interest” (AOI). Gaze data for the following areas were analysed:

- Road centre
- Driving mirror
- Speedometer
- Tachometer
- All screen


**Figure 15:** *Areas of interest for eye-tracking, source: KFV*

The following relevant parameters could thus be generated:

- % gaze at driving relevant areas on the screen (sum of road centre, driving mirror, speedometer, tachometer)
- % gaze at all other areas on the screen
- % gaze off the screen

# 4 RESULTS

## 4.1 Pre-questionnaire

This section includes the results of the pre-questionnaire items pertaining to self-reported distraction behaviour while driving and opinions and intentions with regard to distraction and driving. The analyses were performed using IBM SPSS Statistics 22. For some questions, the responses were dichotomized for comparative analysis purposes. Different non-parametric tests were used. The Wilcoxon signed rank test was used to assess whether population mean ranks of repeated measurements in a single sample differ between self-reported distraction behaviour while driving and self-reported distraction behaviour while waiting at a red light or in a traffic jam. The Friedmann test was used to detect differences on the same statement for different types of distraction. Chi-square tests were used to assess differences between age groups (20-34 vs. 35-49 years) and gender. Statistical significance was set at a 95% confidence interval ($p \leq 0.05$).

### 4.1.1 Self-reported behaviour

Participants were asked how often they had engaged in ten different distracting activities while driving during the 12 months prior to the simulation. The answers were dichotomized as never (= 1) versus at least once (= 2 to 5). Figure 16 shows the results ordered according to reported frequency.

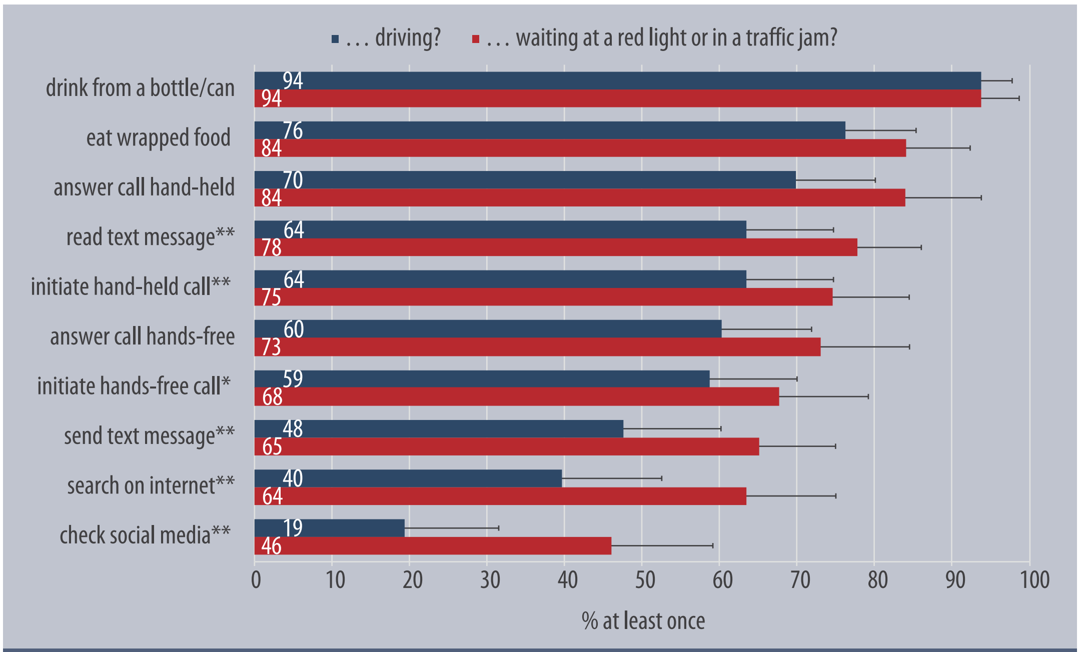



**Figure 16:** *Frequency of distracting activities while driving (within 12 months prior to simulation)* *Significance levels: ** $p \leq 0.01$ ; * $p \leq 0.05$ (Wilcoxon)*

Most participants reported having drunk (94%) or eaten (76%) while driving. Checking social media was ranked lowest (19%), followed by conducting an internet search (40%), and sending text messages (48%). These activities were reported by less than half the sample, while the others were all reported by over 50%. During the 12 months prior to the simulation, 70% of the participants indicated that they had answered a phone call "hand-held" while driving on at least one occasion, while a smaller percentage (60%) reported having done so "hands-free". A similar percentage (64%) stated that they had read a text message or initiated a hand-held phone call while driving on at least one occasion. On a descriptive level, a comparative analysis evaluating differences according to driving context (while driving vs. while waiting at a red light or in a traffic jam) indicated that each secondary activity, with the exception of drinking (2 x 94%), was reported more frequently while waiting at red light or in a traffic jam. This difference is significant for some distractions, namely reading/sending text messages, initiating phone calls (hand-held and hands-free), and using the internet/social media. Indeed, the percentage of participants who reported using the internet or social media almost doubled (from 19% to 46%, and from 40% to 64% respectively).

The following figures provide an overview of self-reported distractions analysed by age group (Figure 17) and by gender (Figure 18). In general, all distraction activities were reported more frequently by participants in the younger age group (20-34 years) than the older age group (35-49 years). The only exceptions were eating (76% and 77%) and using social media (16% and 17%) while driving. One significant age-related difference (excl. 50+) was detected: young participants reported having written/sent a text message while driving significantly more often than their older counterparts (60% vs. 32%; p ≤ 0.01, Wilcoxon). The top three reported distractions while driving (drinking, eating, and answering a phone call hand-held) are the same for young and middle-aged participants. Answering a phone call hand-held and reading texts come in equal third place in the younger group, while reading texts is only ranked in seventh place (of 10) for the older group (35-49 years).

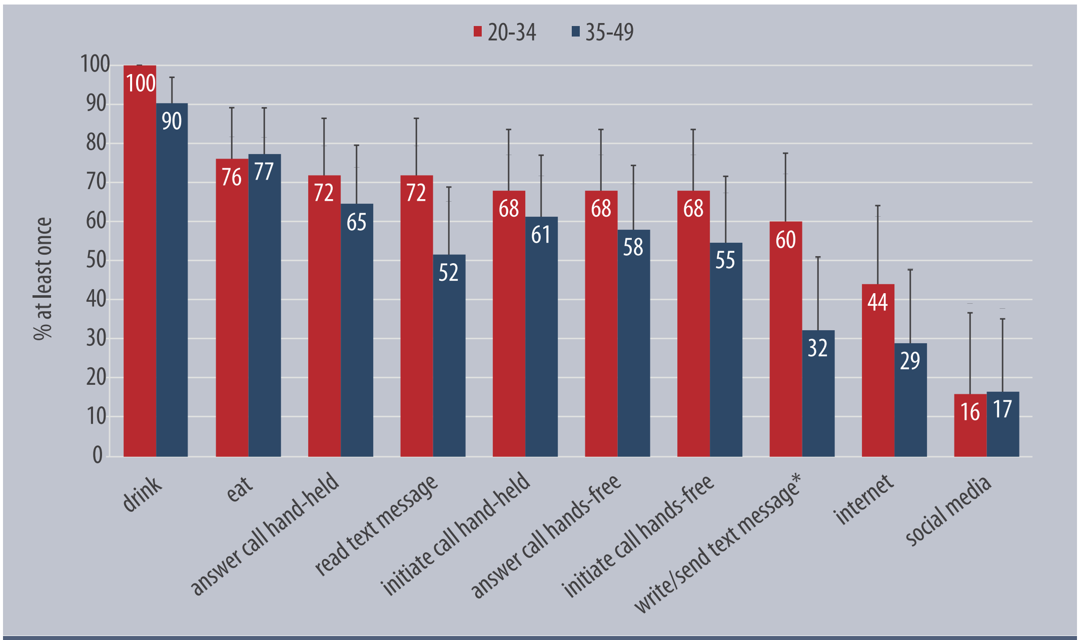



**Figure 17:** *Frequency of distracting activities during driving (past 12 months) – by age category* *Significance levels: ** p ≤ 0.01 ; * p ≤ 0.05 (Chi-square)*

Male participants reported a higher level of participation in nine out of ten of the distractions while driving during the 12 months prior to the simulation than their female counterparts. The only exception here was answering a phone call hands-free (59% of males vs. 62% of females). Gender difference was significant for reading text messages (83% vs. 47%) and for searching for information on the internet (59% vs. 24%). The top three self-reported distractions for male participants were drinking (97%), eating, and reading text messages (both 83%). The top three distractions for females were drinking (91%), eating (71%), and answering a phone call hand-held (65%.)

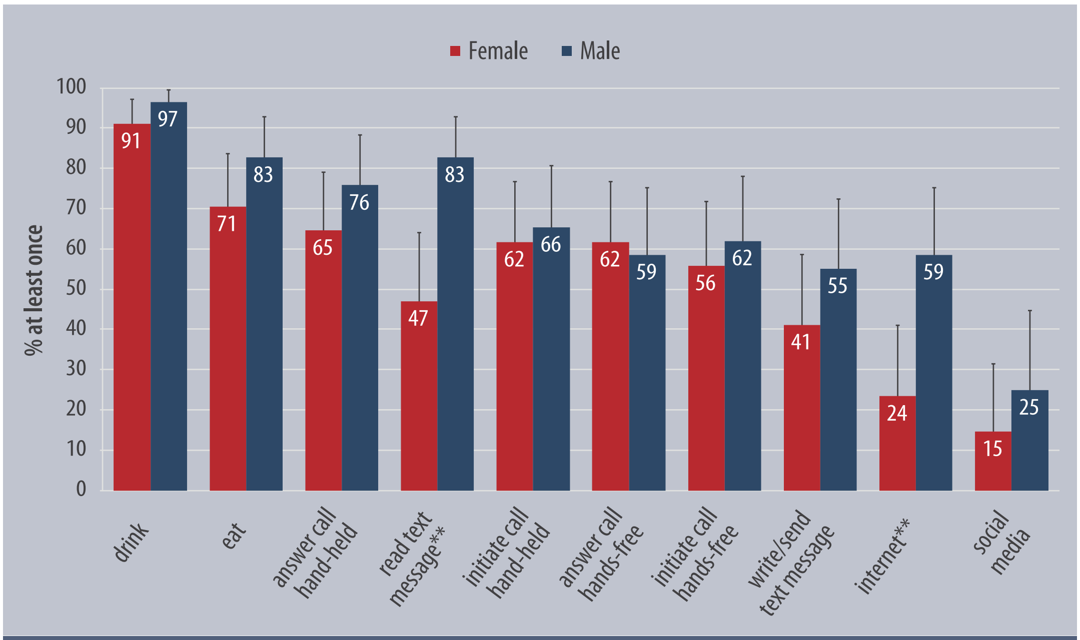



**Figure 18:** *Frequency of distracting activities during driving (past 12 months) – by gender* *Significance levels: ** p ≤ 0.01 ; * p ≤ 0.05 (Chi-square)*

### 4.1.2 Opinions

Another question related to the extent to which participants agreed with the statement that their attention to traffic decreases while driving for six distractions that corresponded to the experimental conditions in the simulator study. They were asked to indicated their response on a scale from 1 (disagree) to 5 (agree). The participants' answers were dichotomized, and those with a score of 4 or 5 ((somewhat) agree) are shown in Figure 19.

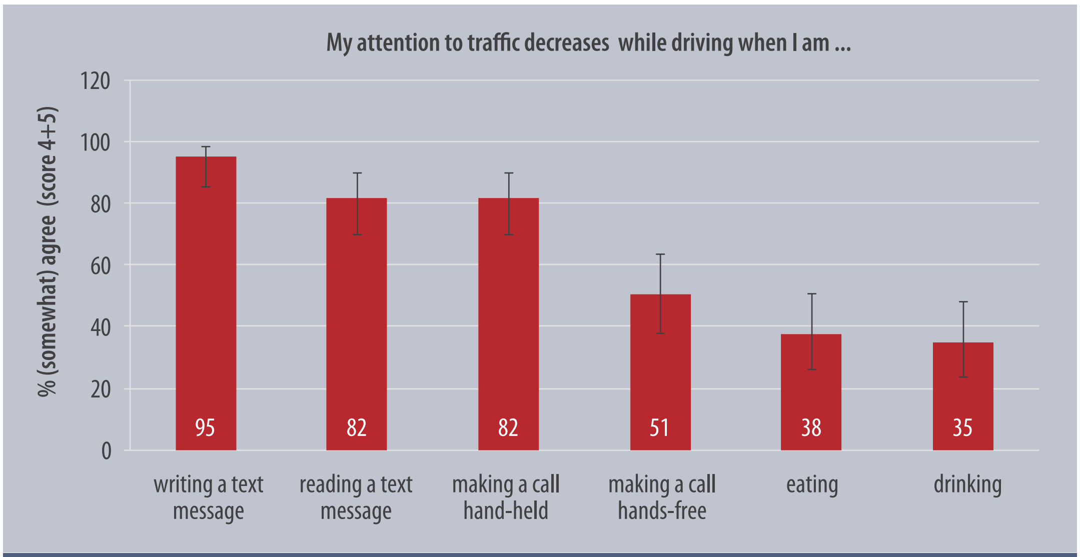



**Figure 19:** *Extent to which participants agree with statements* *Significance levels: ** p ≤ 0.01 ; * p ≤ 0.05 (Chi-square/Friedmann)*

There was a very high consensus among the participants (95%) that writing a text message leads to decreased attention to traffic. Over 80% agreed on the same statement regarding reading text messages and hand-held phoning. In comparison, significantly fewer participants agreed that hands-free phoning (51%), eating (38%), and drinking (35%) have a negative effect on attention ($p \leq 0.01$, Friedmann). Furthermore, there was a significant gender related difference with regard to hand-held phoning: 91% of females vs. 71% of males (somewhat) agreed that hand-held phoning while driving decreases attention to traffic ($p \leq 0.05$, Chi-square) (the significance disappears when participants in the 50+ age group are excluded). No age related differences could be observed (excl. 50+).

Opinions on a total ban of the use of mobile phones while driving also formed part of the questionnaire. The possible responses here were: "fully support", "support, but only for hand-held phoning", and "oppose". The response frequencies are presented in .

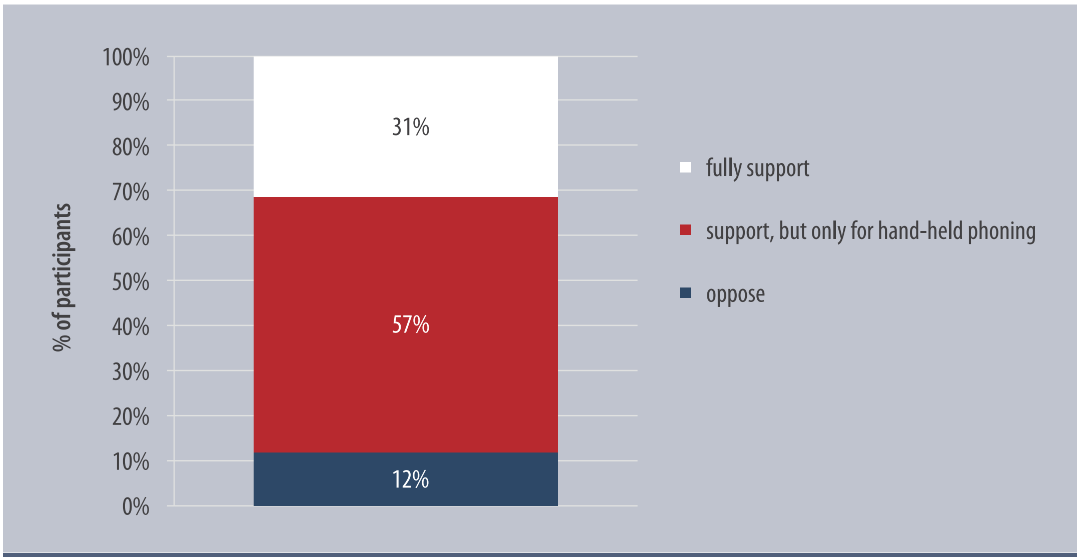



**Figure 20:** *Support of a total ban of mobile phone use while driving*

Eighty-eight percent of the participants support a ban on mobile phone use while driving: The majority (57%) would support a ban on hand-held phoning, while 31% support a complete ban on phoning while driving.

### 4.1.3 Intentions

Participants were also asked to indicate whether they intended to engage in the six distracting behaviours while driving in the next four weeks on a scale from 1 (= definitely not) to 5 (= definitely). The answers were dichotomized, and those with a score of 4 (fairly definitely) or 5 (definitely) are presented in Figure 21.

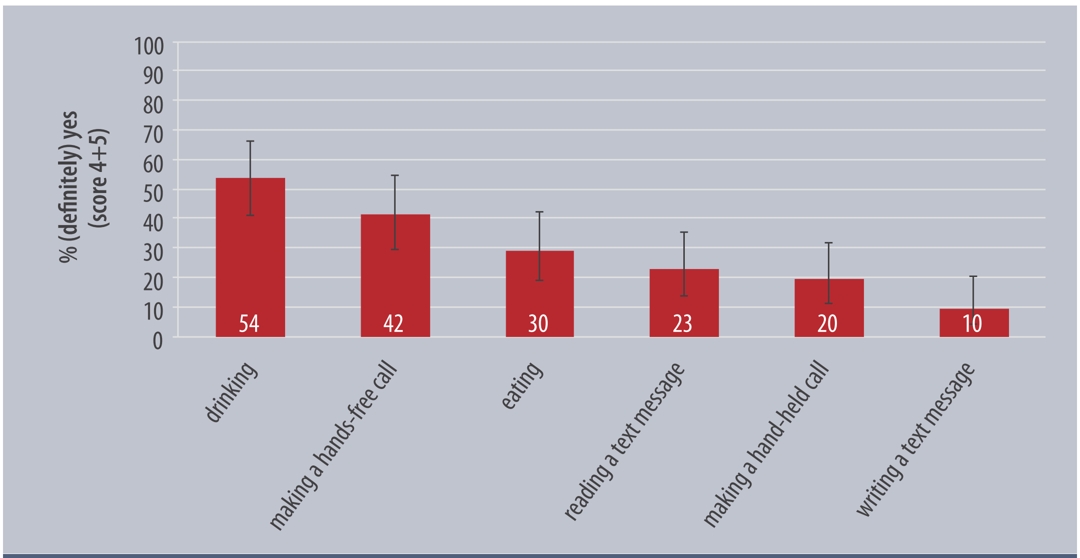



**Figure 21:** *Intention to do the indicated acts while driving in the next four weeks*

The intention to drink while driving was reported by significantly more participants than all other distractors (1 in 2 or 54% vs. 10% for writing texts or 42% for hands-free phoning). Writing text messagess was also reported by significantly fewer participants than hands-free phoning ($p \leq 0.01$, Friedmann). Furthermore, there were two significant differences here between age groups (excl. 50+): 72% of the younger participants (20-34 years) intended to drink and make hand-held calls versus 41% and 32%, respectively, of the older participants (35-49 years) ($p \leq 0.05$, Chi-square). No gender related differences were observed (incl./excl. the 50+ age group).

#### 4.1.4 Summary

The pre-questionnaire results relating to the experimental conditions in this study can be summarized as follows:

- There was considerable consensus among participants on the negative effects of reading/writing text messages and hand-held phoning (>80%) on attention to traffic when driving. One in two participants believes that hands-free phoning has a negative effect.
- Although the risks involved in texting and using hand-held phones seemed to be acknowledged by most participants (>80%), these were nonetheless behaviours that were self-reported by 64% (reading text messages) and 70% (hand-held phoning).
- Despite the fact that most participants (>80%) believe that reading text messages and hand-held phoning have a negative effect on driver attention, 70% read a text message while driving, with males doing so significantly more frequently than females.
- Writing text messages was considered the most detrimental factor with regard to attention to traffic and is also the least self-reported behaviour. Yet almost half of the participants admitted to having texted while driving. This level of self-reported activities is mostly attributable to the young participants (20-34 years).
- Eating and drinking were rarely considered to have a negative effect on driver attention (only one in three participants thought this to be the case). This was also reflected in the self-reported behaviour: drinking and eating are the top two reported sources of distraction while driving.

### 4.2 Simulator driving variables

This section presents the results of the descriptive and in-depth analyses relating to the six dependent variables (speed, standard deviation of lateral position, detection/reaction time to sudden critical events, crashes, N=56). The 50+ age group is excluded in the descriptive and mathematical analyses in this section because of the small sample size (low statistical power). An overview of the entire sample (including 50+) can be found in the Appendix. For each dependent variable, model sample (N=56) boxplots (for continuous driving variables) and scatterplots (for the dichotomized crash variables) are first presented. The boxes in the boxplots indicate the median value and upper and lower quartile; the lines indicate the minimum and maximum value. Outliers are represented by dots. The results of the mathematical (G)LMM models estimating the effects of different independent variables on each of the driving variables are presented next. Additional boxplots are included in cases of significant interaction effects between the experimental conditions and age category and/or gender. A complete overview of boxplots and scatterplots for the mathematical model sample (N=56) (general, by age group, and by gender) can also be found in the Appendix.

### 4.2.1 Mean speed

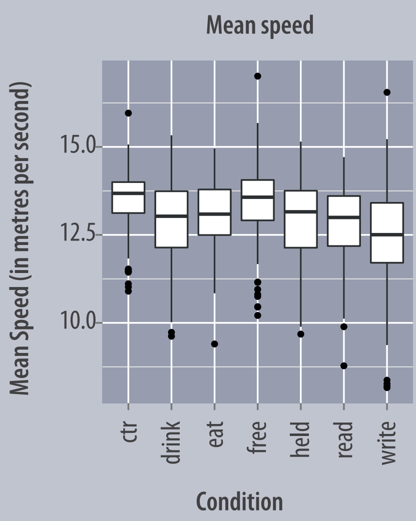



**Figure 22:** *Mean speed boxplot (N=56)*

The boxplot in Figure 22 shows that the median of the mean driving speed in the control condition was higher than for all experimental conditions with the exception of hands-free phoning. The bar graph (Figure 23) shows that the participants drove at an average speed of 13.5 m/s in the control conditions, which is slightly less than the indicated speed limit of 50 km/h (=13.8 m/s). The lowest mean speed was measured while writing text messages (12.4 m/s = 44.5 km/h), which is also where the biggest variance in data can be observed.

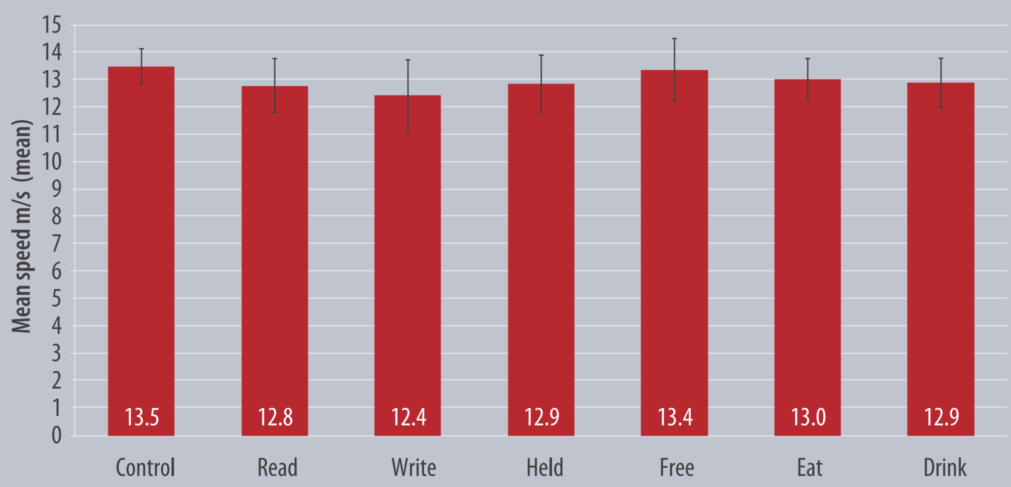



**Figure 23:** *Mean speed bar graph (N=56)*

| Term | Est. | S.E. | Sign. |
|---|---|---|---|
| Intercept | 13.16 | 0.36 | *** |
| **Reading text messages** | **-0.82** | **0.19** | *** |
| **Writing text messages** | **-1.13** | **0.19** | *** |
| **Hand-held phoning** | **-0.68** | **0.19** | *** |
| Hands-free phoning | -0.30 | 0.19 | |
| **Eating** | **-0.76** | **0.19** | *** |
| **Drinking** | **-0.94** | **0.19** | *** |
| Self-report composite | 0.14 | 0.13 | |
| Age category (ref: 20-34 years) | -0.17 | 0.22 | |
| Gender (ref: female) | -0.06 | 0.23 | |
| Km in last 12months | 0.08 | 0.10 | |
| **Task order (1 to 16 tasks)** | **0.01** | **0.01** | * |
| **Interactions** | | | |
| read x gender | 0.51 | 0.21 | * |
| write x gender | 0.63 | 0.21 | ** |
| held x gender | 0.45 | 0.21 | * |
| drink x gender | 0.75 | 0.21 | *** |
| write x age category | -0.49 | 0.21 | * |

**Table 2:** *Mean speed linear mixed model (N=56)* *Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1*

Significant estimated effects were found for experimental conditions. This means that all distraction tasks with the exception of hands-free phoning (p = 0-0.001) led to a significant decrease in mean speed compared to the control value. Writing text messages had the biggest effect on driver speed. Gender also played a major role for specific experimental conditions (see interaction effects): females drove significantly slower while drinking (p = 0-0.001), writing text messages (p = 0.001-0.01), hand-held phoning (p = 0.01-0.05), and reading text messages (p = 0.01-0.05). No such gender effects were found in the main model. Middle-aged participants drove significantly slower than their younger counterparts while writing text messages (p = 0.01-0.05). The relevant boxplots are presented in . There is also a significant task order effect (p = 0.01-0.05), which was controlled for by counterbalancing the order of the conditions.

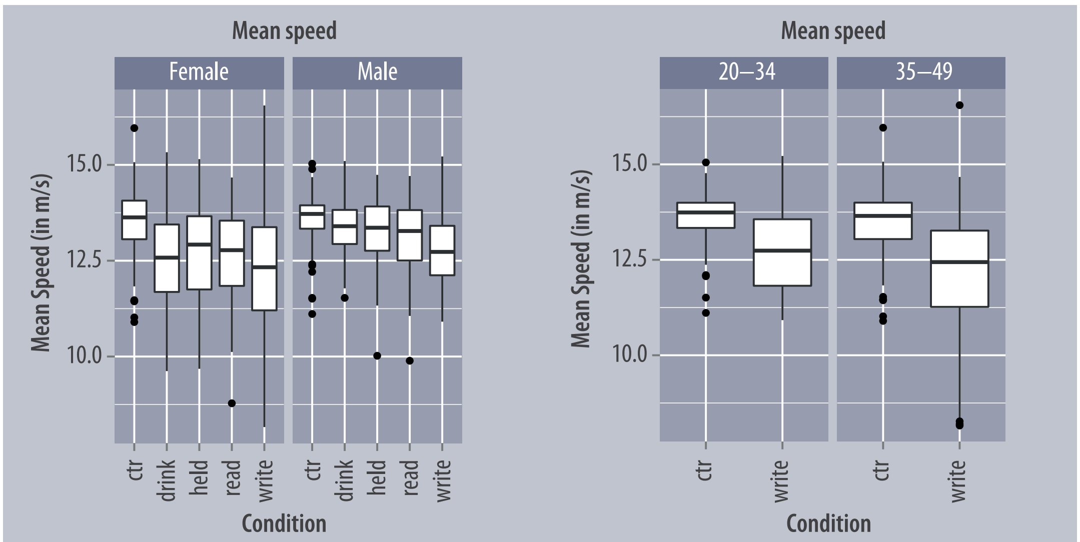



**Figure 24:** *Mean speed boxplot – by age and gender*

### 4.2.2 Standard deviation of lateral position (SDLP)

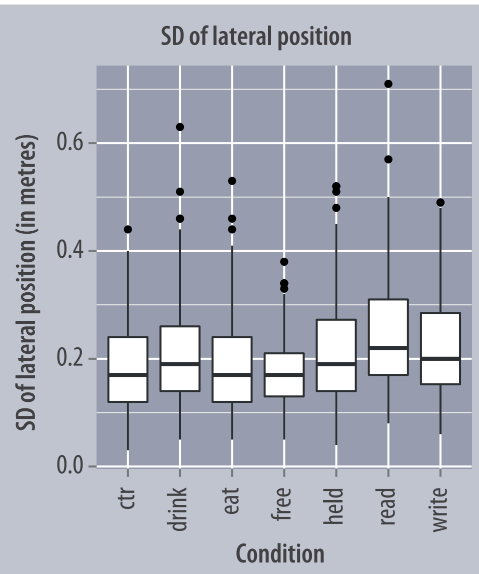



**Figure 25:** *SDLP boxplot (N=56)*

Based on the boxplot (Figure 25), only small differences were found between the experimental and the control conditions. SDLP was highest while reading and writing text messages. The bar graph for mean SDLP (Figure 26) confirms the highest increase for reading text messages.

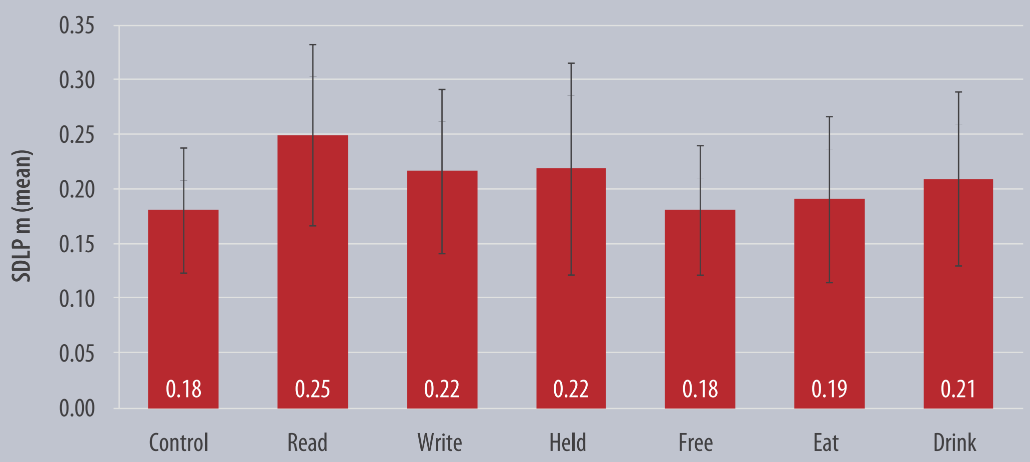



**Figure 26:** *Standard deviation of lateral position bar graph (N=56)*

| Term | Est. | S.E. | Sign. |
|---|---|---|---|
| Intercept | 0.198141 | 0.020323 | *** |
| **Reading text messages** | **0.048060** | **0.015027** | ** |
| Writing text messages | 0.024300 | 0.014590 | , |
| Hand-held phoning | 0.007410 | 0.014925 | |
| Hands-free phoning | -0.001016 | 0.014912 | |
| Eating | -0.013413 | 0.015172 | |
| Drinking | 0.023908 | 0.014694 | |
| Age category (ref: 20-34 years) | 0.019876 | 0.015354 | |
| Gender (ref: female) | -0.026109 | 0.012308 | * |
| **Interactions** | | | |
| read x age category | 0.050853 | 0.020324 | * |
| held x age category | 0.046561 | 0.020124 | * |
| eat x age category | 0.043413 | 0.020047 | * |

**Table 3:** *SDLP Linear Mixed Model (N=56)* [17] *Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 ',' 0.1 ' ' 1*

In general, the effects of the different experimental conditions on SDLP were very small. There was one significant effect: while reading text messages, the SDLP was significantly higher than for the control condition (p = 0.001-0.01). The larger SDLP during text message writing was only a trend difference (p = 0.05-0.1). A significant gender difference was also seen: male participants were generally better at keeping in lane than their female counterparts (p = 0.01-0.05). Furthermore, the older age group (35-49 years) showed a significantly increased SDLP compared to the younger age group (20-34 years) during text message reading, hand-held phoning, and eating (p = 0.01-0.05) (Figure 27).

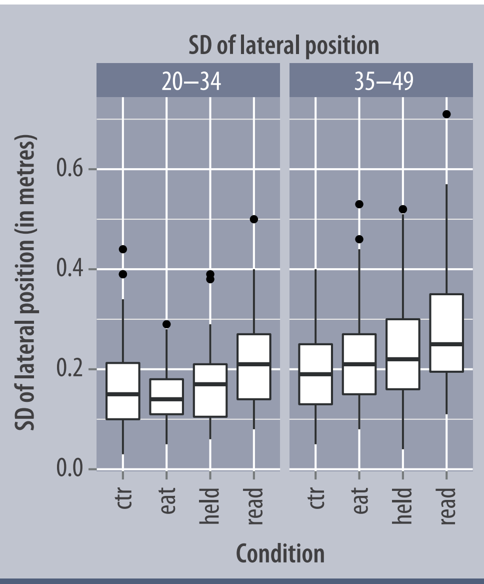



**Figure 27:** *SDLP boxplot of significant age category differences in the LMM (N=56)*

17 Due to much noise in the data, this model was simplified by removing the interactions with gender. In the full model there was only 1 significant interaction effect with gender.

### 4.2.3 Detection time (DT)

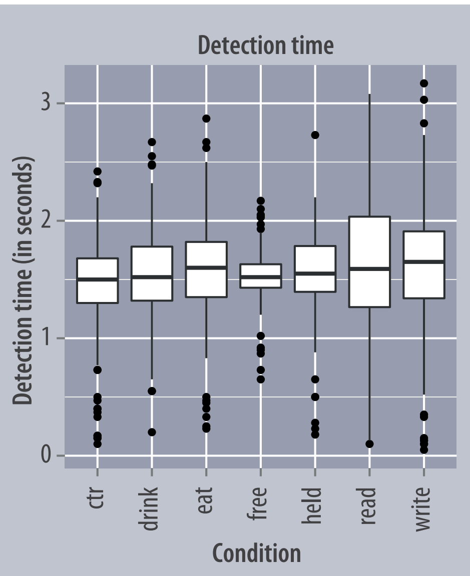



**Figure 28:** *DT boxplot (N=56)*

In general, an elevated spread of data is seen for the critical event detection time, especially for the texting tasks. The median values do not differ greatly to the control values.

| Term | Est. | S.E. | Sign. |
|---|---|---|---|
| Intercept | 1.43 | 0.11 | *** |
| **Reading text messages** | **0.24** | **0.11** | * |
| Writing text messages | 0.15 | 0.10 | |
| **Hand-held phoning** | **0.22** | **0.10** | * |
| Hands-free phoning | 0.09 | 0.11 | |
| Eating | 0.14 | 0.11 | |
| Drinking | 0.12 | 0.10 | |
| Self-report composite | 0.01 | 0.04 | |
| Age category (ref: 20-34 years) | 0.05 | 0.08 | |
| Gender (ref: female) | 0.06 | 0.08 | |
| Km in last 12months | -0.01 | 0.03 | |
| Task order (1 to 16 tasks) | -0.01 | 0.00 | |
| **Interactions** | | | |
| held x gender | -0.24 | 0.12 | * |

**Table 4:** *DT Linear Mixed Model (N=56)* *Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1*

The LMM (Table 4) indicates that the time taken to detect critical events significantly increased during text message reading and hand-held phoning activities (p = 0.01-0.05). Furthermore, female participants detected sudden events significantly more slowly than their male counterparts while hand-held phoning (p = 0.01-0.05) (Figure 29).

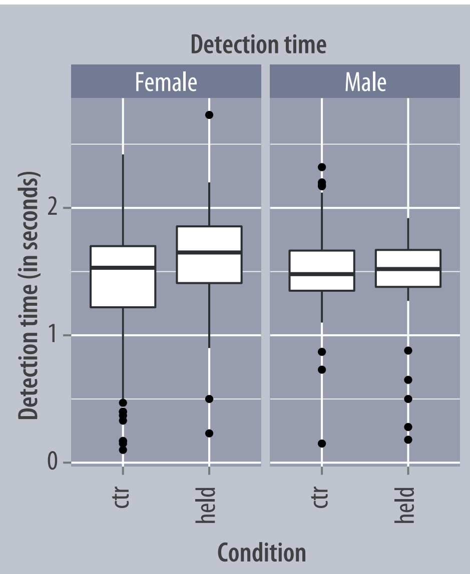



**Figure 29:** *DT boxplot of significant gender differences in the LMM (N=56)*

### 4.2.4 Reaction time (RT)

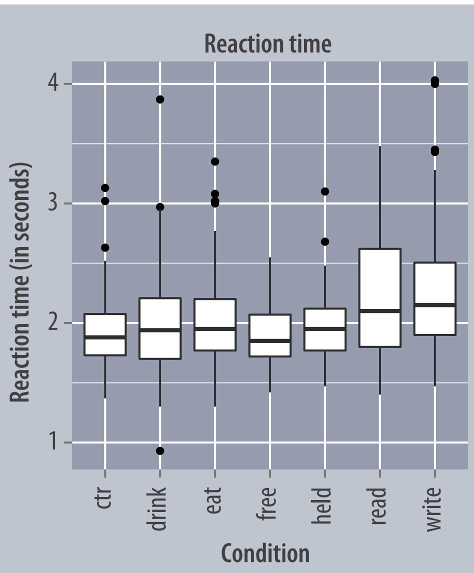



**Figure 30:** *RT boxplot (N=56)*

In general, all distraction tasks with the exception of hands-free phoning seem to lead to an increased reaction time in critical events (braking) compared to the control conditions (Figure 30). Highest RTs are seen during both texting tasks (reading and writing), where the data is also most widely spread.

| Term | Est. | S.E. | Sign. |
|---|---|---|---|
| Intercept | 1.97 | 0.10 | *** |
| **Text reading** | **0.37** | **0.08** | *** |
| **Text writing** | **0.31** | **0.07** | *** |
| Hand-held phoning | 0.03 | 0.07 | |
| Hands-free phoning | -0.02 | 0.08 | |
| Eating | 0.11 | 0.08 | |
| Drinking | 0.11 | 0.07 | |
| Self-report composite | -0.01 | 0.04 | |
| Age category (ref: 20-34) | 0.08 | 0.07 | |
| Gender (ref: female) | -0.03 | 0.07 | |
| Km last 12 months | -0.02 | 0.03 | |
| **Task order (1 to 16 tasks)** | **-0.01** | **0.00** | ** |
| **Interactions** | | | |
| read x gender | -0.22 | 0.09 | * |
| write x gender | -0.14 | 0.08 | . |
| drink x gender | -0.16 | 0.08 | . |
| write x age category | 0.20 | 0.08 | * |

**Table 5:** *RT Linear Mixed Model (N=56)* *Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1*

LMM (Table 5) indicates a highly significant effect of reading and writing text messages on the RT to sudden events: the reaction is significantly slower compared to the control condition (p = 0-0.001). There is also a significant task order effect (p = 0.001-0.01), indicating that the RTs decreased in subsequent tasks as a learning effect. This effect was controlled for by counterbalancing the task order. Furthermore, there were also some interaction effects (Figure 31). Females were significantly slower at reacting to sudden events than males while reading text messages (p = 0.01-0.05) and, to a lesser extent, also while writing text messages and drinking (trend). Middle-aged participants had a significantly longer RT to critical events while writing text messages than their younger counterparts (p = 0.01-0.05).

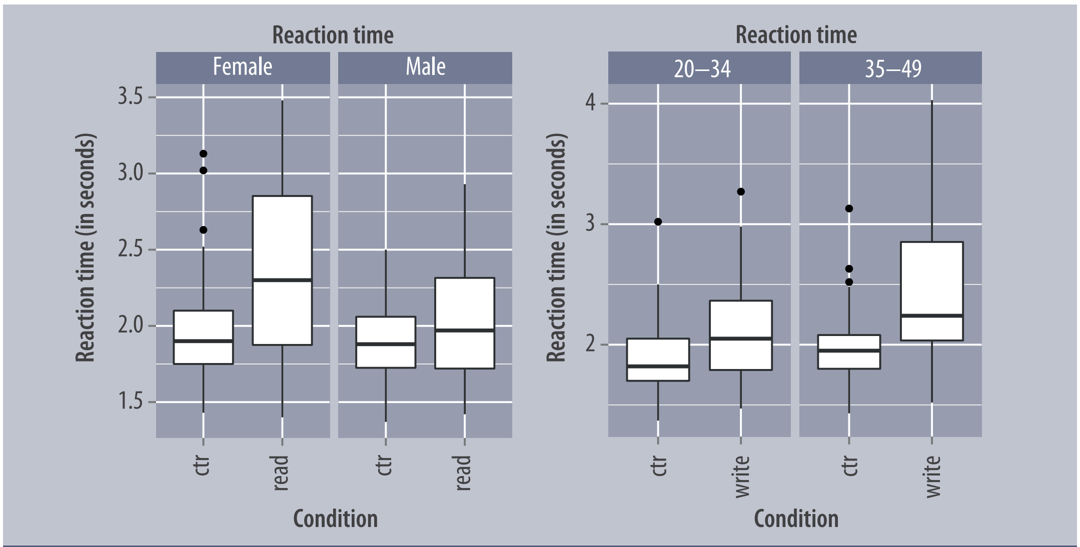



**Figure 31:** *RT boxplots of significant interaction effects in the LMM (N=56)*

### 4.2.5 Crashes and crash probability

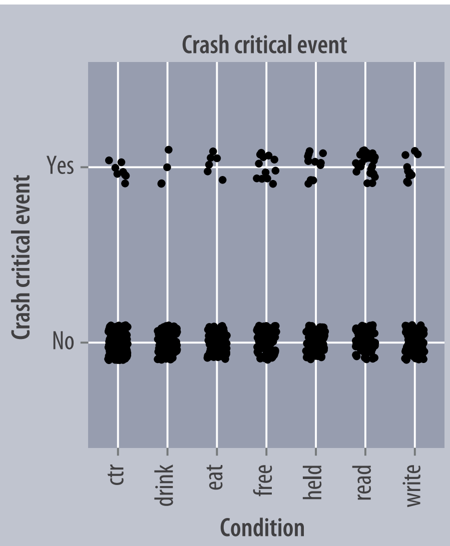



**Figure 32:** *Crashes with critical event (CE) scatterplot (N=56)*

In total, there were 83 crashes with critical events (N=56) during the experimental and control conditions (Figure 32). Most pedestrians were hit while the drivers were reading text messages. 'Other' crashes (not with the pedestrian) happened in 14 sections. Figure 33 shows the dichotomized crash probability for all sections (crash in section: yes/no > total number of yes/no sections in scatterplot). In total, crashes took place in 97 sections (mostly one crash per section; two crashes in one section), and most of these sections included a text message reading task.

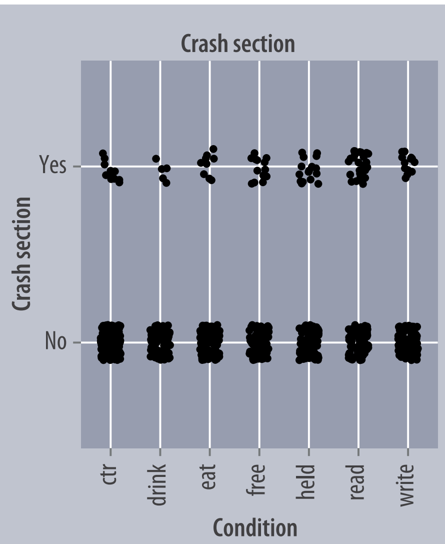



**Figure 33:** *Crash probability with section scatterplot (CE) scatterplot (N=56)*

| Term | Est. | S.E. | Sign. |
|---|---|---|---|
| Intercept | -3.89 | 1.19 | ** |
| **Reading text messages** | **3.34** | **1.15** | ** |
| Writing text messages | 1.75 | 1.29 | |
| **Hand-held phoning** | **1.89** | **1.24** | |
| Hands-free phoning | 2.32 | 1.21 | |
| Eating | 2.19 | 1.32 | |
| Drinking | 2.19 | 1.30 | |
| Self-report composite | 0.16 | 0.21 | |
| Age category (ref: 20-34 years) | 1.89 | 1.09 | |
| Gender (ref: female) | -0.02 | 0.79 | |
| Km in last 12months | -0.03 | 0.15 | |
| **Task order (1 to 16 tasks)** | **-0.16** | **0.03** | *** |

**Table 6:** *Crash with CE Generalized Linear Mixed Model (N=56)* [18] *Significance codes: 0 '***' 0.001 '**' 0.01*

As expected from analysing the scatterplot (Figure 32), the GLMM indicates that reading text messages led to a significantly higher accident probability for critical events (p = 0.001-0.01) when compared to control condition. There was also a clear learning effect related to the expectation of the critical events, which led to fewer accidents (p = 0-0.001) in subsequent tasks. Since this had been expected, the task order was counterbalanced between participants. The same effects were found in the GLMM for section crash probability.

18 For reasons of statistical reliability, only the highly significant factors (<0,01) in this GLMM result were interpreted.

### 4.2.6 Summary and comments on the mathematical models

Table 7 provides an overview of the parameter estimates (Est.) and standard errors (S.E.) for the different factors in the models for the five driving measures. Only results for significant interactions are shown.

| Term | Mean speed | | SDLP[19] | | Detection time | | Reaction time | | Crashes | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Est. | S.E. | Est. | S.E. | Est. | S.E. | Est. | S.E. | Est. | S.E. |
| Intercept | 13.16*** | 0.36 | 0.20*** | 0.02 | 1.43*** | 0.11 | 1.97*** | 0.10 | -3.89** | 1.19 |
| Reading text message | -0.82*** | 0.19 | 0.05** | 0.02 | 0.24* | 0.11 | 0.37*** | 0.08 | 3.34** | 1.15 |
| Writing text message | -1.13*** | 0.19 | 0.02′ | 0.01 | 0.15 | 0.10 | 0.31*** | 0.07 | 1.75 | 1.29 |
| Hand-held phoning | -0.68*** | 0.19 | 0.01 | 0.01 | 0.22* | 0.10 | 0.03 | 0.07 | 1.89 | 1.24 |
| Hands-free phoning | -0.30 | 0.19 | -0.001 | 0.01 | 0.09 | 0.11 | -0.02 | 0.08 | 2.32 | 1.21 |
| Eating | -0.76*** | 0.19 | 0.01 | 0.01 | 0.14 | 0.11 | 0.11 | 0.08 | 2.19 | 1.32 |
| Drinking | -0.94*** | 0.19 | 0.02 | 0.01 | 0.12 | 0.10 | 0.11 | 0.07 | 2.19 | 1.30 |
| Self-report composite | 0.14 | 0.13 | | | 0.01 | 0.04 | -0.01 | 0.04 | 0.16 | 0.21 |
| Age category (ref: 20-34 years) | -0.17 | 0.22 | 0.02 | 0.02 | 0.05 | 0.08 | 0.08 | 0.07 | 1.89 | 1.09 |
| Gender (ref: female) | -0.06 | 0.23 | -0.03* | 0.01 | 0.06 | 0.08 | -0.03 | 0.07 | -0.02 | 0.79 |
| Km last 12months | 0.08 | 0.10 | | | -0.01 | 0.03 | -0.02 | 0.03 | -0.03 | 0.15 |
| Task order (1 to 16 tasks) | 0.01* | 0.01 | | | -0.01 | 0.00 | -0.01** | 0.00 | -0.16*** | 0.03 |
| Interactions | | | | | | | | | | |
| read x gender | 0.51* | 0.21 | | | | | -0.22* | 0.09 | | |
| write x gender | 0.63** | 0.21 | | | | | -0.14, | 0.08 | | |
| held x gender | 0.45* | 0.21 | | | -0.24* | 0.12 | | | | |
| drink x gender | 0.75*** | 0.21 | | | | | -0.16′ | 0.08 | | |
| read x age catg. | | | 0.05* | 0.02 | | | | | | |
| write x age catg. | -0.49* | 0.21 | | | | 0.20* | 0.08 | | | |
| held x age catg. | | | 0.05* | 0.02 | | | | | | |
| eat x age catg. | | | 0.04* | 0.02 | | | | | | |

**Table 7:** *Parameter estimates and standard errors for the different factors in the (G)LMM models for the driving variables*
*Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1*

All distraction tasks except hands-free phoning were combined with significantly lower driving speed, which can be seen as a compensation mechanism while dealing with distraction. Of all the distraction sources, texting had the most effect on driving parameters. Reading text messages had the most significant negative effects, with increased detection and reaction times to the sudden critical events, an increased deviation from the position in the centre of the lane, and an increased crash probability. Writing text messages led to the biggest decrease in speed, a significant increase in the reaction time to critical events, and increased deviations from the position in the centre of the lane (trend). Finally, hand-held phoning led to a significantly slower detection of critical events. Eating and drinking tasks only led to a significantly decreased mean driving speed. In this study, hands-free phoning had no significant effects on the driving parameters.

Several significant age and gender effects were seen. Female participants drove more slowly than their male counterparts while drinking, writing/reading text messages and hand-held phoning. Further-

19 Due to the noise in the data, this model was simplified by removing the self-report composite, km driven in last 12 months, task order, and interactions with gender. In the full model, there was only one significant interaction effect with gender.

more, the detrimental effects of hand-held phoning (slower CE detections) and reading text messages (slower reactions to CEs) were greater for females. Higher RTs were also seen during text message writing and drinking, but this was merely a trend difference. Finally, females had a higher SDLP than males (not specifically related to distraction tasks). Middle-aged participants (35-49 years) differed significantly from their younger counterparts (20-34 years). In particular, they drove more slowly and also reacted more slowly to critical events while writing text messages (which are related phenomena). Furthermore, the 35-49-year-old participants deviated further from the centre of the road than the 20-24-year-olds while reading text messages, hand-held phoning, and eating.

The mathematical models indicated that task order significantly affected mean speed, RT, and crash probability. Task order effects were controlled for as far as possible by counterbalancing the tasks between participants. However, the task of reading a text message did have a "disadvantage" when it came to order effects in this study, because the tasks in the texting track had a fixed order (first reading the text message, then writing the text message, and repeated).
No effect of the composite score from the pre-questionnaire "self-reported distraction behaviour while driving" on the driving parameters was found.

### 4.3 Post-ride questionnaires

This section presents the results of the post-ride questionnaires that were completed directly after each of the three experimental trials (texting (reading/writing text messages), phoning (hand-held/hands-free), eating/drinking). The answers provide subjective information on the experience of driving in combination with the distracting side activities. The responses to nine questions are presented, each of which was answered using a scale from 1 to 7. The following figures show the mean scores and 95% confidence intervals for each task. Task related differences were analysed using the Friedmann Chi-square test; the Mann-Whitney U-test was used to evaluate differences according to gender and age (young vs. middle-aged).

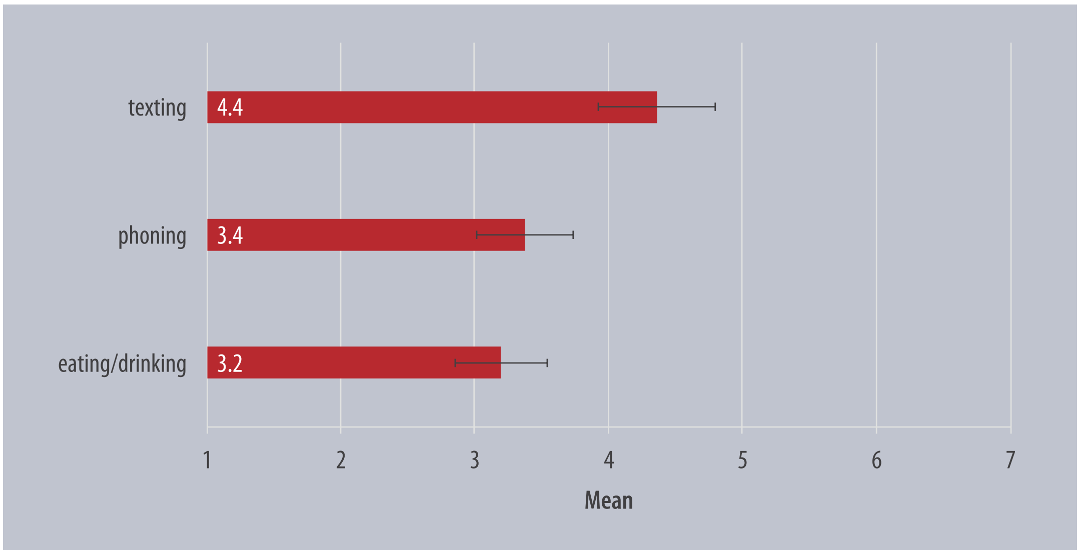



**Figure 34:** *Perceived performance during the drive in general (1: very good - 7: very poor)*

The **self-assessment of general driving performance** differed significantly between all three experimental trials ($p \leq 0.01$) (Figure 34). General driving performance was estimated to be poorer during the texting trial (reading and writing/sending) and fairly good in the phoning and eating/drinking trials. There was no difference between gender and age categories.

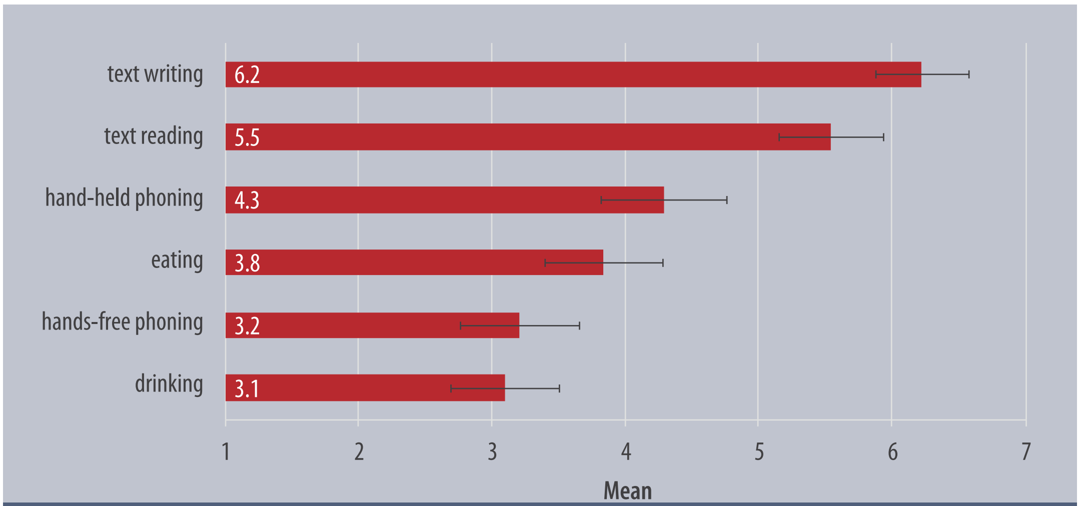



**Figure 35:** *Effort to complete the task (1: absolutely no effort - 7: extreme effort required)v*

The **perceived effort required** differed significantly between the distraction tasks ($p \leq 0.01$) (Figure 35). The text message writing task required the most effort (average score of 6.2/7), followed by text message reading (5.5/7) and hand-held phoning (4.3/7).

Females reported requiring significantly more effort to complete the drinking task ($p \leq 0.05$) than their male counterparts. A similar trend was observed for the task of eating (excl. 50+: only for drinking). No differences were observed among age categories (young vs. middle-aged).

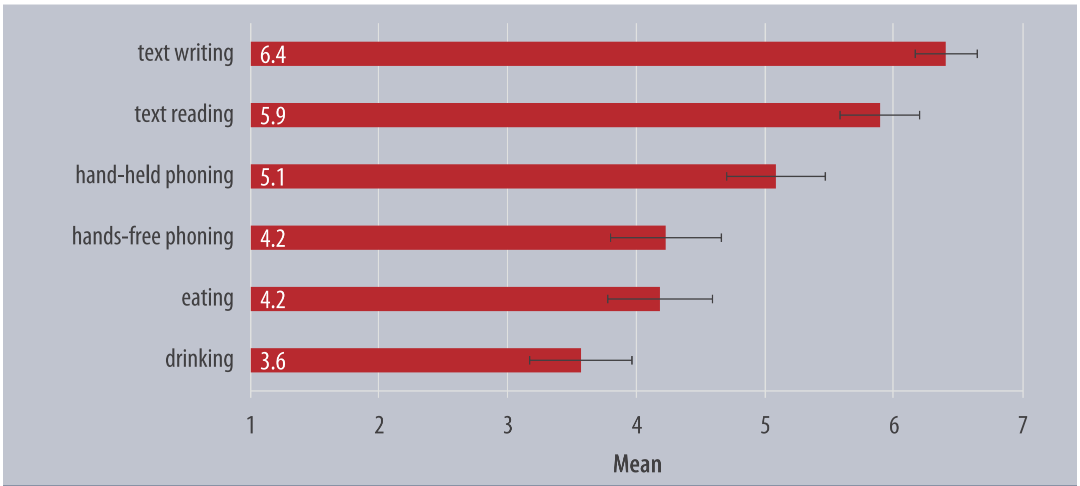



**Figure 36:** *How well do you think you drove during the task? (1: very well - 7: very poorly)*

The **self-assessments of driving performance** during the different experimental tasks differed significantly ($p \leq 0.01$) (Figure 36). Driving performance was assessed worst during the text message writing (mean score of 6.4/7), text message reading (5.9/7), and hand-held phoning (5.1/7) tasks. Female participants considered their driving to be significantly poorer than male participants during the drinking task ($p \leq 0.05$). This trend was also observed for the eating and text message reading tasks (excl. 50+: only for eating and drinking). Furthermore, the participants in the older age group (35-49 years) gave themselves a poorer self-assessment of their driving performance than their counterparts in the younger age group (20-34 years) during the text message reading task, but this was only a trend difference.

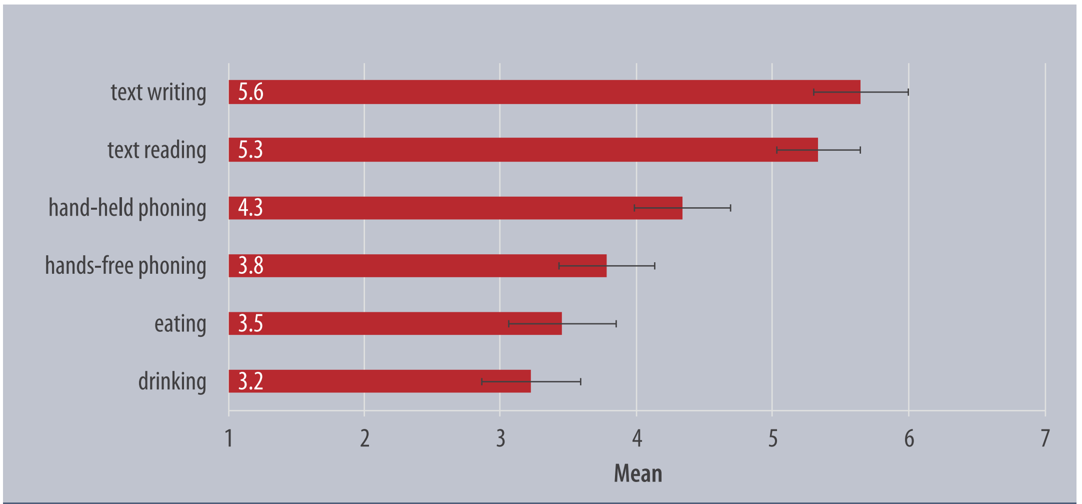



**Figure 37:** *Level of concentration for . . . while performing task (1: virtually no concentration - 7: total concentration)*

According to the participants, different distracting tasks required significantly different **levels of concentration** ($p \leq 0.01$) (Figure 37). They indicated that more of their focus was directed to (the devices during) text message writing, followed by text message reading and hands-free phoning. Hand-held phoning, eating, and drinking required less concentration. There were no differences here between the gender and age categories.

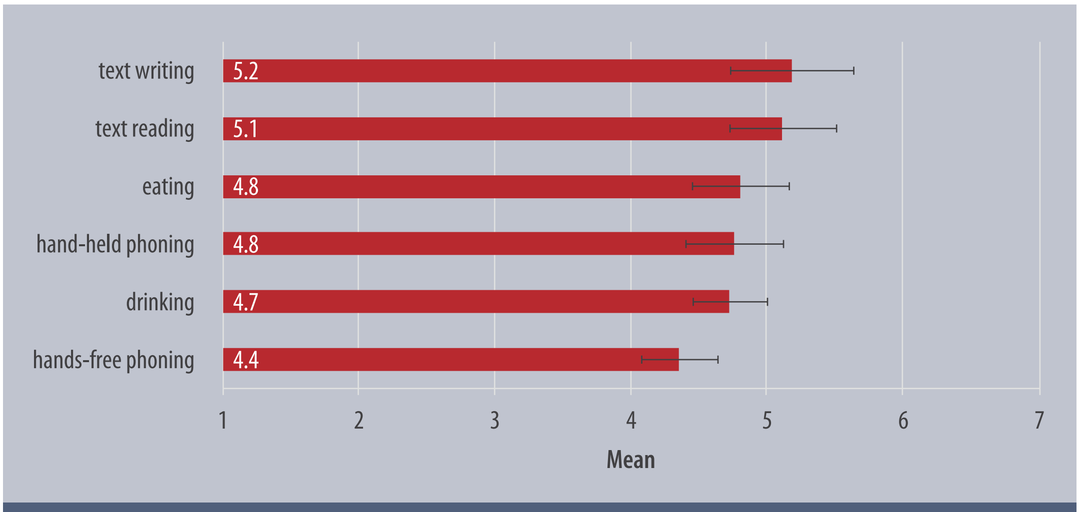



**Figure 38:** *Felt effect on driven speed (1: drove faster - 7: drove slower)*

According to the participants, the various distraction tasks had significantly different **effects on driving speed** ($p \leq 0.01$) (Figure 38). Writing a text message led to the highest decrease in driving speed, while hands-free phoning caused the smallest decrease. Female participants indicated significantly more frequently than their male counterparts that they had driven more slowly while hands-free phoning ($p \leq 0.01$). A similar trend difference was observed for the task of drinking. Participants in the 35-39-year-old age group indicated more frequently than their younger counterparts (20-34 years) that they had driven more slowly during the writing a text message ($p \leq 0.05$) and reading a text message (trend) tasks.

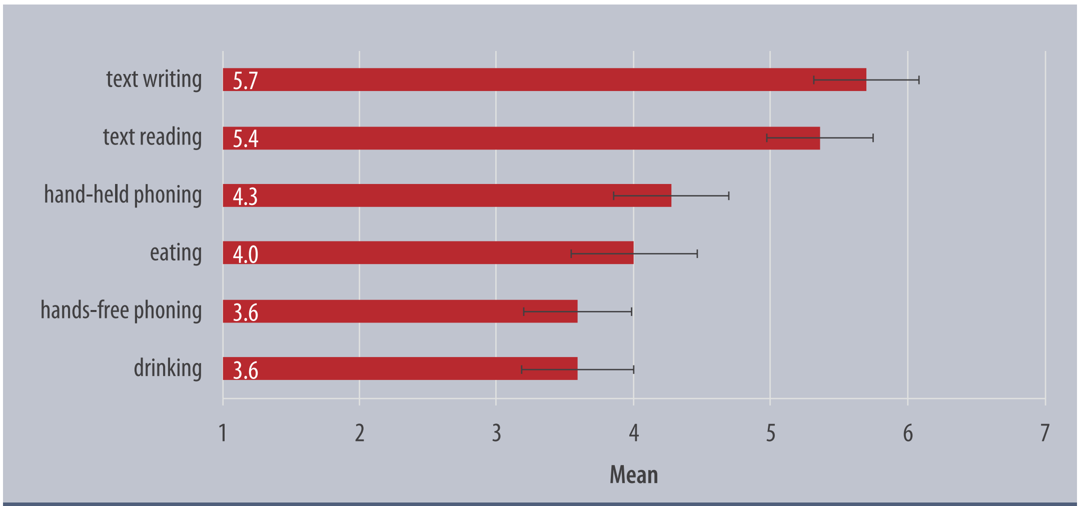



**Figure 39:** *Effect on ability to keep to the centre of the lane (1: maintained a central position - 7: struggled to maintain a central positioning)*

Participants perceived significantly more difficulty in **keeping to the centre of the lane** during the texting (writing and reading) tasks than for the other distractions ($p \leq 0.01$) (Figure 39). There were no differences according to gender and age category

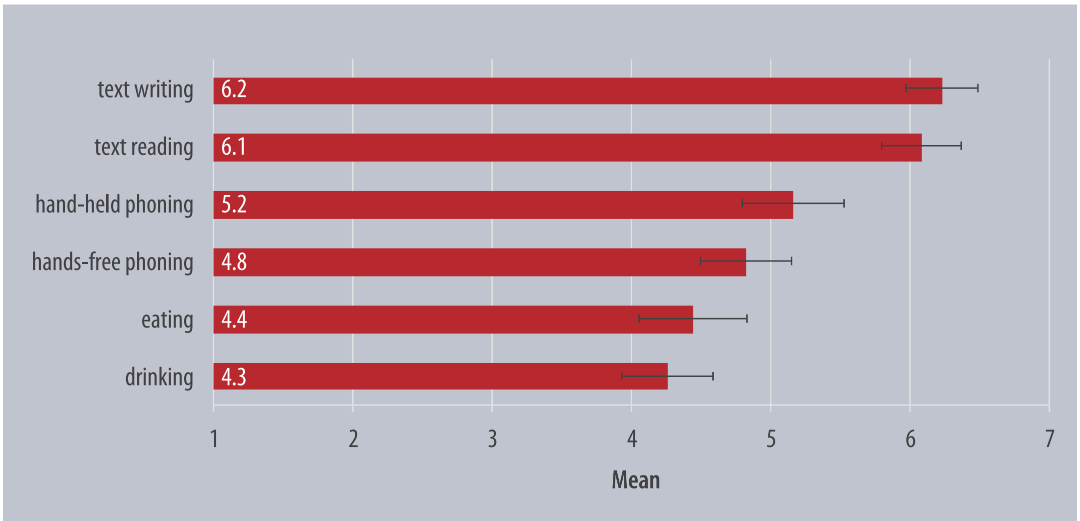



**Figure 40:** *Change in awareness of road hazards (1: more aware - 7: less aware)*

The different tasks had different effects on the **perceived awareness of road hazards** ($p \leq 0.01$) (Figure 40). Participants felt that they were less aware of road hazards during texting tasks than during all other distraction tasks. Middle-aged participants tended to feel less aware of road hazards during hand-held phoning than their younger counterparts. No gender related differences were observed.

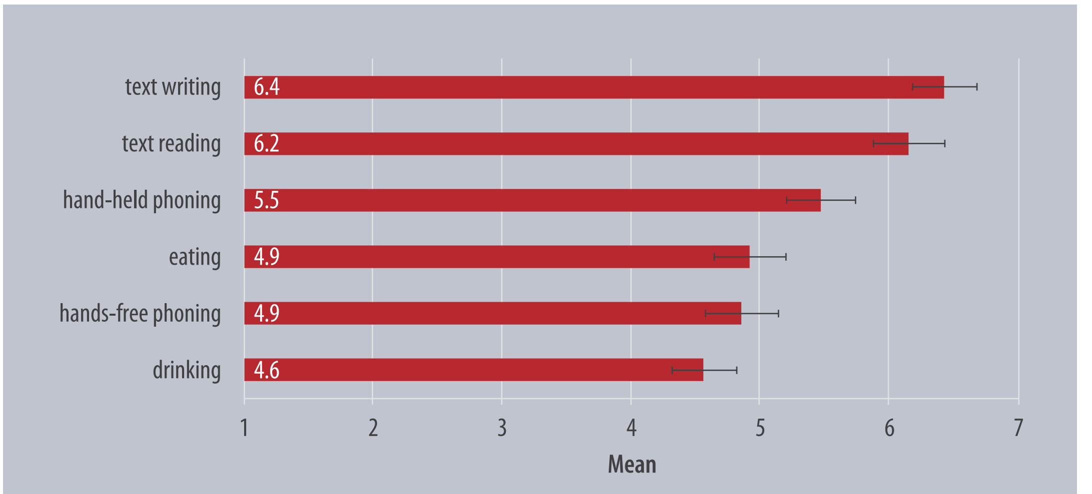



**Figure 41:** *Change in driving performance (1: improved - 7: worsened)*

The **perceived effects of distraction tasks on driving performance** differed significantly ($p \leq 0.01$) (Figure 41). Participants indicated the highest degree of deterioration in their driving performance during the text message writing and reading tasks (mean scores of 6.4/7 and 6.2/7 respectively) as well as during hand-held phoning (5.5/7). Females indicated significantly more often than males ($p < 0.05$) that their driving performance deteriorated while reading text messages. A similar trend was observed for hands-free phoning (excl. 50+: for text message reading and hands-free phoning).

**Summary of post-ride questionnaires**

The subjective post-ride questionnaire results indicate that the participants perceived most negative effects during the text message writing task: this required the most effort and had the most detrimental effects on driving. Reading text messages was next, followed by hand-held phoning. Overall, there was a good match between the "perceived effects" and the actual effects of the different distraction tasks on driving performance.

## 4.4 Comparison of pre- and post-questionnaires

This section presents the results of the comparison of the identical questions in the pre- and post-questionnaires. This comparison allows an evaluation of the impact of participation on the perceived effects of distractions, attention to traffic, opinion regarding a total ban on the use of mobile phones while driving, intentions to engage in distractions while driving, as well on simulator sickness symptoms. The analyses were performed using IBM SPSS Statistics 22. The Wilcoxon signed rank test was used to assess whether the population mean ranks (of repeated measurements in a single sample) differ (here: pre- and post-participation differences). Statistical significance was set at a 95% confidence interval ($p \leq 0.05$).

#### 4.4.1 Opinions

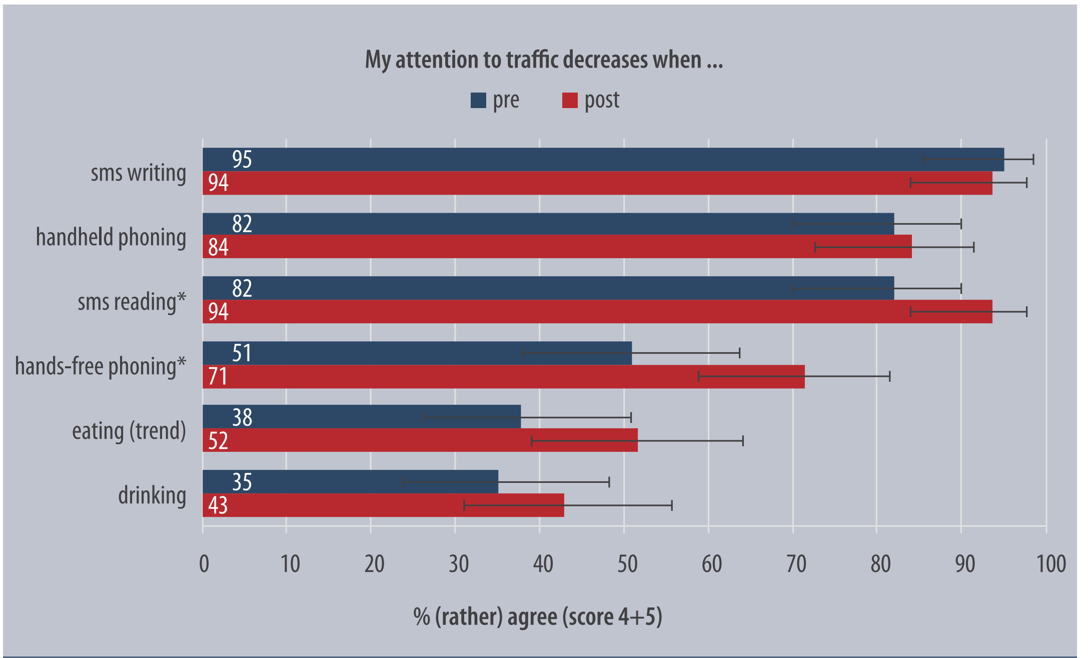



**Figure 42:** *Extent of agreement with the statements*

After participating in the study, participants demonstrated a higher awareness of the negative effects of distractions on driving (with the exceptions of text message writing and hand-held phoning, where awareness levels were already high in the pre-questionnaire). This increase in pre-to-post risk awareness was significant ($p \leq 0.05$) for reading and/or writing text messages (from 82% to 94%) and hands-free phoning (51% to 71%).

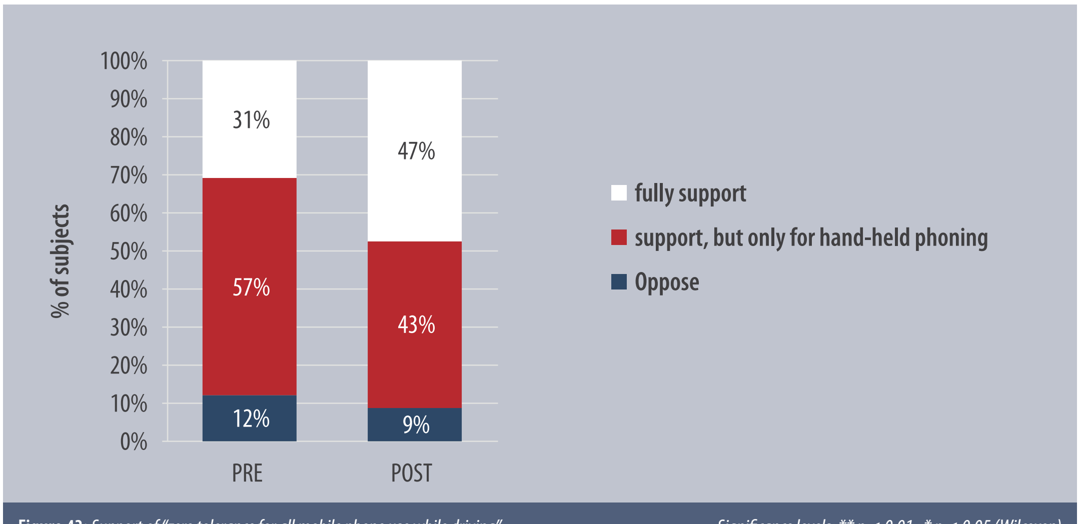



**Figure 43:** *Support of "zero tolerance for all mobile phone use while driving"* *Significance levels: ** $p \leq 0.01$ ; * $p \leq 0.05$ (Wilcoxon)*

After participating in the study, significantly more participants fully agreed with a total ban on (hand-held and hands-free) mobile phone use while driving ($p \leq 0.05$) (31% to 47%).

### 4.4.2 Intentions

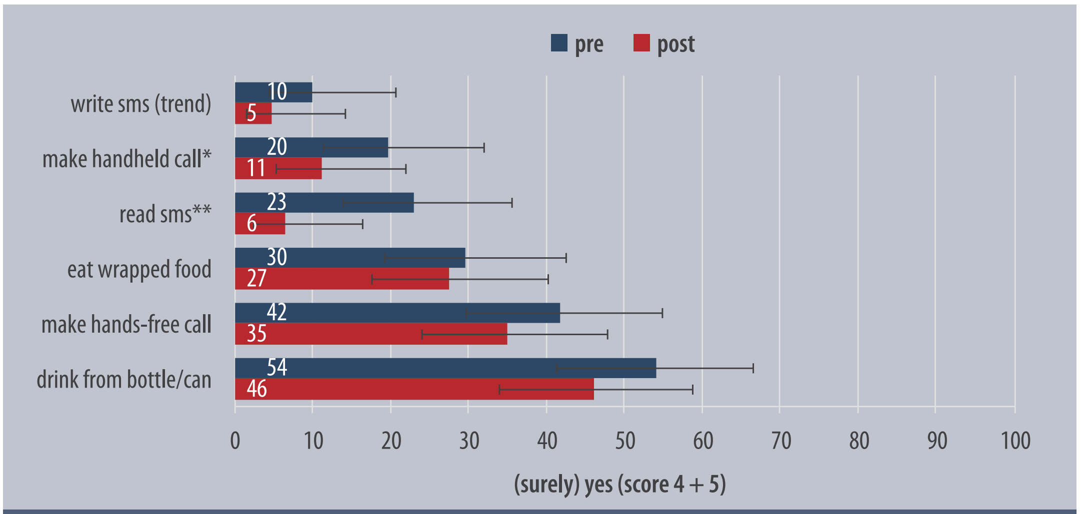



**Figure 44:** *Intention to do the following things in the next four weeks while driving a car* *Significance levels: ** p ≤ 0.01 ; * p ≤ 0.05 (Wilcoxon)*

After participating in the study, participants indicated fewer intentions to engage in all tested side activities. The results indicated significantly reduced intentions for reading text messages (from 23% to 6%; p ≤ 0.01) and making hand-held phone calls (from 20% to 11%; p ≤ 0.05), and a trend for writing text messages with the lowest pre-level percentage (from 10% to 5%, i.e. the lowest value to begin with).

### 4.4.3 Simulator sickness

Before and after participation in the study, the participants were asked to indicate the strength of the presence of different simulator sickness symptoms on a scale from 0 to 4 (where 0 = no, 1 = a bit, 2 = distinct, 3 = heavy). The symptoms in question were:

- Malaise (*)s
- Fatigue (*)
- Headache
- Heavy eyes (trend)
- Drowsiness/sleepiness (trend)
- Problems to see clearly (trend)
- Increased salivation
- Sweating
- Sickness
- Dry mouth
- Poor concentration
- Feeling of a “full head” (**)
- Blurred sight
- Dizziness when eyes open
- Dizziness when eyes closed
- Loss of orientation
- Stomach pressure
- Eructation (trend)

Three symptoms were present significantly more often in the sample after participation in the study: feelings of a “full head” (p ≤ 0.01), discomfort, and fatigue (p ≤ 0.05).

## 4.5 Eye-tracking

Gaze data were available for 37 participants (for the others, the calibration was not valid or the data were excluded after data cleansing). Furthermore, the sample size varies between conditions. The tasks of “eating” and “drinking” were subdivided into “unwrapping/opening” and “consuming”. Due to the limited data on “drinking in terms of consuming” (N=9), this condition was excluded from further analysis.

Figure 45 presents the average gaze at driving relevant areas during the control and distraction tasks.

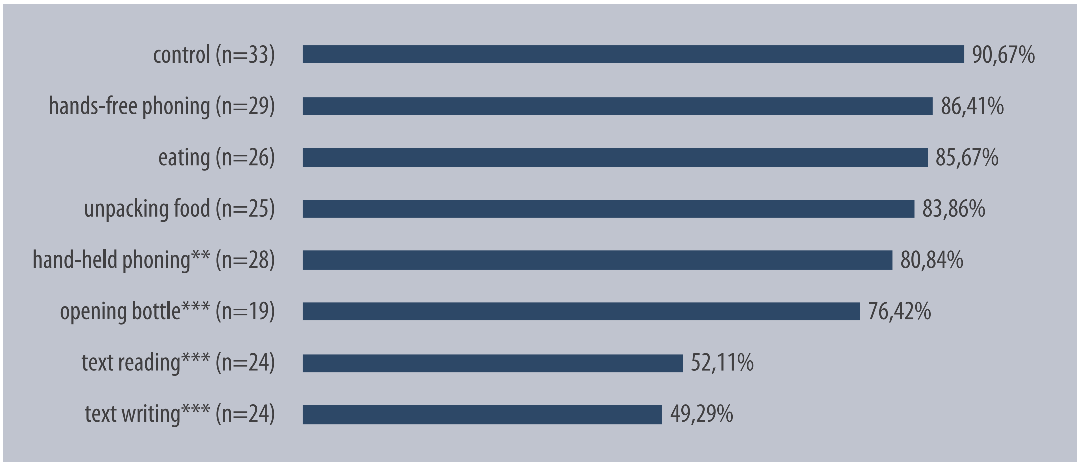



**Figure 45:** *Average gaze at driving relevant areas during different conditions* *Significance levels: *** p≤0.001; ** p ≤ 0.01 ; * p ≤ 0.05*

The participants showed the longest average gaze at driving relevant areas while driving without any distracting activity (control). ANOVA post-hoc (Dunnett-T) test results comparing the different experimental tasks with the control condition indicate that during the texting tasks (both writing and reading), the average gaze at driving relevant areas decreased significantly to half the time driven ($p < 0.001$). Furthermore, hand-held phoning ($p = 0.007$) and opening the drink bottle ($p < 0.001$) led to significantly reduced gaze at relevant areas. No significant differences were found with regard to age. A significant gender difference was found for reading text messages, with male participants averting their eyes from the driving relevant areas (52.8%) more often than their female counterparts (42.1%).

Comparisons between different experimental conditions showed no significant differences. Given the results of the simulator driving variables and the first eye-tracking results displayed in Figure 45, the subsequent analysis was limited to the phoning and texting tasks.

An efficient measure for assessing attention or distraction is the “percentage road centre” (PRC), which represents the percentage of time that a driver is attending to the road in front during a driving trial.[20] On average, the PRC value lies between 70% and 80% per minute for driving without any side activities.[21] Higher PRC values indicate more attention to the road ahead; a value higher than 92% can be associated with cognitive distraction. Since lower values indicate a diversion of visual attention away from the road, a PRC value lower than 58% can be associated with visual distraction. Figure 46 shows the PRC for the phoning and texting texts and indicates considerable visual distraction by the latter, but no cognitive distraction by the former.

20 Victor T.W., Harbluk J.L, Engström J. (2005) Sensitivity of eye-movement measures to in-vehicle tasks difficulty. Transportation Research Part F: Traffic Psychology and Behaviour, 8(2), 167-190

21 Kircher K., Ahlström C., & Kircher A. (2009). Comparison of two eye-gaze based real-time driver distraction detection algorithms in a small-scale field operational test. In: Driving assessment 2009: 5th international driving symposium on human factors in driving assessment, training and vehicle design. Big Sky, Montana.

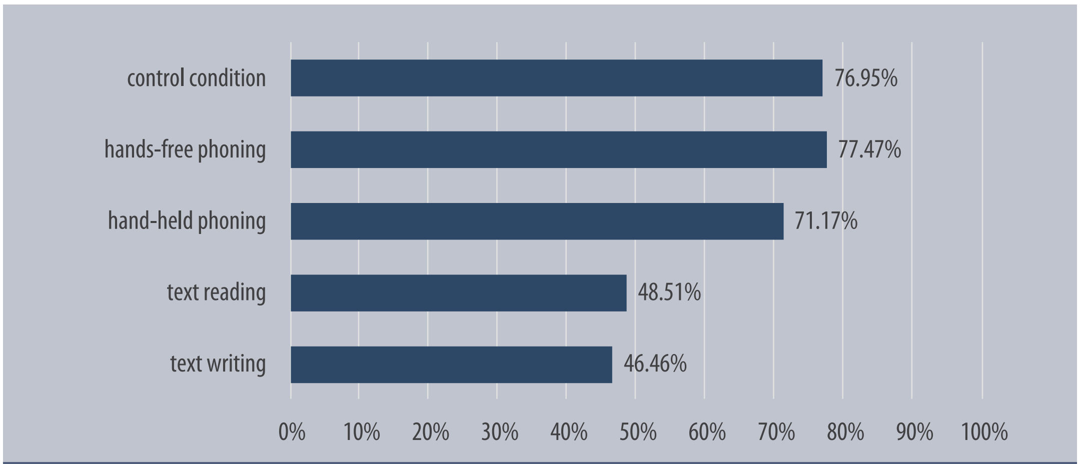



**Figure 46:** *Percent road centre gaze for texting and phoning tasks*

Beside average gaze, fixations on the screen and averted gazes were also analysed. The idea here was that to detect critical events in time, the surrounding roadway (i.e. the simulator screen) had to be scanned by continuous fixations. Conversely, the risk of missing something grows with an increase in averted gazes. The lower limit for fixations is usually defined at 100ms to 200ms.[22] Accordingly, 100ms was defined as the lower limit for fixations. This is also a physiologically determined limit, below which conscious information reception is not possible under it.[23] For safe driving, the maximum time of averted gazes is defined at between 1,200ms and 2,000 ms.[24] Figure 47 shows the average gaze at the simulator screen.

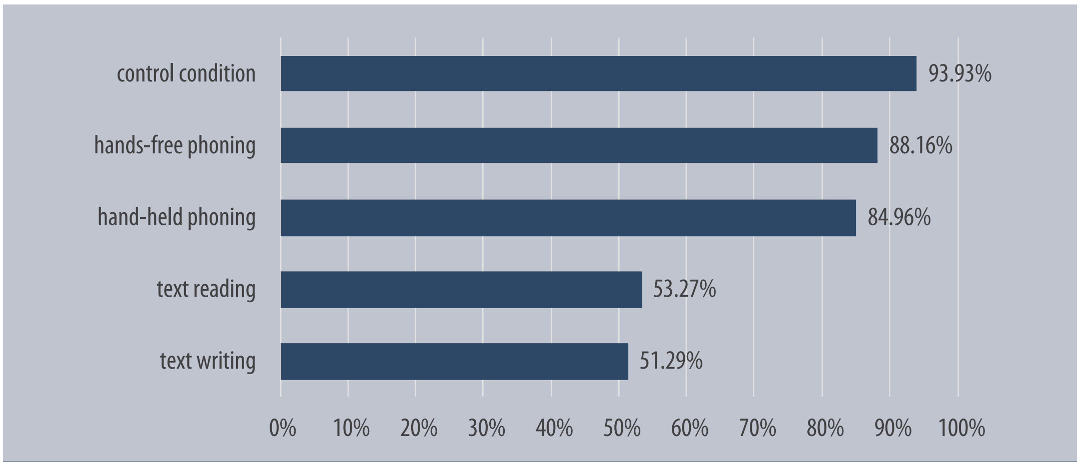



**Figure 47:** *Average gaze at the whole simulator screen*

As shown in Figure 47, the average gaze increased only slightly when considering the whole screen rather than just the centre of the road. During the texting tasks in particular, almost half of gazes were averted – with more gaze at the screen during reading than writing. In any case, the results of the simulator driving variables indicated that reading text messages was even more dangerous than

22 Jacob R.J. & Karn K.S. (2003). Eye Tracking in Human-Computer Interaction and Usability Research: Ready to Deliver the Promises. In: Hyona, Radach & Deubel, The Mind's Eye: Cognitive and Applied Aspects of Eye Movement Research (S. 573-603); Holmqvist, K., Nyström, M., Andersson, R., Dewhurst, R., Jarodzka, H. & Van de Weijer, J. (2011). Eye Tracking – A Comprehensive Guide to Methods and Measures. New York: Oxford University Press.

23 Schulz, R. (2012). Blickverhalten und Orientierung von Kraftfahrern auf Landstraßen. Dissertation. [Gaze Behaviour and Orientation of Motorists on Regional Roads. Doctora Thesis.] Technische Universität Dresden.

24 Metz, B. (2009). Worauf achtet der Fahrer? Steuerung der Aufmerksamkeit beim Fahren mit visuellen Nebenaufgaben. Dissertation. [What do drivers pay attention to? Controlling driver attention during visual side tasks. Doctoral Thesis.] Universität Würzburg; Monk (2013). Driver distraction research and policy: An update from NHTSA. Proceedings of the 3rd International Conference on Driver Distraction and Inattention. Göteborg.

writing them. For this reason, fixation data were analysed for both text message reading and text message writing.

The results for the average number of fixations and averted gazes during the texting trials are shown in Figure 48.

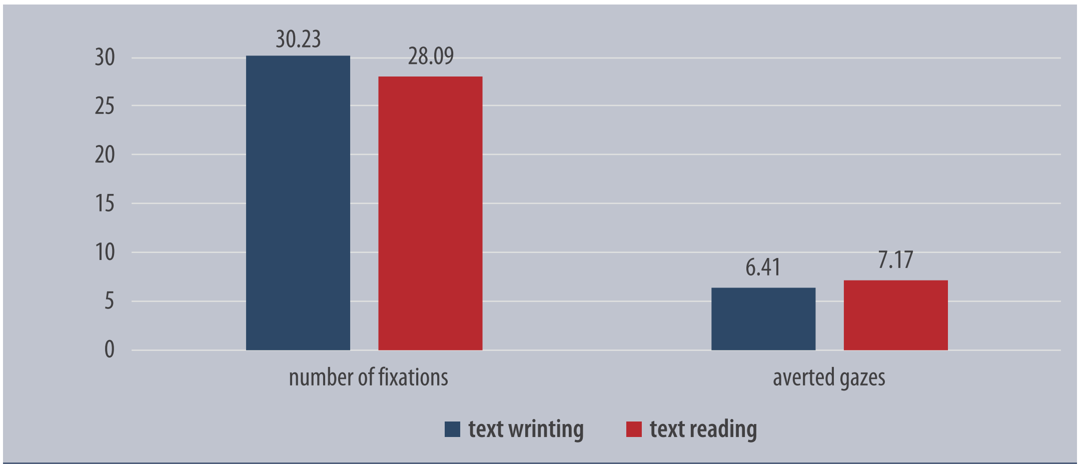



**Figure 48:** *Average number of fixations and averted gazes per minute during texting tasks*

Accordingly, the study participants showed more fixations (> 100ms) on the screen during text message writing than text message reading tasks. They also averted their gazes for longer than 1,200ms (more often while reading than while writing text messages). Although this is only a trend, it may be an indication that participants scanned the surrounding roadway more efficiently during text message writing by means of continuous short fixations.

# 5 SUMMARY & CONCLUSIONS

The results of this study show that reading text messages had the most significant effects on driving behaviour. Participants drove more slowly, had worse positioning in the centre of the road, responded more slowly to critical events and also had more accidents. When writing text messages, driving speed decreased even more than for reading text messages, and participants responded significantly more slowly to critical events. In line with this, eye-tracking data revealed that gaze percentage at driving relevant areas decreased to 52.1% while reading text messages and to 49.3% while writing text messages. This confirms the visual distraction caused by texting.

There was also a general agreement among participants that writing and reading text messages and hand-held phoning have negative effects on driver attention. Over 80% of participants in the study believed that these activities had a negative impact. Significantly fewer of them considered hands-free phoning, eating, and drinking to have a similar negative effect. This opinion was also reflected in the self-reported behaviour – writing and reading text messages were the least frequently reported activities.

Drinking and eating are the two most frequently performed activities, followed by hand-held phoning. Overall, there was a very good match between the "perceived effects of the distractions on driving performance" and the "actual driving performance during the distraction tasks" (speed, hazard awareness, perceived workload).

With regard to age and/or gender differences, the driving behaviour of females and middle-aged subjects is affected more by distraction, mainly while writing/reading text messages and hand-held phoning (mean speed, DT and RT). The reported frequency of involvement in distracting behaviour while driving was not found to significantly affect driving performance.

The results of this study are partly in line with Boets et al. (2015), who also observed a significant effect on mean speed (decreased) during reading/writing of text messages and a significant increase in DT and RT while reading text messages (but not writing). Additionally, the current study found that writing text messages had a significant effect on RT to hazards, while reading them had a significant effect on accidents – a finding which is generally more in line with other studies (e.g. Yannis et al. (2013), Caird et al. (2014)). In contrast to the current study, Farah et al. (2015) found that the variability of the steering wheel angle was considerably larger when texting than when phoning and eating. They also found that average speed is generally lower during distraction, with the largest decrease encountered during texting. While various studies have found similar effects for hand-held and hands-free phoning (e.g. Kircher et al, 2004), there is still a lack of research showing that hands-free phoning has significant effects on driving behaviour.

One important remark also has to be made concerning the results obtained in this study for hands-free phoning: most of the invalid – and thus excluded – driving data stemmed from the hands-free phoning task. This indicates that the highest frequency of task related problems occurred during hands-free phoning (e.g. no task, connection failed, no connection, pushing the wrong button, earplug fell out, etc.). Moreover, the pre-questionnaire revealed that 40% of participants were not normally equipped with hands-free systems or did not use hands-free devices to make phone calls while driving.

Generally speaking, engaging in other tasks while driving can lead to visual, cognitive, manual and auditory distraction. The results of this study indicate that texting (reading/writing) has more negative effects on driving performance than phoning, eating, and drinking and leads to increased accident risk. Contrary to popular belief, reading text messages proved to be even more dangerous than writing them, although drivers did lose most sight of the road they were driving on when writing text messages. One reason for this might be that writing is more self-controlled than reading, it can be easily split up into small parts. In contrast, receptive reading requires us to read more parts of the text at once and thus commands more of our resources.

As already mentioned, the effects of hands-free phoning were rather limited in this study, a result which could be related to the set-up of the experiment. However, the results did show that hand-held phoning does have endangering effects on driving.

Furthermore, the research revealed that drivers reduce speed as a compensation mechanism when they are distracted. In most cases, they slow down while writing text messages, perhaps because most of them are aware of the dangerous effects of this activity.

Of all the possible sources of distraction studied, eating and drinking appeared to have the lowest effect on drivers' attention and behaviour. Negative effects mainly occurred here while opening a bottle unwrapping food.

With regard to age and/or gender differences, the results of this study show that women generally slowed down more than men. Women also detected and reacted to sudden hazards much more slowly while reading text messages and hand-held phoning.

Although drivers seem to be well aware of the risks involved, a clear majority (except for writing text messages) nonetheless admits to engaging in the studied distraction behaviours.

In conclusion, the results of this study add to the weight of scientific evidence that texting – compared with phoning, eating and drinking – has clear degrading effects on driving performance, leads to significantly more visual distraction, and increases accident risk. While subjective data also rank texting as the most demanding tasks with the most effect on driving behaviour, the subjective, visual, and drive data are not completely in line in this regard. The results further suggest that there are some particular age and gender related effects for different distraction sources, but that these could also be linked to different levels of exposure.

A suggestion for further research would be a study design that allows drivers to decide for themselves how and when to perform distracting activities (strategic compensation). Considering the speed of technological development in communication devices, a multitude of possible additional distraction activities that affect visual, manual, and cognitive resources can be expected in future. Combined efforts with regard to legislation, enforcement, blocking technologies, campaigns, and education continue to be required.

**Recommendations**

Due to both the frequency of phone use during driving and the observed effects – especially of texting – on driving behaviour, measures are needed which counter the risk of distraction in traffic.

**Awareness raising**

Awareness raising activities are essential to override distracted driving, and corresponding measures do serve to sensitise drivers to the risks involved. The website www.ab-gelenkt.at for example, which was developed on behalf of KFV, is an online application for raising awareness of distraction while driving, the risks involved, and correct behaviour in traffic. The application is addressed at different target groups (including drivers).

The use of smartphones is now omnipresent, particularly among young drivers. At the same time young drivers lack driving experience, which increases the dangers of distraction. For this reason, KFV works with other institutions to develop distraction workshops for young people. In these workshops, participants are shown the consequences of distraction and have the opportunity to experience them first-hand in practical exercises. The aims of the workshops are to impart knowledge, raise awareness and hazard perception, and communicate personal strategies for changing behaviour.

**Effective execution of the prohibition of the use of mobile phones while driving**

The 32nd Amendment to the Austrian Motor Vehicles Act (KFG-Novelle), which came into force from June 2016, expanded the ban on phone use while driving and clarified its extent. Henceforth, any phone use – aside from hands-free phoning and navigating with a phone that is mounted in the car – is prohibited in Austria. Furthermore, the 34th Amendment to the Austrian Motor Vehicles Act allows the use of pictures taken by speed cameras, distance measurements, red light radars, and camera tracking from police cars in the detection of distracted driving, which will increase the efficiency of enforcement.

# REFERENCES

Aleksa, M., Aichinger, C., Hahn, M., Harnisch, M., Kaiser, S., Nitsche, P., Rußwurm, K., Winkelbauer, M. (2014) ORTUNG. Objektive Beurteilung von Navigationssystemen mit Empfehlungen für den Gesetzesgeber [Objective assessment of navigation systems and recommendations for policy makers], https://www.bmvit.gv.at/service/publikationen/verkehr/strasse/verkehrssicherheit/vsf/downloads/37_ortung.pdf

Boets, S., Ross, V., Van Belle, G., Vanroelen, G. & Jongen, E. (2015) Effects of texting on driving behaviour of young drivers in urban traffic. Results of a simulator-based study. Road Safety and Simulation Conference, Orlando, USA (Oct. 6-8 2015).

Caird, J.K., Johnston, K., Willness, C. & Asbridge, M. (2013) The Use of Meta-analysis or Research Synthesis to Combine Driving Simulation or Naturalistic Study Results on Driver Distraction. Road Safety and Simulation Conference, Rome, Italy (Oct. 23-25 2013).

Cuenen, A., Jongen, E.M.M., Brijs, T., Brijs, K., Lutin, M., Van Vlierden, K. & Wets, G. (2015) Does attention capacity moderate the effect of driver distraction in older drivers? Accident Analysis and Prevention 77 (2015) 12–20.

DaCoTA (2012). Driver distraction, Deliverable 4.8f of the EC FP7 project DaCoTA

Dingus, T.A., Guo, F., Lee S., Antin, J.F., Perez, M., Buchanan-King, M., & Hankey, J. (2016). Driver crash risk factors and prevalence evaluation using naturalistic driving data. PNAS Early Edition, 113(10), 2636-2641

Engström, J., Johansson, E. & Ostlund, J. (2005) Effects of visual and cognitive load in real and simulated motorway driving. Transportation Research Part F 8 (2005) 97–120.

Farah, H., Zatmeh, S., Toledo, T. (2015) Impact of distracting activities and drivers' cognitive failures on driving performance. Road Safety and Simulation Conference, Orlando, Florida, USA (Oct. 6-8 2015).

Fitch, G.M., Soccolich, S.A., Guo, F., McClafferty, J., Fang, Y., Olson, R.L., Perez, M.A., Hanowski, R-J., Hankey, J.M. & Dingus T.A. (2013) The impact of handheld and hands-free cell phone use on driving performance and safety critical event risk. DOT HS 811 757. USA: National Highway Traffic Safety Administration.

Holmqvist, K., Nyström, M., Andersson, R., Dewhurst, R., Jarodzka, H. & Van de Weijer, J. (2011). Eye Tracking – A Comprehensive Guide to Methods and Measures. New York: Oxford University Press.

Jacob, R.J. & Karn, K.S. (2003). Eye Tracking in Human-Computer Interaction and Usability Research: Ready to Deliver the Promises. In: Hyona, Radach & Deubel, The Mind's Eye: Cognitive and Applied Aspects of Eye Movement Research (S. 573-603)

Klauer S.G., Dingus T.A., Neale V.L., Sudweeks J., Ramsey D., The impact of driver inattention on near-crash/crash risk: An analysis using the 100-car naturalistic driving study data. Washington DC: NHTSA; 2006. (Technical Report Technical report).

Kircher, K., Ahlström, C., & Kircher, A. (2009). Comparison of two eye-gaze based real-time driver distraction detection algorithms in a small-scale field operational test. In: Driving assessment 2009: 5th international driving symposium on human factors in driving assessment, training and vehicle design. Big Sky, Montana.

Kircher, A., Vogel, K., Törnros, J., Bolling, A., Nilsson, L., Patten, C., Malmström, T., Ceci, R. (2004) Mobile telephone simulator study. Swedish National Road and Transport Research Institute (VTI), Linköping, Sweden.

Kühnelt-Leddihn, A., Bauer, R., Schuster, M., Braun, E. & Hofer, M. (2013) Get Smart. Smartphone Verwendung und Verkehrssicherheit bei jugendlichen FußgängerInnen und RadfahrerInnen [Smartphone use and road safety among young pedestrians and cyclists], https://www.bmvit.gv.at/verkehr/strasse/publikationen/sicherheit/vsf/downloads/26_endbericht_getsmart.pdf

McKeever, J.D., Schultheis, M.T., Padmanaban, V. & Blasco, A. (2013) Driver Performance While Texting: Even a Little is Too Much. Traffic Injury Prevention, 14:2, 132-137, DOI: 10.1080/15389588.2012.699695.

Metz, B. (2009). Worauf achtet der Fahrer? Steuerung der Aufmerksamkeit beim Fahren mit visuellen Nebenaufgaben. Dissertation. [What do drivers pay attention to? Controlling driver attention during visual side tasks. Doctoral Thesis.] Universität Würzburg.

Monk (2013). Driver distraction research and policy: An update from NHTSA. Proceedings of the 3rd International Conference on Driver Distraction and Inattention. Göteborg.

Nitsche, P., Aichinger, C., Aigner-Breuss, E., Hahn, M., Kaiser, S., Rußwurm, K., Stütz, R. (2014) FAST. Fahrverhaltensstudien zur Ablenkungsbewertung von Straßeninfrastruktur [Driving Behaviour Studies on the Impact of Road Infrastructure on Driver Distraction] (2014), http://www.bmvit.gv.at/verkehr/strasse/sicherheit/fonds/vsf/downloads/33_fast.pdf

Pommer, A., Donabauer, M., Winkelbauer, M., Schneider, F. & Robatsch, K. (2016). KFV- Sicher Leben. Band #1. 100-Car Study Österreich. Wien.

Ramaekers, J. G. (2003). Antidepressants and driver impairment: empirical evidence from a standard on-the-road test. Journal of Clinical Psychiatry, 64, 20-29.

RoSPA, 2012. Road Safety Information. Fact Sheet: Driver Distraction. Birmingham. Available at: http://www.rospa.com/road-safety/advice/drivers/distraction/fact-sheet/

Schulz, R. (2012). Blickverhalten und Orientierung von Kraftfahrern auf Landstraßen. Dissertation. [Gaze Behaviour and Orientation of Motorists on Regional Roads. Doctoral Thesis.] Technische Universität Dresden.

Statistics Austria: Road traffic accidents, Available at: http://www.statistik.at/web_en/statistics/EnergyEnvironmentInnovationMobility/transport/road/road_traffic_accidents/index.html

SWOV, 2012. SWOV- Fact sheet. Naturalistic Driving: observing everyday driving behaviour. Leidschendam, the Netherlands, Institute for Road Safety Research. Available at: https://www.swov.nl/sites/default/files/publicaties/gearchiveerde-factsheet/uk/fs_naturalistic_driving_uk_archived.pdf

SWOV, 2013. SWOV- Fact sheet. Distraction in traffic. Leidschendam, the Netherlands, Institute for Road Safety Research. Available at: http://www.swov.nl/rapport/Factsheets/UK/FS_Distraction_in_traffic.pdf

Verkehrsunfallstatistik 2013, 2014; Statistik Austria. Available at: http://www.statistik.at/web_de/statistiken/energie_umwelt_innovation_mobilitaet/verkehr/strasse/unfaelle_mit_personenschaden/index.html

Victor T.W., Harbluk J.L., Engström J. (2005) Sensitivity of eye-movement measures to in-vehicle tasks difficulty. Transportation Research Part F: Traffic Psychology and Behaviour, 8(2), 167-190

Yannis G., Laiou A., Papantoniou P., Christoforou C. (2014) Impact of texting on young drivers' behaviour and safety in urban and rural roads through a simulation experiment. Journal of Safety Research, Vol. 49, 2014, pp.25-31.

# APPENDIX

## 1. Detailed procedure

After arrival, the study was briefly explained to the participants (see Appendix: study information form), after which they filled out the pre-questionnaire. The different devices required for the experiment were then checked (personal/supplied smartphone/earplugs). The smartphone settings were: shell case removed, sound off, and display unlocked. The predictive text option was not changed from the original setting. The participants then did trial runs for text message opening/reading, text message writing/sending, and answering the phone (with and without earplugs). They also chose something to eat (a sandwich with cheese or ham) and drink (still, mild or sparkling mineral water) in the experiment.

They then proceeded to the driving simulator, where the seat position was adjusted, the vehicle manuals checked, and the eye-tracker configured and calibrated. If the calibration resulted in a mean angular error below 2° with no central deviations, eye-tracking was included in the experiment.
Each participant first completed two familiarization rides (approx. 10 minutes in total), which also included a trial of the phone answering task (with earplugs). The first familiarization track consisted of driving on an empty forest road to practice vehicle handling, speed control, sudden/smooth braking, and accelerating. The aim of the second trial ride was to familiarize the subject with the road and traffic characteristics for the subsequent tests.

All task devices and supplies (phone, earplug, food, water) were placed on a chair to the right of the driver (like a passenger seat), and standard start-up instructions were provided by the test leader (see Appendix). The participants were asked to drive as they would normally drive on a road in similar circumstances. They then drove the three experimental and control tracks in the predetermined counterbalanced order. Standard instructions (see Appendix) were provided prior to each test track. An observation grid (see Appendix) was used by the test leaders to record qualitative information on how each ride and task was performed and to note any relevant information that could affect the validity of driving and eye-tracking data in each condition (section). A post-ride questionnaire was completed after each track.

At the end of the complete experiment, each participant was required to fill out the post-questionnaire and received the agreed incentive for participation.

The entire procedure lasted approximately 75 minutes per participant.

## 2. Standard instructions (start-up and for each test track)

**Standard instructions at START**

Please adjust the seat position. The car controls work in the same manner as a normal car with an automatic transmission (no manual gearbox – so you only have to use your right leg to control the gas and brake pedals).

It is important that you drive as you would normally drive on the road in similar circumstances. We do not want you to drive as if you were taking a driving test or as if the simulation is a computer game. We are not here to judge your driving competence, so please do not feel anxious.

The test drives will start on an outer city road and, after a while, will go through a city centre. You should try to keep your speed to 50 km/h from then on. The simulator will assess your ability to keep to the centre of the lane.

Before each test ride, you will receive standard instructions for specific tasks during the drive.

We will start with two trial rides on the simulator to familiarize you with the equipment and set-up.

**Standard instructions TEXTING**

During the next simulator drive, you will use the standard smartphone for this study. We will do a trial run before the test ride to show you how the phone works. During the drive, you will suddenly hear a ringing sound indicating that a text message has arrived. As soon as you hear this signal, you have to pick up the phone from the base, open the message, and read it. You have to continue driving while reading the message, so do not pull over or stop at the side of the road. When you have read the message, you have to place the phone back on its base. The text message will include an instruction to write a message in reply. Follow this instruction carefully. The same ringing sound will indicate when you can start writing the text message. When you hear a loud stop sound, you must send the text that you have written, even if you have not yet completed the writing task. Similar text message reading and writing tasks will be repeated during the test drive. To allow you to recognise them, the start and stop signals will be played to you before the test ride.

**Standard instructions PHONING**

During the next simulator drive, you will use the smartphone and the standard earplug used in this study. The earplug will be worn on one of your ears. We will do a trial run before the test ride to show you how to use the phone with the earplug. During the test drive, you will receive several phone calls. When you hear the phone ringing, you should pick it up immediately. You will either hear it ringing through the earplug – and should pick up the call via the earplug button – or via the smartphone itself – when you should pick up the call via the smartphone and bring it to your ear. You have to continue driving while talking and listening to the phone, so do not pull over or stop at the side of the road. The caller will ask you some questions. After a while, the phone call will be stopped by the test leader, even if you did not yet finish the task. You will answer a total of four phone calls – two with the earplug and two with the smartphone. The test leader will switch the earplug on or off accordingly during the drive. You cannot take the earplug off yourself. Please also return the phone to its base at the end of the hand-held calls.

**Standard instructions EATING/DRINKING**

During the next simulator drive, you will hear two ringing signals indicating that you have to start eating or drinking. The test leader will inform you which task to do first. You have to continue driving while eating/drinking, so do not pull over or stop at the side of the road. You then have to eat/drink continuously until you hear a clear stop signal. When you hear the stop signal, lay the sandwich/ water bottle back down on the chair at your side. The start and stop signals will be played to you prior to the test ride for recognition purposes.

**Standard instructions CONTROL**

During the next simulator drive, you should drive as you would normally drive in similar traffic circumstances. You should always keep driving straight ahead.

## 3. Operationalization of tasks

**Text reading and writing task**

1. Test leader sends the first message in real-time at the start of the scenario.
2. The programmed first start sound in the scenario goes off indicating the start of the text message reading task, i.e. pick up the phone immediately from the passenger seat, open the text message and read it (no stopping or parking), then lay the phone back down on the passenger seat when finished.
3. When start sound two is played, the participant has to complete the following task: pick up the phone again immediately from the passenger seat, write and send back a message, and lay the phone back down on the seat. If a stop sound is heard, the task must be stopped even if it has not yet been completed.
4. The test leader sends a second message immediately after the stop sound.
5. The same procedure is repeated for the next two start sounds.

The order of the tasks was identical for all participants for this scenario only.

**Hand-held phoning:**

1. At a specific point in the scenario, the first test leader sends a Skype message to the second test leader (in another room) to start the phone call.
2. When the programmed start sound in the scenario goes off, the participant immediately picks up the phone from the passenger seat and starts the call with the phone in his/her hand and placed to his/her ear (no stopping or parking).
3. Different questions are asked, to which the participant has to respond.
4. The phone call is stopped when as the second test leader receives a stop message via Skype from the first test leader. The participant then lays the phone back down on the passenger seat.
5. The same procedure is repeated for a second time.

The task operationalization for **hands-free phoning** was identical to that for hand-held phoning, with the exception of the use of the earplugs. These were worn on the participants ears and plugged into the phone prior to the start of the hands-free phoning tasks, either at the start of the scenario or shortly after the two hand-held phoning tasks. When the participant heard the start sound, he/she had to immediately answer the phone via the earplug button or the phone screen and start the call.

**Eating and drinking**

1. When the programmed start sound in the scenario goes off, the participant has to immediately take the food/bottle from the passenger seat, unwrap the food/open the bottle and then eat/drink continuously (no stopping or parking).
2. When the programmed stop stound is heard, the participant should stop eating/drinking at once and lay the food/bottle back down on the passenger seat

### 4. Text messages – English translation

- The time has come at last. Our vacation started! But we don't know where to go yet. Please send us a text message with your 5 favourite destinations. But pay attention and only start writing when you have passed the road sign with the sun.
- I am very hungry. I would like to eat something healthy, not fast food. Could you send me a text message naming 5 types of fruits or vegetables? Only start writing when you have passed the road sign with the sun on your right.

### 5. Questions in the phoning task and order in the scenario

*"Can you please name 5 ..."*

Task 1 in scenario (hand-held or hands-free):
- Car brands
- Zoo animals
- Austrian cities

Task 2 in scenario (hand-held or hands-free):
- World cities
- Female names
- Male names

Task 3 in scenario (hand-held or hands-free) :
- Farm animals
- Favourite dishes
- Music bands or singers

Task 4 in scenario (hand-held or hands-free):
- Clothes
- Colours
- Things found in a toilet bag

## 6. Pre-questionnaire – English translation

To be filled in by the researchers

Participant number: Date of trial: ../../..

Note: All information on this form is confidential
It will be stored securely at KfV/BRSI
No individuals will be identified

The aim of this questionnaire is to obtain information on your opinions, behaviour and attitudes with respect to road traffic risks**. Questions** are asked about your driving experience, your use of a mobile phone/smartphone (both in general and while driving), and other things you may do while driving. You are not obliged to answer all the questions if you do not want to. Completing the questionnaire will take approx. 15 minutes. We would like to emphasize that there are no right or wrong answers. The responses to this questionnaire are only taken into account on a group level and thus remain strictly confidential and anonymous.

### DRIVING EXPERIENCE

**How often do you drive a car?**

At least 4 days a week
1 to 3 days a week
A few days a month
A few days a year
Never >> exit recruitment

**How many kilometres would you estimate that you have driven in a car in the past 12 months? (rounded to the nearest hundred)**

____ km in total <10,000 >> exit recruitment

### SMARTPHONE USE

**Which Samsung Galaxy model (number) did you bring with you today for the study? (example format GT-S7275R). The model (number) can be found under 'settings' 'more' 'device info'.**

________

**How many months or years have you owned a smartphone?** ____ months ____ years

**How easy do you find it to use your smartphone for sending/reading texts?**

Please indicate your response on a scale from 1 to 10, where 1 is "very easy" and 10 is "very difficult".

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| very easy | | | | | | | | | | | very difficult |

**How many text messages do you send on an average day?** __________

**How many text messages do you receive on an average day?** __________

**In the past 12 months, how often did you use your smartphone to ...**

Please indicate your response on a scale from 1 to 5, where 1 is “never” and 5 is “(almost) always”. The numbers in between can be used to refine your response.

| | never 1 | 2 | 3 | 4 | (almost) always 5 |
|---|---|---|---|---|---|
| answer a phone call | | | | | |
| initiate a phone call | | | | | |
| send a text message or e-mail | | | | | |
| read a text message or e-mail | | | | | |
| check or update social media (Facebook, Twitter…) | | | | | |
| search for information on the internet | | | | | |

## Self-reported behaviour

**In the past 12 months, how often did you do the following things as a car driver while waiting at a red light or in a traffic jam?**

Please indicate your response on a scale from 1 to 5, where 1 is “never” and 5 is “(almost) always”. The numbers in between can be used to refine your answer.

| | never 1 | 2 | 3 | 4 | (almost) always 5 |
|---|---|---|---|---|---|
| initiate a hand-held phone call | | | | | |
| answer a phone call hand-held | | | | | |
| initiate a hands-free phone call | | | | | |
| answer a phone call hands-free | | | | | |
| read a text message or e-mail on a smartphone | | | | | |
| send a text message or e-mail on a smartphone | | | | | |
| check or update social media (e.g. Facebook, Twitter…) on a smartphone | | | | | |
| search for information on the internet on a smartphone | | | | | |
| eat wrapped food (e.g. sandwich, chocolate bar) | | | | | |
| drink from a bottle/can | | | | | |

**In the past 12 months, how often did you do the following things with your smartphone while driving a car?**

Please indicate your response on a scale from 1 to 5, where 1 is “never” and 5 is “(almost) always”. The numbers in between can be used to refine your answer.

| | never 1 | 2 | 3 | 4 | (almost) always 5 |
|---|---|---|---|---|---|
| initiate a hand-held phone call | | | | | |
| answer a phone call hand-held | | | | | |
| initiate a hands-free phone call | | | | | |
| answer a phone call hands-free | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| read a text message or e-mail on a smartphone | | | | | |
| send a text message or e-mail on a smartphone | | | | | |
| check or update social media (e.g. Facebook, Twitter…) on a smartphone | | | | | |
| search for information on the internet on a smartphone | | | | | |
| eat wrapped food (e.g. sandwich, chocolate bar) | | | | | |
| drink from a bottle/can | | | | | |

**Do you own any devices that allow you to make hands-free phone calls in the car?**
If so, please indicate which of the following devices you own. Multiple answers possible.

Earplug
Headphone
Hands-free kit installed in car
Other: ……………………………..........
No

**Does your smartphone have a speech to text function?**

Yes -> How often do you use it while driving? O always O sometimes O never
No

**Opinions/intentions**

**To what extent do you agree with each of the following statements?**
Please indicate your response on a scale from 1 to 5, where 1 is "disagree" and 5 is "agree". The numbers in between can be used to refine your answer.ss

Do you support the following measure: Zero tolerance for the use of a mobile phone/smartphone while driving (hand-held or hands-free) for all drivers?

support (for)
oppose (against)
no opinion

Do you intend to do the following things in the next four weeks while driving a car?
Please indicate your response on a scale from 1 to 5, where 1 is "surely no" and 5 is "surely yes". The numbers in between can be used to refine your answer .

| | Surely no 1 | 2 | 3 | 4 | Surely yes 5 |
|---|---|---|---|---|---|
| Make a hand-held phone call | | | | | |
| Make a hands-free phone call | | | | | |
| Read a text message | | | | | |
| Send a text message | | | | | |
| Eat wrapped food (e.g. sandwich, chocolate bar) | | | | | |
| Drink from a bottle/can | | | | | |

## Background information

**Are you …?**

- male
- female

**What is your date of birth?** dd/mm/yyyy

**What is the highest qualification or educational certificate you have obtained?**

- None
- Primary education
- Secondary education
- Bachelor's degree or similar
- Master's degree or higher
- No answer

## Symptoms

**Indicate how strongly the following symptoms are present now:**

| Malaise/feeling of discomfort | Not at all | A little | Quite strongly | Very strongly |
|---|---|---|---|---|
| fatigue | Not at all | A little | Quite strongly | Very strongly |
| Headache | Not at all | A little | Quite strongly | Very strongly |
| Heavy eyes | Not at all | A little | Quite strongly | Very strongly |
| Sleepy / drowsy feeling | Not at all | A little | Quite strongly | Very strongly |
| Trouble seeing sharp | Not at all | A little | Quite strongly | Very strongly |
| Increased amount of saliva | Not at all | A little | Quite strongly | Very strongly |
| Sweating | Not at all | A little | Quite strongly | Very strongly |
| Nausea | Not at all | A little | Quite strongly | Very strongly |
| Dry mouth | Not at all | A little | Quite strongly | Very strongly |
| Difficulty concentrating | Not at all | A little | Quite strongly | Very strongly |
| Feeling of "full head" | Not at all | A little | Quite strongly | Very strongly |
| Hazy or blurred vision | Not at all | A little | Quite strongly | Very strongly |
| Dizziness with eyes open | Not at all | A little | Quite strongly | Very strongly |
| Dizziness with eyes closed | Not at all | A little | Quite strongly | Very strongly |
| Loss of orientation | Not at all | A little | Quite strongly | Very strongly |
| Clearly feeling the stomach | Not at all | A little | Quite strongly | Very strongly |
| Burping | Not at all | A little | Quite strongly | Very strongly |

**Additional questions**

**Please indicate the phone number of the smartphone you have brought with you today for the study:**

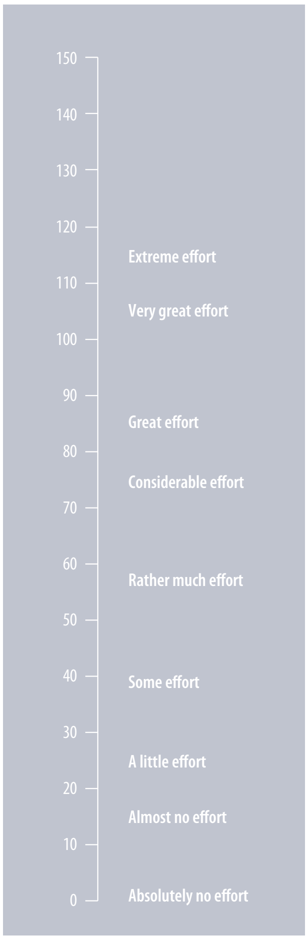
______________________

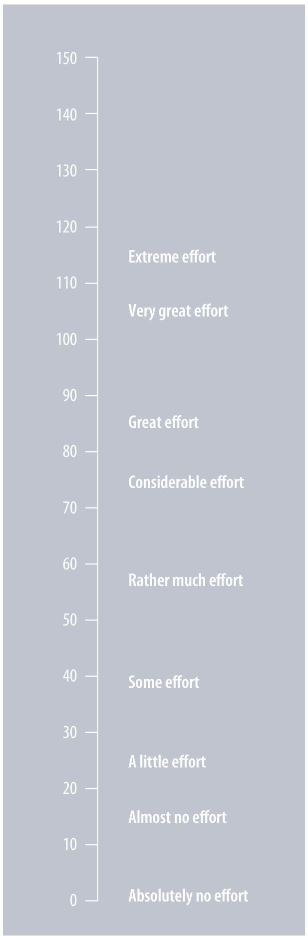
**What is your preferred meal?**

## 7. Post-ride questionnaires – English summary

1. Please indicate by marking the vertical axis how much effort it took you to complete the tasks you have just finished?

Text reading | Text writing
Hand-held phoning | Hands-free phoning
Eating | Drinking




2. How do you feel you performed during the drive in general (i.e., not only during the texting tasks) (i.e., not only during the phoning tasks) (i.e., not only during the eating/drinking tasks)? (rating from ‘very poorly’ to ‘very well’)

3. How easy or difficult was it to keep to the speed limit of 50 km/h? (rating from ‘very difficult’ to ‘very easy’)

4. Compared to how you normally drive, how well do you think you drove during the text reading sections (rating from 'very poorly' to 'very well')

5. Compared to how you normally drive, how well do you think you drove during the text writing sections / during the hand-held phoning sections / during the hands-free phoning sections / during the eating section / during the drinking section (rating - from 'very poorly' to 'very well')

6. What proportion of your concentration was directed at the mobile phone while reading the text messages? (rating from 'complete concentration' to 'virtually no concentration')

7. What proportion of your concentration was directed at the mobile phone / at the phone task / at the sandwich / at the bottle of water / while writing the text messages / while picking up the hand-held phone / while hand-held phoning / while picking up the hands-free phone / while hands-free phoning / while unwrapping the sandwich / while eating / while opening the water bottle / while drinking ? (rating from 'full concentration' to 'virtually none')

8. How do you think the text reading tasks affected your driving speed? (rating from 'drove slower' to 'drove faster')

9. How do you think the text writing tasks / the hand-held phoning tasks / hands-free phoning / eating / drinking tasks affected your driving speed? (rating from 'drove slower' to 'drove faster')

10. How did the text reading affect your ability to keep to the centre of the lane? (rating from 'maintained central positioning ' to 'struggled to maintain central positioning')

11. How did the text writing / hand-held phoning / hands-free phoning / eating / drinking affect your ability to keep to the centre of the lane? (rating from 'maintained central positioning' to 'struggled to maintain central positioning')

12. While text reading, did you feel there was a change in your awareness of road hazards? (rating line 'more aware' to 'less aware')

13. While text writing / hand-held phoning / hands-free phoning / eating / drinking, did you feel there was a change in your awareness of road hazards? (rating from 'more aware' to 'less aware')

14. How do you feel your driving performance changed when reading a text message? (rating from 'improved' to 'worsened')

15. How do you feel your driving performance changed when writing a text message / hand-held phoning / hands-free phoning / eating / drinking? (rating line from 'improved' to 'worsened')

## 8. Post questionnaires (original German version)

### Version for texting:

**1. Wie anstrengend war es für Sie, die soeben beendeten Aufgaben zu erledigen?**

- 1.1 Text lesen

überhaupt nicht anstrengend 1 2 3 4 5 6 7 extrem anstrengend

- 1.2 Text schreiben

überhaupt nicht anstrengend 1 2 3 4 5 6 7 extrem anstrengend

**2. Wie schätzen Sie Ihre Leistung während der Fahrt allgemein ein (nicht nur während des Lesens/Schreibens von Textnachrichten)?**

sehr schlecht 1 2 3 4 5 6 7 sehr gut

**3. Wie leicht oder schwierig war es für Sie, das Tempolimit von 50 km/h einzuhalten?**

sehr leicht 1 2 3 4 5 6 7 sehr schwierig

**4. Verglichen mit Ihrem normalen Fahrverhalten, wie schätzen Sie Ihre Fahrleistung während der Leseaufgaben ein?**

sehr schlecht 1 2 3 4 5 6 7 sehr gut

**5. Verglichen mit Ihrem normalen Fahrverhalten, wie schätzen Sie Ihre Fahrleistung während der Fahrtabschnitte ein, in denen Sie den Text eingegeben haben?**

sehr schlecht 1 2 3 4 5 6 7 sehr gut

**6. Welchen Anteil Ihrer Konzentration haben Sie auf Ihr Mobiltelefon gelenkt, während Sie die Textnachrichten gelesen haben?**

keine Konzentration 1 2 3 4 5 6 7 gesamte Konzentration

**7. Welchen Anteil Ihrer Konzentration haben Sie auf Ihr Mobiltelefon gelenkt, während Sie die Textnachrichten eingebeben haben?**

keine Konzentration 1 2 3 4 5 6 7 gesamte Konzentration

**8. Wie sehr hat die Textlese-Aufgabe Ihrer Einschätzung nach Ihre Geschwindigkeit beeinflusst?**

fuhr langsamer 1 2 3 4 5 6 7 fuhr schneller

**9. Wie sehr hat die Aufgabe, den Text einzugeben, Ihrer Einschätzung nach Ihre Geschwindigkeit beeinflusst?**

fuhr langsamer 1 2 3 4 5 6 7 fuhr schneller

**10. Wie hat das Lesen des Textes Ihre Fähigkeit beeinflusst, die Spurmitte zu halten?**

gar nicht, habe die Spur gehalten 1 2 3 4 5 6 7 hatte Mühe, die Spur zu halten

**11. Wie hat das Verfassen des Textes Ihre Fähigkeit beeinflusst, die Spurmitte zu halten?**

gar nicht, habe die Spur gehalten 1 2 3 4 5 6 7 hatte Mühe, die Spur zu halten

**12. Hatten Sie während des Lesens das Gefühl, dass es eine Veränderung in Bezug auf Ihre Aufmerksamkeit gegenüber Gefahren im Straßenverkehr gab?**

war weniger aufmerksam 1 2 3 4 5 6 7 war aufmerksamer

**13. Hatten Sie während des Verfassens des Textes das Gefühl, dass es eine Veränderung in Bezug auf Ihre Aufmerksamkeit gegenüber Gefahren im Straßenverkehr gab?**

war weniger aufmerksam 1 2 3 4 5 6 7 war aufmerksamer

**14. Wie hat sich Ihre Fahrleistung Ihrem Gefühl nach beim Textlesen verändert?**

verschlechterte sich 1 2 3 4 5 6 7 verbesserte sich

**15. Wie hat sich Ihre Fahrleistung Ihrem Gefühl nach beim Text schreiben verändert?**

verschlechterte sich 1 2 3 4 5 6 7 verbesserte sich

**Version for phoning:**

**1. Wie anstrengend war es für Sie, die soeben beendeten Aufgaben zu erledigen?**

- 1.2 Telefonieren mit dem Smartphone in der Hand

überhaupt nicht anstrengend 1 2 3 4 5 6 7 extrem anstrengend

- 1.2 Telefonieren mit Freisprecheinrichtung

überhaupt nicht anstrengend 1 2 3 4 5 6 7 extrem anstrengend

**2. Wie schätzen Sie Ihre Leistung während der Fahrt allgemein ein (nicht nur während des Telefonierens?**

sehr schlecht 1 2 3 4 5 6 7 sehr gut

**3. Wie leicht oder schwierig war es für Sie, das Tempolimit von 50 km/h einzuhalten?**

1 2 3 4 5 6 7
sehr leicht sehr schwierig

**4. Verglichen mit Ihrem normalen Fahrverhalten, wie schätzen Sie Ihre Fahrleistung während dem Telefonieren mit Handy in der Hand ein?**

1 2 3 4 5 6 7
sehr schlecht sehr gut

**5. Verglichen mit Ihrem normalen Fahrverhalten, wie schätzen Sie Ihre Fahrleistung während der Fahrtabschnitte ein, in denen Sie mit Freisprecheinrichtung telefoniert haben?**

1 2 3 4 5 6 7
sehr schlecht sehr gut

**6. Welchen Anteil Ihrer Konzentration haben Sie auf Ihr Mobiltelefon gelenkt, während Sie mit dem Handy am Ohr telefoniert haben?**

1 2 3 4 5 6 7
keine Konzentration gesamte Konzentration

**7. Welchen Anteil Ihrer Konzentration haben Sie auf Ihr Mobiltelefon gelenkt, während Sie mit dem Headset telefoniert haben?**

1 2 3 4 5 6 7
keine Konzentration gesamte Konzentration

**8. Wie sehr hat das Telefonieren mit Handy am Ohr Ihrer Einschätzung nach Ihre Geschwindigkeit beeinflusst?**

1 2 3 4 5 6 7
fuhr langsamer fuhr schneller

**9. Wie sehr hat die Aufgabe, mit Headset zu telefonieren, Ihrer Einschätzung nach Ihre Geschwindigkeit beeinflusst?**

1 2 3 4 5 6 7
fuhr langsamer fuhr schneller

**10. Wie hat das Telefonieren mit Handy am Ohr Ihre Fähigkeit beeinflusst, die Spurmitte zu halten?**

1 2 3 4 5 6 7
gar nicht, habe die Spur gehalten hatte Mühe, die Spur zu halten

**11. Wie hat das Telefonieren mit Headset Ihre Fähigkeit beeinflusst, die Spurmitte zu halten?**

1 2 3 4 5 6 7
gar nicht, habe die Spur gehalten hatte Mühe, die Spur zu halten

**12. Hatten Sie während des Telefonierens mit Handy am Ohr das Gefühl, dass es eine Veränderung in Bezug auf Ihre Aufmerksamkeit gegenüber Gefahren im Straßenverkehr gab?**

1 2 3 4 5 6 7
war weniger aufmerksam war aufmerksamer

**13. Hatten Sie während des Telefonierens mit Headset das Gefühl, dass es eine Veränderung in Bezug auf Ihre Aufmerksamkeit gegenüber Gefahren im Straßenverkehr gab?**

war weniger aufmerksam 1 2 3 4 5 6 7 war aufmerksamer

**14. Wie hat sich Ihre Fahrleistung Ihrem Gefühl nach beim Telefonieren mit Handy am Ohr verändert?**

verschlechterte sich 1 2 3 4 5 6 7 verbesserte sich

**15. Wie hat sich Ihre Fahrleistung Ihrem Gefühl nach beim Telefonieren mit Headset verändert?**

verschlechterte sich 1 2 3 4 5 6 7 verbesserte sich

**Version for eating/drinking:**

**1. Wie anstrengend war es für Sie, die soeben beendeten Aufgaben zu erledigen?**

- 1.3 Essen

überhaupt nicht anstrengend 1 2 3 4 5 6 7 extrem anstrengend

- 1.2 Trinken

überhaupt nicht anstrengend 1 2 3 4 5 6 7 extrem anstrengend

**2. Wie schätzen Sie Ihre Leistung während der Fahrt allgemein ein (nicht nur während des Essens/Trinkens?**

sehr schlecht 1 2 3 4 5 6 7 sehr gut

**3. Wie leicht oder schwierig war es für Sie, das Tempolimit von 50 km/h einzuhalten?**

sehr leicht 1 2 3 4 5 6 7 sehr schwierig

**4. Verglichen mit Ihrem normalen Fahrverhalten, wie schätzen Sie Ihre Fahrleistung während dem Essen ein?**

sehr schlecht 1 2 3 4 5 6 7 sehr gut

**5. Verglichen mit Ihrem normalen Fahrverhalten, wie schätzen Sie Ihre Fahrleistung während der Fahrtabschnitte ein, in denen Sie getrunken haben?**

sehr schlecht 1 2 3 4 5 6 7 sehr gut

**6. Welchen Anteil Ihrer Konzentration haben Sie auf das Essen gelenkt?**

1 2 3 4 5 6 7

keine Konzentration gesamte Konzentration

**7. Welchen Anteil Ihrer Konzentration haben Sie auf das Trinken gelenkt?**

1 2 3 4 5 6 7

keine Konzentration gesamte Konzentration

**8. Wie sehr hat das Essen Ihrer Einschätzung nach Ihre Geschwindigkeit beeinflusst?**

1 2 3 4 5 6 7

fuhr langsamer fuhr schneller

**9. Wie sehr das Trinken Ihrer Einschätzung nach Ihre Geschwindigkeit beeinflusst?**

1 2 3 4 5 6 7

fuhr langsamer fuhr schneller

**10. Wie hat das Essen Ihre Fähigkeit beeinflusst, die Spurmitte zu halten?**

1 2 3 4 5 6 7

gar nicht, habe die Spur gehalten hatte Mühe, die Spur zu halten

**11. Wie hat das Trinken Ihre Fähigkeit beeinflusst, die Spurmitte zu halten?**

1 2 3 4 5 6 7

gar nicht, habe die Spur gehalten hatte Mühe, die Spur zu halten

**12. Hatten Sie während dem Essen das Gefühl, dass es eine Veränderung in Bezug auf Ihre Aufmerksamkeit gegenüber Gefahren im Straßenverkehr gab?**

1 2 3 4 5 6 7

war weniger aufmerksam war aufmerksamer

**13. Hatten Sie während dem Trinken das Gefühl, dass es eine Veränderung in Bezug auf Ihre Aufmerksamkeit gegenüber Gefahren im Straßenverkehr gab?**

1 2 3 4 5 6 7

war weniger aufmerksam war aufmerksamer

**14. Wie hat sich Ihre Fahrleistung Ihrem Gefühl nach beim Essen verändert?**

1 2 3 4 5 6 7

verschlechterte sich verbesserte sich

**15. Wie hat sich Ihre Fahrleistung Ihrem Gefühl nach beim Trinken verändert?**

1 2 3 4 5 6 7

verschlechterte sich verbesserte sich

## 9. Post-questionnaire – English translation

To be filled in by KfV

Participant number: Date of trial: ../../..

Note: All information on this form is confidential
It will be stored securely at KfV/BRSI
No individuals will be identified

**Opinions/intentions**

**To what extent do you agree with each of the following statements?**

Please indicate your answer on a scale from 1 to 5, where 1 is "disagree" and 5 is "agree". The numbers in between can be used to refine your answer.

| | disagree<br>1 | 2 | 3 | 4 | agree<br>5 |
|---|---|---|---|---|---|
| My attention to traffic decreases when talking on a hands-free mobile phone while driving | | | | | |
| My attention to traffic decreases when talking on a hand-held mobile phone while driving | | | | | |
| My attention to traffic decreases when reading a text message on a mobile phone while driving | | | | | |
| My attention to traffic decreases when writing a text message on a mobile phone while driving | | | | | |
| My attention to traffic decreases when eating a sandwich while driving | | | | | |
| My attention to traffic decreases when drinking from a bottle of water while driving | | | | | |

**Do you support the following measure: Zero tolerance for the use of a mobile phone/smartphone while driving (hand-held or hands-free) for all drivers?**

Fully support

Only support in the case of hand-held phoning

Oppose

Do you intend to do the following things in the next four weeks while driving a car?

Please indicate your response on a scale from 1 to 5, where 1 is "definitely not" and 5 is "definitely". The numbers in between can be used to refine your answer.

| | Definitely not<br>1 | 2 | 3 | 4 | Definitely<br>5 |
|---|---|---|---|---|---|
| Make a hand-held phone call | | | | | |
| Make a hands-free phone call | | | | | |
| Read a text message | | | | | |
| Send a text message | | | | | |
| Eat wrapped food (e.g. sandwich, chocolate bar) | | | | | |
| Drink from a bottle/can | | | | | |

## Symptoms

**Indicate how strongly the following symptoms are present now:**

| | | | | |
|---|---|---|---|---|
| Malaise/feeling of discomfort | Not at all | A little | Quite strongly | Very strongly |
| fatigue | Not at all | A little | Quite strongly | Very strongly |
| Headache | Not at all | A little | Quite strongly | Very strongly |
| Heavy eyes | Not at all | A little | Quite strongly | Very strongly |
| Sleepy / drowsy feeling | Not at all | A little | Quite strongly | Very strongly |
| Trouble seeing sharp | Not at all | A little | Quite strongly | Very strongly |
| Increased amount of saliva | Not at all | A little | Quite strongly | Very strongly |
| Sweating | Not at all | A little | Quite strongly | Very strongly |
| Nausea | Not at all | A little | Quite strongly | Very strongly |
| Dry mouth | Not at all | A little | Quite strongly | Very strongly |
| Difficulty concentrating | Not at all | A little | Quite strongly | Very strongly |
| Feeling of "full head" | Not at all | A little | Quite strongly | Very strongly |
| Hazy or blurred vision | Not at all | A little | Quite strongly | Very strongly |
| Dizziness with eyes open | Not at all | A little | Quite strongly | Very strongly |
| Dizziness with eyes closed | Not at all | A little | Quite strongly | Very strongly |
| Loss of orientation | Not at all | A little | Quite strongly | Very strongly |
| Clearly feeling the stomach | Not at all | A little | Quite strongly | Very strongly |
| Burping | Not at all | A little | Quite strongly | Very strongly |

## Open question

**Do you have any further remarks or would you like to add anything about your participation in this study?**

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

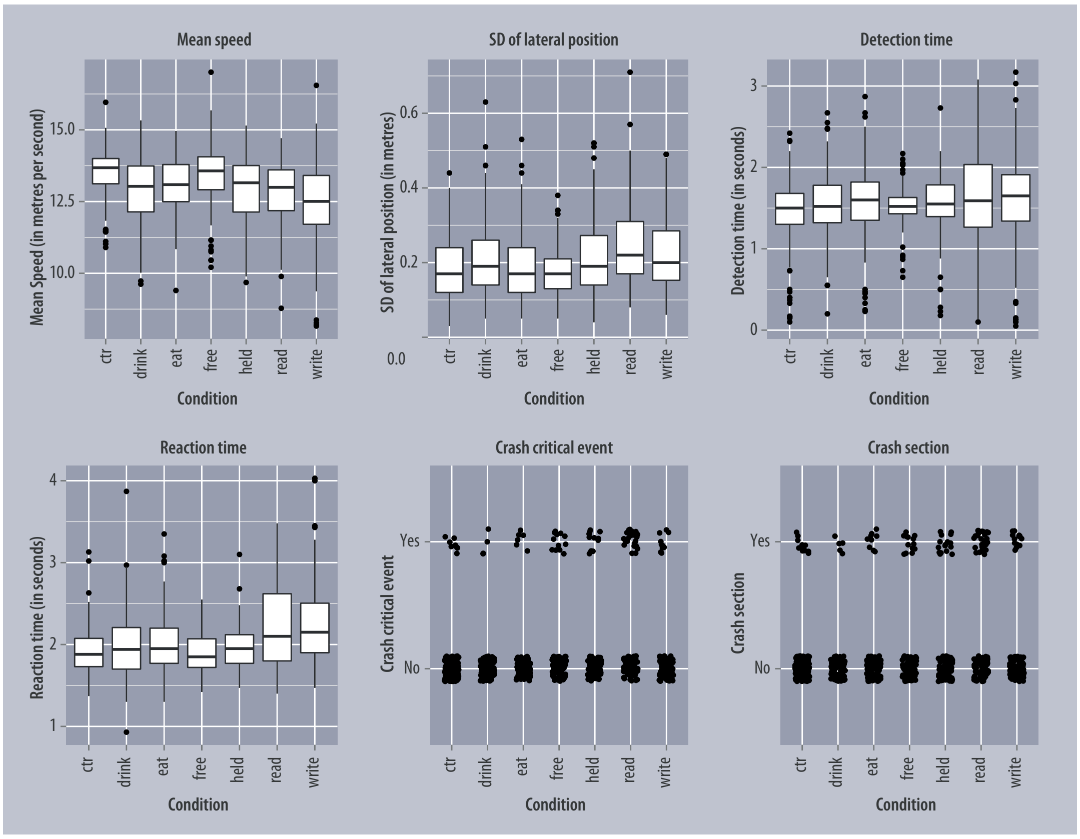
______________________________________________________________________________

______________________________________________________________________________

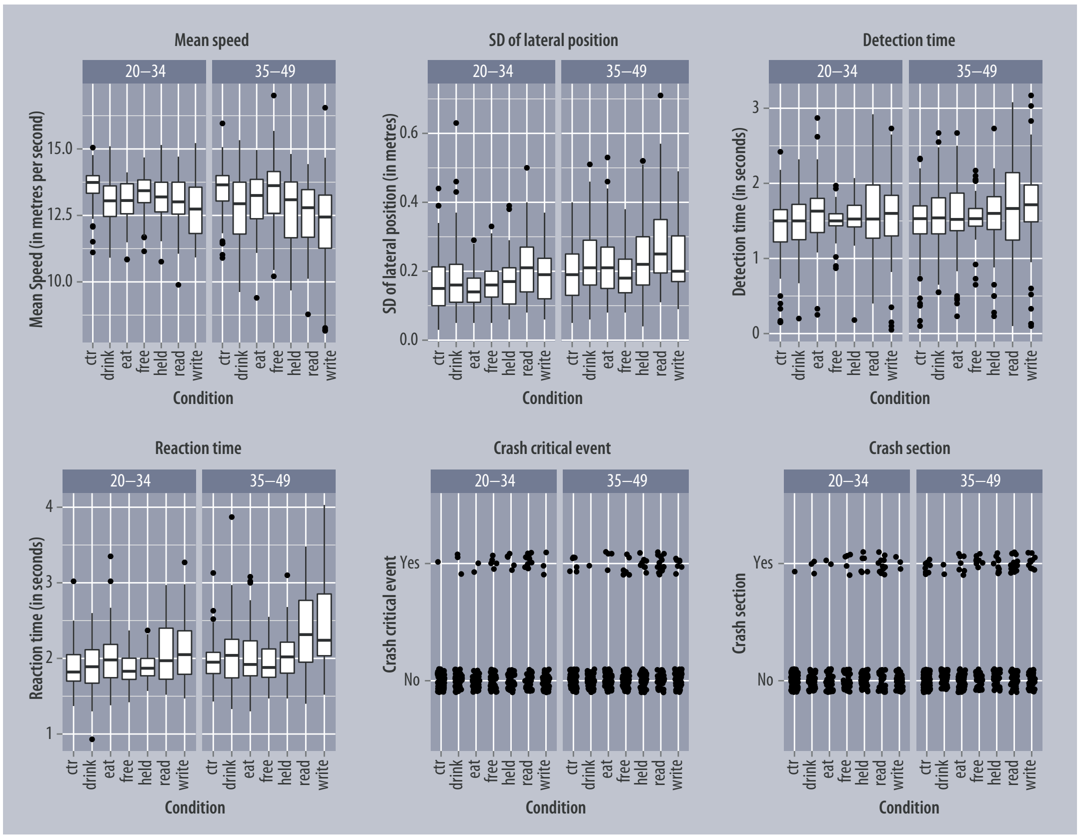
______________________________________________________________________________

## 10. Mathematical model sample boxplots (N56)

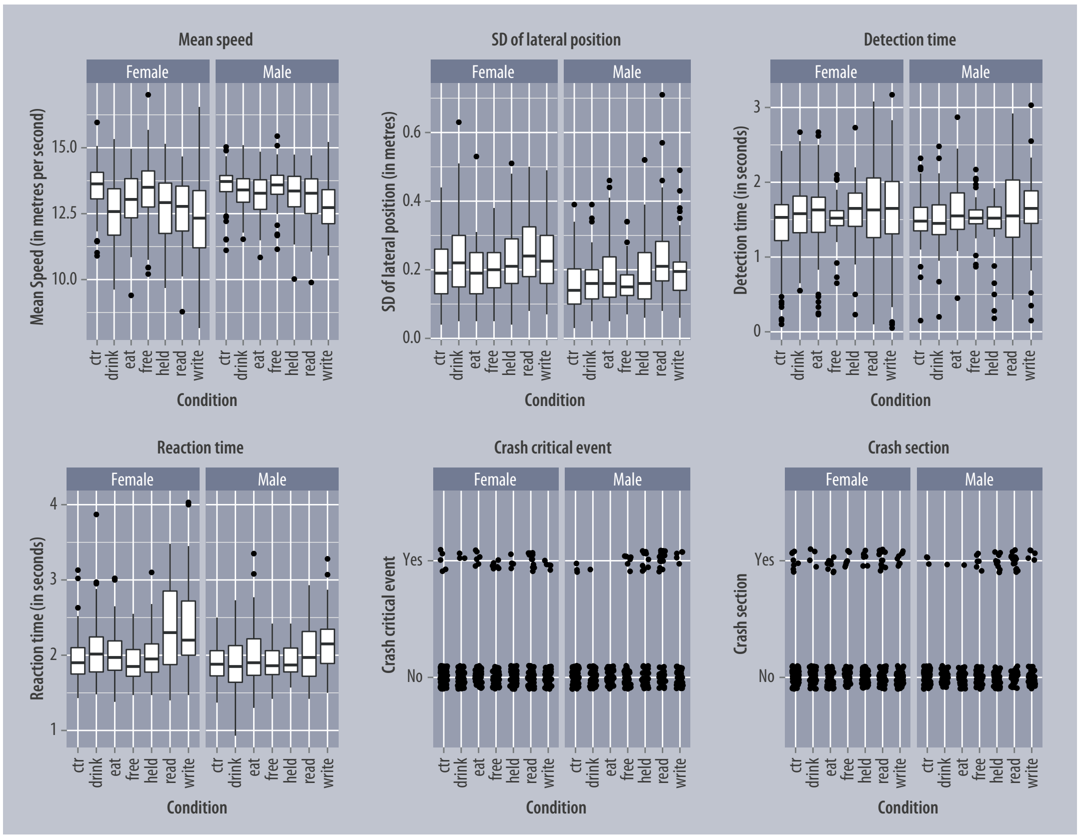
### Model sample boxplots: general (N=56)




### Model sample boxplots: by two age categories (N=56)

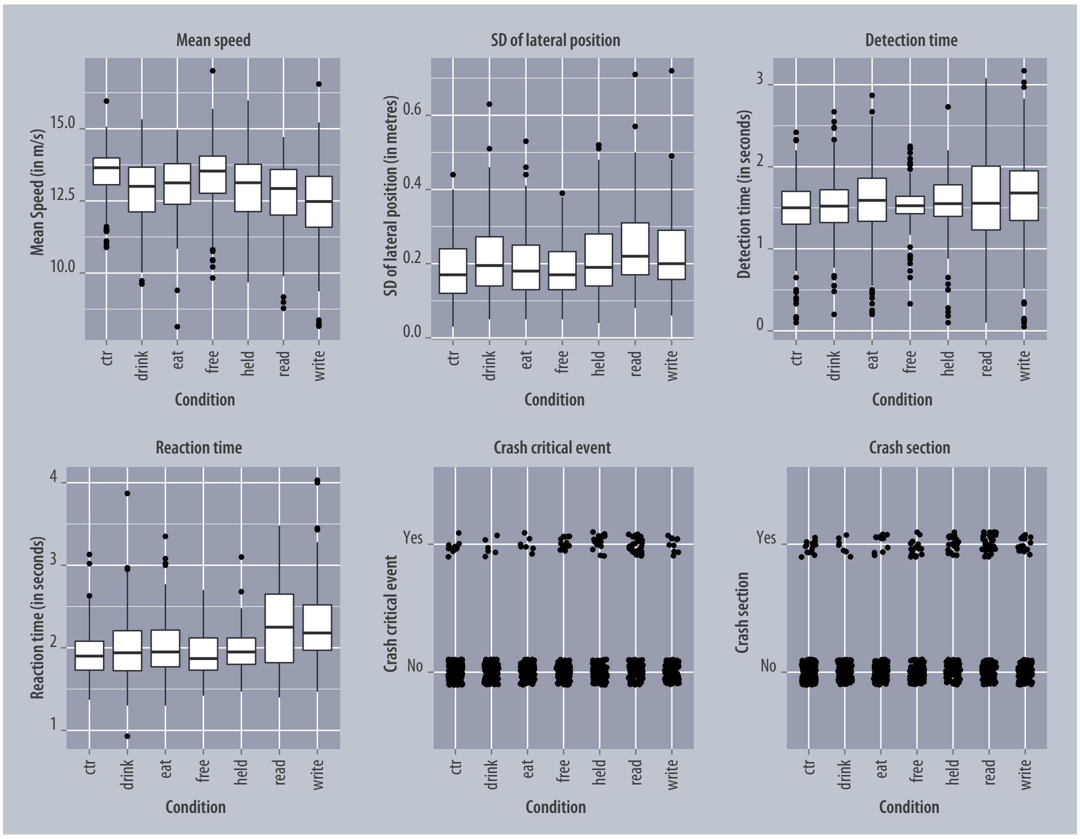


### Model sample boxplots: by gender (N=56)

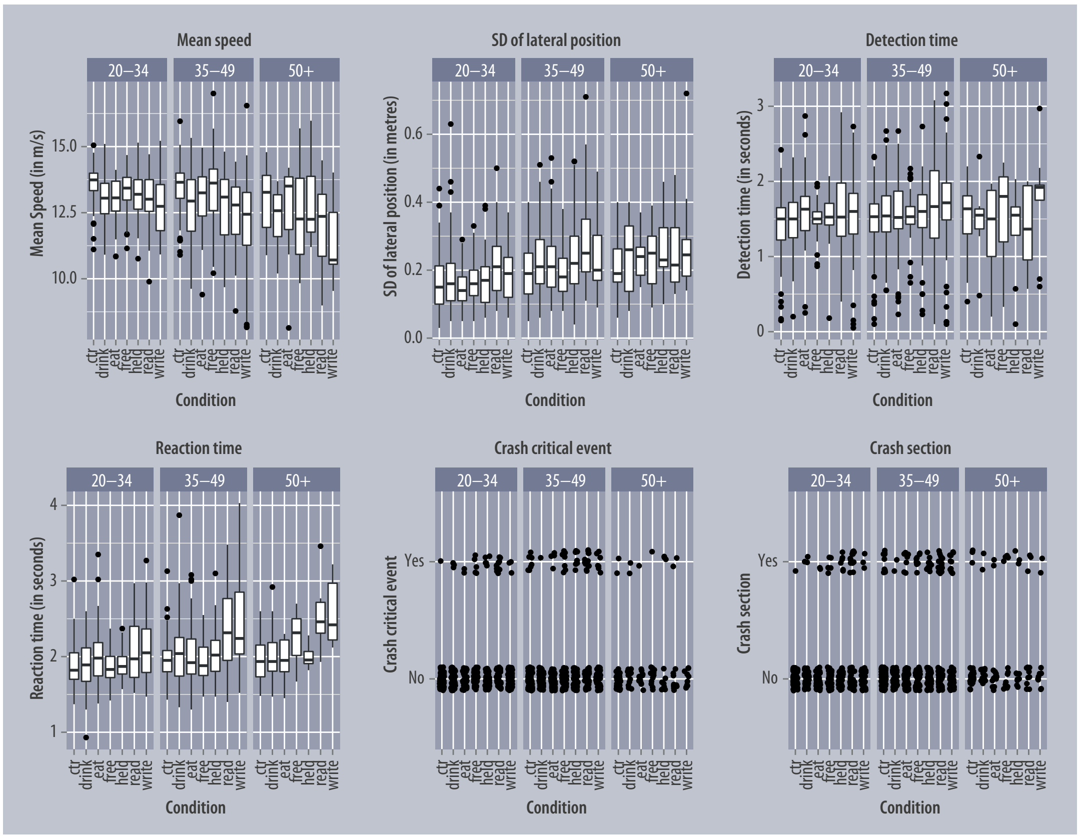



## 11. Full sample boxplots (N63)

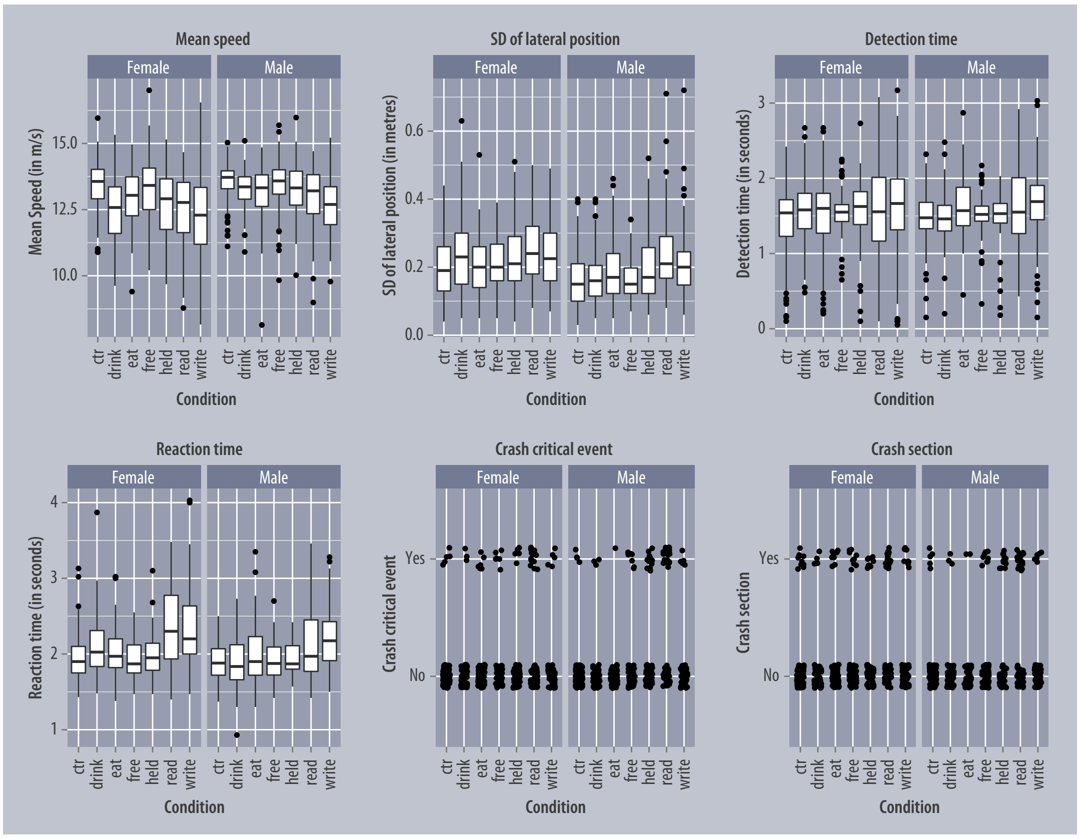
### Full sample boxplots: general (N=63)



### Full sample boxplots: by three age categories (N=63)




### Full sample boxplots: by gender (N=63)



# IMPRESSUM

**Media owner and publisher**
KFV (Austrian Road Safety Board)
Schleiergasse 18
1100 Vienna
Tel.: +43 (5)577 0 77-1919
Fax.: +43 (0)577 0 77-8000
kfv@kfv.at
www.kfv.at

**Purpose of the association and orientation**
The association is an institution responsible for all purposes of accident prevention and a coordination centre for measures which serve the safety in road traffic and other areas of everyday life. It is divided into the fields of road traffic and mobility, home, leisure, sports, property and fire as well as further fields of safety.

**Executive board**
Dr. Othmar Thann, Dr. Louis Norman-Audenhove

**Association registration number**
801 397 500

**Principle direction**
The publication series "KFV – Safe Living" serves the dissemination of studies in the field of road traffic safety, which have been conducted by or on behalf of the KFV.

**Authors**
Monika Pilgerstorfer (KFV)
Sofie Boets (BRSI)

**Specialist responsibility**
Dipl.-Ing. Klaus Robatsch

**Editorial team**
Mag. Christoph Feymann
Mag. Ingrid Rozhon, MAS
KFV (Austrian Road Safety Board)
Schleiergasse 18
1100 Vienna

**Publishing place**
Vienna, 2017

**Copy-editing**
Angela Dickinson

**Graphics**
Catharina Ballan .com

**Photos**
© KFV (Austrian Road Safety Board)
KFV (Austrian Road Safety Board) respectively the referred sources

ISBN pdf-version: 978-3-7070-0136-5

**Citation**
KFV – Safe Living, Vol. #7, The impact of distraction on driving behaviour in urban traffic. Results of a simulator-based study. Vienna, 2017

**Disclaimer**
Despite of careful examination, all information in this publication is provided without guarantee. All liability by the authors or the KFV shall be excluded.
Due to rounding summations may undercut or exceed the 100% figure.

Any personal references shall refer equally to men and women.

Disclosure in accordance with § 25 of the Media Act and reporting obligation in accordance with § 5 of the E-Commerce-Act are to be found under www.kfv.at/footer-links/impressum

ISBN (PDF): 978-3-7070-0136-5