

September 4-6, 2013
Lindholmen Science Park
Gothenburg, Sweden



3rd International Conference on Driver Distraction and Inattention

Abstract Booklet

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INTRODUCTION

Driver distraction and inattention are significant road safety problems worldwide. DDI 2013 aims to bring participants up-to-date on recent developments in the field. On the one hand, there is an increase of connected lifestyle and connected-car functionality (smartphone and on-board apps) for information and entertainment, and on the other hand, there is an increase in driver assistance and automated driving functionality for safety.

Many stakeholders are developing countermeasures to improve attention – regulation, design guidelines, consumer electronics innovation, and vehicles that will not crash. DDI 2013 will bring into the spotlight relevant developments in research from mainstream and neighbouring disciplines, and showcase new and emerging technologies, products and countermeasures. It is the premier international conference on this topic, bringing together all stakeholders – researchers, policy makers, vehicle manufacturers and many others.

The conference features keynote speakers, plenary sessions, and presentations on theory, measurement, effects, crash risk and prevention/mitigation. It includes special symposia on current research and mitigation challenges, and brings together basic and applied research, the latest policy developments, priorities for research and countermeasure development - and more!

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KEYNOTES

Opening speeches by:

- Catharina Elmsäter-Svärd, Minister for Infrastructure
- Mats Viberg, First Vice President and deputy executive officer, Chalmers University of Technology

Keynote speakers:

- PhD Asaf Degani, General Motors R&D, Israel
- Prof Charles Spence, University of Oxford, UK
- Prof Heikki Summala, University of Helsinki, Finland

KEYNOTE ABSTRACTS

Distraction, Inattention, and Monitoring: Some Observations from Aviation Research

PhD Asaf Degani
General Motors R&D, Israel

Abstract: Distraction and inattention of operators (such as pilots, controllers, and technicians) is a serious problem in high-risk industries, especially when associated with the use of automation. As operators' role changes from manual involvement in the control loop to monitoring -- ample opportunities open up to engage in other activities.

To further compound the problem, monitoring of automated systems, as opposed to being kinesthetically involved, makes it difficult to comprehend and keep track of the system's state. Consequently, we see situations where operators have difficulty returning back into the control loop when the automatic system has become inoperable, incapable, or has made an unacceptable response.

I will begin this talk by illustrating and elucidating these automation monitoring problems with several examples from airline operations. We will then focus our attention on specific countermeasures involving interface design and training for monitoring to alleviate some of these problems.

The talk will conclude with a discussion about the need and process to formulate a manufacturer's automation philosophy and its implications for automation design, training, and operations.

Background: Asaf Degani is a Technical Fellow at General Motor's R&D center in Israel. His research focuses on developing design methods and specification schemes for HMI systems, with special emphasis on automated driving. He is also involved in research in the areas of adaptive automation, visualization, and interface design.

Prior to joining GM Israel he was with NASA Ames where he conducted research on airline cockpit automation, procedure/checklist design, organization of information, and formal methods.

Driving by the seat of your pants!

A multisensory approach to capturing driver attention

Prof Charles Spence

Crossmodal Research Group, Oxford University, UK

Abstract: The increasing availability of complex in-vehicle technologies means that 'driver inattention' constitutes one of the leading causes of car accidents. The question therefore arises as to how best to alert 'distracted' drivers to potential road dangers.

I will review the latest laboratory- and simulator-based studies from the Crossmodal Research Laboratory in Oxford detailing a novel brain-based approach to the design of auditory, tactile, and multisensory warnings signals. I will highlight research demonstrating the potential for improving driver behavior in potentially dangerous situations and so reducing the incidence of road traffic accidents that such multisensory warning signals offer.

I will also outline the results of recent studies showing that multisensory stimuli can capture the attention of the driver in the simulator (and the average participant in the psychology laboratory) far more effectively than unisensory stimuli.

The importance of spatial co-location in multisensory warning signal design will also be discussed, as will new evidence regarding the potentially beneficial effects of presenting warning signals in near-rear peripersonal space (i.e., from the headrest) on drivers' head-turning responses. Finally, I will take a look at the latest evidence concerning the potential benefits of using looming auditory and/or tactile alerts.

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Visual guidance, anticipation, and distraction in car driving

Prof Heikki Summala
University of Helsinki, Finland

Abstract: To keep in lane and maintain sufficient safety margins drivers have to anticipate the future path and potential obstacles ahead. At low-radius curves on rural roads they appear to fixate on the future path 1-2 s ahead and to make, whenever possible, anticipatory look-ahead fixations further over the curves in the approach phase. Cognitive load however reduces these anticipatory glances. In straight road sections, and even more on wider roads, drivers have more tolerance in steering. This allows them to share time and visual attention between roadway and in-car tasks and targets.

With practice drivers learn to use ambient (peripheral) vision to keep the car in lane, also when they glance away from road. However, driving experience does not facilitate the peripheral perception of slow or decelerating vehicles or other obstacles ahead. This discrepancy may easily deceive an experienced driver.

Learning to use ambient vision for lane keeping obviously supports time sharing between the roadway and in-car targets. Both on-road and simulator studies indeed show that novices fail more often than experienced drivers in returning the gaze back to road safely, within a reasonable time. (And so do older drivers and even more those with mild Alzheimer or frontal brain damage.) Very interestingly, however, recent simulator studies suggest that this experience effect in time sharing disappears when the target (a billboard) is outside the vehicle.

Experienced drivers appear to do overlong glances as often as novices at targets located in the allocentric world coordination, in contrast to in-vehicle targets that are located in the egocentric car coordination which does not support lane keeping similarly. This condition again presumably deceives the experienced drivers: they are at risk of missing hazards in the peripheral vision.

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O = Oral Only (Non-Paper); P = Peer-reviewed Paper

2-P: BikeCOM: cooperative safety application supporting cyclists and drivers at intersections

Per Gustafsson, Juan Camilo Muñoz, Linus Lindgren, Christian-Nils Boda, and Marco Dozza

Chalmers University of Technology, Sweden

In 2010, 2083 cyclists died while riding bicycles in Europe. Many of those accidents occurred at road intersections, typically involving one vehicle and one bicycle, and were caused by distraction or inattention of either the driver or the cyclist.

This study describes the development and verification of BikeCOM: a cooperative smartphone application able to prevent accidents at intersections by warning both the driver and cyclist in case of an imminent threat. The BikeCOM application runs on Android smartphones and relies on bicycle-to-vehicle communication to exchange safety relevant information.

Naturalistic cycling data from the BikeSAFE and BikeSAFER projects was used to identify the safety critical situation to be addressed. This safety critical situation was described with use cases to envision different application scenarios and derive technical and functional requirements. After the prototype implementation, a pilot test was performed to 1) test the application, 2) develop a data analysis tool, and 3) design the protocol for a larger experiment.

Both a bicycle and a car were used in this larger experiment to recreate the safety critical situation in a controlled real-world scenario.

Results from this experiment show that cooperative applications based on smartphones and connecting bicycles and cars are feasible and possibly desirable. However, present limitations on positioning and latency strongly limit their reliability.

The BikeCOM application promoted smartphones from a distraction hazard to a distraction countermeasure; proposing that banning smartphone technology from traffic might, in the long-term, harm safety and suggesting that integration of safety applications to more traditional and distractive applications such as SMS writing, dialing, and mailing, may be an acceptable solution to limiting distraction from smartphones.

3-O: The Cell Phone Paradox: How do we explain the Differences between Simulator and Naturalistic Driving Research?

Jeffrey S. Hickman and Richard J. Hanowski

Virginia Tech Transportation Institute, USA

Most simulator studies have found that talking on a cell phone while driving results in significant performance decrements [see National Safety Council (2010) for a review]. However, various naturalistic studies (Hickman & Hanowski, 2012; Klauer et al., 2006; Sayer, Devonshire, & Flanagan, 2007) have found that talking on a cell phone while driving does not increase the odds of involvement in a safety-critical event (and is protective in some circumstances) Hanowski (2011) modeled the hypothesized four-fold crash risk of talking on the phone while driving using U.S. crash statistics and cell phone use subscriber rates. He found the estimated crash rates differed from the actual crash rates up to 25 percent from 2000 to 2009. Thus, the paradox of predicted cell phone risk while driving and actual crash rates.

The finding that performance decrements under stress are more common under laboratory conditions than naturalistic conditions is not new. Where there are overt decrements in laboratory settings, they are usually quite small in magnitude [see National Safety Council (2010)], as is the case when talking on a cell phone while driving. However, the reason for this discrepancy between simulator and naturalistic data has not been explored. The current paper will propose a possible framework to explain the cell phone paradox, Cognitive Compensatory Control [Hockey (1997) suggested that performance may be protected under stress by recruitment of further resources or reduction of performance goals], as well as several other factors that may contribute to the variance seen in simulator and naturalistic studies, including: consider cell phone use as a task and not separate sub-tasks, hazard perception, gaze concentration, arousal, and driver choice/motivation.

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5-P: Roadside Advertising Affects Driver Attention and Road Safety

Lene Herrstedt, Poul Greibe and Puk Andersson

Trafitec, Denmark

For many years, roadside advertising along rural roads has been strongly restricted in Scandinavian countries, mostly for safety reasons and aesthetic considerations. But during the last decades, a growing pressure on road authorities caused by significant financial interests has resulted in a rapidly increasing number of advertising signs along rural roads.

The signs are placed with the purpose of capturing drivers' visual attention. Every time the drivers' visual attention is distracted away from the road and towards competing advertising signs, the time available for the drivers' response to avoid a crash if something unexpected occurs is reduced. In this perspective, it is relevant to ask whether roadside advertising affects driver attention and road safety.

With the purpose of clarifying this question, a literature study followed by empirical studies has been carried out. The empirical studies were made by use of an instrumented car equipped with a camera system to track eye movements, GPS for registration of speed behaviour, and laser scanner for measurement of distances to other road users.

The overall results of the empirical studies show that advertising signs do affect driver attention to the extent that road safety is compromised.

6-P: Can You Ignore It?

– Effects of Album Artwork on Driver Distraction

Annegret Lasch¹ and Tuomo Kujala²

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*²Department of Computer Science and Information Systems,
University of Jyväskylä, Finland*

Influence of album artwork on driver distraction when searching for music albums was investigated in a driving simulator experiment with 24 participants.

Participants searched music lists comprising of neutral artwork, attractive artwork showing halfnaked men or women, or no artwork at all. It was expected that searching is more distracting when artwork is presented due to higher visual load. Further, attractive artwork was expected to be more distracting than neutral one. However, no significant distraction effects of album artwork were found.

Attractive artwork seemed to capture somewhat more attention than neutral art. Results seem to suggest that drivers are able to ignore album artwork although the findings could be limited to search-oriented in-car tasks and unfamiliar artwork.

7-O: Inhibition of Return Prevails in In-Car Visual Search when Interrupted by Driving

Tuomo Kujala

*Department of Computer Science and Information Systems,
University of Jyväskylä, Finland*

Inhibition Of Return (IOR) refers to an inhibitory mechanism in visual search encouraging orienting towards novel locations and hence facilitating foraging and other search behaviors. The perseverance of the mechanism for facilitating visual search on an in-car display was investigated in a driving simulator experiment with 12 participants.

Participants searched lists of music tracks on an in-car touch screen display with varying menu formats of grid or list menu structure, and with 6, 9 or 12 tracks per page. Participants' eye movements on the display were recorded with a sampling rate of 500 Hz. For each condition and for each participant, a page with interrupted search was selected for closer analysis on revisits per item. For the list-conditions there were no revisits at all, whereas for grid-conditions there were a couple of revisits for 4 participants on 5 pages (G6: 1, G9: 3, G12: 1).

In total only 7.5% of the searches included revisits. The analyzed data does not reveal if the IOR span is limited, i.e., if the IOR is dependent on the duration of the interruption but the findings give strong support for the perseverance of IOR for facilitating visual search on an in-car display when interrupted by the visual demands of the driving task.

The practical value of the finding is in providing details of drivers' visual behaviors for modeling efforts.

8-P: What drives off-road glance durations during multitasking – capacity, practice or strategy?

Robert Broström¹, Mikael Ljung Aust¹, Linnea Wahlberg², Laban Källgren²

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NHTSA has proposed compliance criteria for in-vehicle tasks in driving simulators. These criteria exclude usage of interfaces with too many long glancing participants. In the current study 30 participants performed three infotainment tasks while driving a high-fidelity driving simulator. Off-road glance durations for three data-trails were analysed to assess the prevalence of long glancers and possible reasons for the existence of long glancers.

Results show that 85th percentile off-road glance durations were common, and significantly varied between participants. Also, the number of long glancers was reduced with repetition, but did not change between task types.

Furthermore, there was no correlation between drivers' performance on a Trail Making Test and the 85th percentile off-road glance durations. Hence, variations in glance duration seem more to reflect individual glance strategies than in-vehicle task complexity or individual performance capacity measured by the Trail Making Test. The findings in this study have implications for further development of compliance testing procedures.

10-O: Performance assessment under visual, cognitive and manual secondary task load - How to interpret Lane Change Task (LCT) results

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The Lane Change Task (LCT; Mattes, 2003) is implemented as an ISO standard (ISO DIS 2622:2010) with the aim to provide “a valid, reliable and sensitive laboratory method that estimates the effect on driving performance caused by the demand from in-vehicle information and communication systems. Consideration of the lane keeping performance in lane keeping phases only is supposed as a very sensitive indicator of distraction effects (ISO DIS 2622:2010).” Although it has been sanctioned by the ISO and is used more and more widely, test qualities (especially sensitivity and re-test reliability) are questionable, taking into account the mixed results found in research. For further clarification of effects that might be due to variance in test procedure, test setup and analysis used, a study was conducted with well-trained subjects. Strict instructions like in the ISO standard were used comparing four secondary tasks in two difficulties each. The secondary tasks are arbitrary but well-defined in their attentional demands. Twenty-five well trained subjects completed LCT trials with these different secondary tasks. The secondary tasks were visual-manual self-paced: SuRT (1) and continuous: CTT (2), cognitive: arithmetic calculation (3) and manual: plugging wooden sticks (4). Performance data is analyzed for LCT performance as well as for secondary task performance. Additionally gaze behavior is analyzed for the assessment of visual attention allocation for all tasks. Thus, for each task type, performance in the LCT and all supposed measures can be determined as a whole as well as for specific phases of driving task and/or secondary task. Underlying mechanisms of visual attention can be described and help understanding performance components in this driving-like task.

12-P: A holistic approach for measuring Driver Distraction and Inattention

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The research about inattention and distraction is still struggling to answer all questions coming up from the automotive industry and politicians. A major reason for this is the partial approach in measuring driver inattention and distraction. Therefore a holistic approach with a reference model for driver distraction and inattention was developed. It includes under investigated fields like driver under-stimulation, individual driver traits and driving task. This leads into a holistic theoretical model on driver attention, inattention and distraction. Within this paper the new holistic approach to classify and judge the hazard potential of the driver-driving task-distraction (DDD) interrelation is described. The methodology includes all driver states from under-stimulation to over-stimulation considering factors to classify driver capability, driving tasks and tertiary tasks. In addition a holistic definition of distraction is given. Based on this definition a standardized rating scale was developed and validated which is based on empirical social research methods, driver cognitive workload models and empiric data. Based on the analysis of each variable out of the DDD interrelation a holistic approach is presented to calculate the hazard potential of this interrelation. Finally this approach is for the first time empirically reviewed within an initial driving simulator experiment. Results are presented and discussed in this paper as well.

13-P: Why Sweden should not do as everybody else does

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Sweden is the only country in Europe that does not outlaw handheld phone use while driving. This puts some political pressure on Sweden. The Swedish Government commissioned VTI to conduct a literature review on the effects of mobile communication on driving performance, on the legal situation in other countries, and whether there were any documented effects of a legislation. The literature showed that mobile communication does influence driving behaviour, but there appears to be no increased crash risk in real traffic. Also, laws do not have a lasting effect on how much drivers use their telephones. Therefore, the Swedish Government commissioned VTI to suggest countermeasures against the dangerous use of communication devices. Several countermeasures were presented, ranging from technical solutions over monetary incentives to education and information. It was stressed that no single countermeasure was expected to be satisfactory in itself, and that it is paramount to work with a human centred perspective. While the government proposed in December 2012 not to outlaw handheld phone use, the united political opposition, via its majority in the parliament, mandated the government in March 2013 to pass such a law. Besides that, the government proposed amendments to the current regulations for quick action.

15-P:Cycling and sounds: the impact of the use of electronic devices on cycling safety

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The role of auditory perception of traffic sounds has often been stressed, especially for vulnerable road users such as cyclists or (visually impaired) pedestrians. This often in relation to two growing trends feared to negatively affect the use of auditory signals by road users: popularity of electronic devices (e.g. mobile phones, portable music players) and the number of quiet electric cars. Notwithstanding the concerns about impact of both trends on the safety of vulnerable road users, the potential safety implications of limited auditory information available while cycling have not been systematically studied yet. This paper consolidates current knowledge about the use of electronic devices in relation to cycling safety. Based on a proposed conceptual model, the paper provides a qualitative estimation of the extent to which limited availability of auditory information (caused by the use of electronic devices) while cycling constitutes a road safety hazard. Literature analysing official and self-reported crash data and research into the effects of using electronic devices on cycling performance have been used. Results suggest that the concerns about the use of electronic devices while cycling are justified. Listening to music and talking on the phone negatively influence cycling performance and self-reported crash risk. However, it is difficult to prove that these effects are (only) due to the limited availability of auditory information.

17-P: Effective Utilization of Naturalistic Data for Driver Distraction Outreach Campaigns

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Successful campaigns for combatting public health issues related to driving have focused on three fronts: legislation, enforcement, and public outreach. While considerable efforts have been made at crafting legislation and providing for enforcement to combat distracted driving by commercial vehicle operators, outreach efforts have not been as successful in gaining the population's attention. The United States Federal Motor Carrier Safety Administration hosts the Commercial Motor Vehicle Web-Based Driving Tips site. This public outreach site is oriented towards commercial drivers and covers several safe- and defensive-driving topics, including distraction. This project involved updating distraction information contained within the site in order to ensure that the results of recent naturalistic studies of commercial driving were included, and simplified the site text in order to better convey the information. Additionally, due to the increasing amount of cross-border traffic, the material was reproduced in the Spanish language. The result was site text produced at a more appropriate reading level for the population, updated with results from recently published studies that provided information on distraction risks not previously identified. The process that was followed can be utilized for other targeted outreach efforts for distracted driving campaigns as well as for other transportation-related outreach programs.

18-P: Do drivers prioritise primary driving tasks over secondary tasks within driving simulators? A comparison of simulators of varying fidelity

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There is a fundamental lack of understanding concerning the relationship between the fidelity of driving simulators (extent to which simulators replicate reality) and validity (extent to which drivers behave as they would in equivalent real-world situations). For distraction research, knowledge on how drivers prioritise primary driving tasks over secondary tasks can be a potential indicator of simulator validity. Theoretical propositions, consequently established in on-road research, show that higher primary task demands result in increases in time pressure and forward spatial-scene uncertainty, prompting drivers to return their vision to the road ahead in a predictable fashion.

This paper addresses whether drivers within simulators of varying fidelities exhibit the attention behaviour and time-sharing strategies predicted by theoretical and empirical research. Twenty-four drivers drove in two (low and medium-fidelity) simulators following a simple rural-road scenario comprising straight and curved-road driving, whilst performing a series of visual search tasks using an in-vehicle display. Results showed that drivers exhibited the predicted visual attention behaviours in both simulators. Nevertheless, the low-fidelity simulator was associated with reduced lane keeping performance, due primarily to physical, rather than psychological differences in the driving experience. It is concluded that driving simulators of varying fidelity can successfully be employed in distraction research.

19-O: BikeSAFE – Analysis of Safety-Critical Events from Naturalistic Cycling Data

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Cycling is a risky activity responsible for a large number of injuries and deaths every year. For example, in Europe cycling claims about 2,000 lives each year. In the last decades, numerous research studies used accident databases to better understand the causal factors of bicycle–vehicle accidents in order to estimate the risk of these accidents (e.g., Karsch et al., 2012; Liu et al., 1995; Stone & Broughton, 2003; Wachtel & Lewiston, 1994; Wang & Nihan, 2004). However, so far very few studies (e.g., Gustafsson & Archer, 2012; Johnson et al., 2010) investigated cyclists' behavior using naturalistic cycling data. In addition, these studies only collected GPS and/or video information during cycling. The aim of the BikeSAFE project was to collect naturalistic cycling data from videos, GPS as well as inertial sensors and bicycle controls to 1) analyze cyclists' behavior and their interaction with other road users, 2) investigate safety-critical situations and 3) suggest new countermeasures to increase bicycle safety. Therefore, five equipped bicycles collected naturalistic cycling data in Gothenburg from 16 participants (8 female, 8 male; $M = 39.1$ years, $SD = 11.4$ years). Video recordings captured cyclists' perspective of the road while inertial sensors and GPS recorded kinematics and location information of the bicycles. In total, 114 hours and 332 trips were collected. In addition to cycling data, a trip diary and questionnaire with regard to the participants' cycling patterns were filled in. Preliminary results from BikeSAFE prove the potential of naturalistic cycling data to elucidate bicycle accident causation and cycling behavior including distraction and inattention.

20-P: Spontaneous vs. gaze shift-induced blinks for assessing driver drowsiness/inattention by Electrooculography

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Driver monitoring systems with focus on drowsiness and inattention aim to reduce carcrashes. To achieve this goal, previous research has shown that driver eye blink features (blink frequency, duration etc.) are correlated to some extent with drowsiness. Hence, within a level of uncertainty they can contribute to driver drowsiness warning systems. In order to improve such systems, we investigated blink characteristics with respect to their different origins. We observed that in a real road experiment using electrooculography, blinks occur both spontaneously or due to gaze shift. Gaze shifts between fixed positions, which occurred due to secondary visuomotor task, induced and modulated the occurrence of blinks. Moreover, the direction of the gaze shift affected the occurrence of such blinks. Based on the eye movements during another experiment in a driving simulator without a secondary task, we found that the amount of gaze shift (between various positions) is positively correlated with the probability of the blink occurrence. Therefore, the paper recommends handling gaze shift-induced blinks (e.g. during visual distraction) differently from those occurring spontaneously in drowsiness warning systems.

22-P: Measuring the distraction of alternative list-scrolling techniques when using touchscreen displays in vehicles

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Interactive touchscreen displays are increasingly prevalent in cars, providing direct-manipulation access to information, communication and entertainment services. However, touchscreens are inherently associated with high visual demand and often require physical dexterity to manipulate them. Touchscreens may therefore distract drivers if used while driving. A simulator study investigated the impact of using three existing list-scrolling techniques on driving performance and preferences while driving in a medium-fidelity, fixed-based driving simulator. Twenty experienced drivers used page-by-page, flick-scrolling and page-swiping techniques to locate specified words within structured, vertical word lists displayed on a touchscreen located in the centre console of a right-hand drive car. Page-by-page performed worst during the study – objectively, it was associated with the longest task-times and the highest number of off-road glances and subjectively, was least preferred by participants both before and after driving. Flickscroll and pageswipe performed equally well with respect to task completion time, glance behaviour and driving performance. Drivers preferred flick-scroll before driving but favoured page-swipe afterwards as it was perceived to be “easiest to use” and “less distracting.” Page-swipe offers the benefits of both flick-scroll (large interaction area) and page-by-page (displays discrete ‘chunks’ of information). It may therefore be more easily incorporated into the self-paced nature of driving. Further research is required to quantify the perceived benefits.

23-P: How do you assess the distraction of in-vehicle information systems? A comparison of occlusion, lane change task and mediumfidelity driving simulator methods

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There are several simplistic, low-cost methods for evaluating the distraction of in-vehicle information systems (IVIS), intended primarily for use in the formative design process. This study compared two standardised low-cost evaluation methods, Occlusion and Lane Change Task (LCT), with a medium-fidelity driving simulation. Participants carried out tasks using an in-vehicle information system under three conditions: Using the occlusion protocol; LCT; and while driving on a motorway in the simulator. Findings provided strong evidence that the occlusion technique is a stronger candidate than the LCT for evaluating driving distraction due to IVIS. Measures from the occlusion technique (Total Shutter Open Time –TSOT; and Task Time with full vision) were found to correlate highly with the majority of the driving simulator measures (total glance time, mean glance time, driving task time, standard deviation of headway and standard deviation of lane position). Importantly, TSOT was found to successfully predict the number of long off-road glances (greater than two seconds), a critical safety related measure. In contrast, the key LCT measure of mean deviation provided little predictive ability in considering varying tasks and systems.

24-O: Enhanced Lane Keeping during Driver Distraction: the Effect of Lead Car Presence

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Previous simulator studies on driver distraction suggest that the effect of distracting in-vehicle tasks on driver performance may depend on the nature of the task itself. Whilst tasks that divert drivers' visual attention away from the road impair lateral control of the car and may increase reaction time to a sudden event in the road, non-visual tasks which allow drivers' eyes to remain on the road seem to 'improve' lateral performance, with less deviation in the lane and better steering control (Jamson & Merat, 2005; Merat & Jamson, 2008). Drivers' eye movements are also shown to be more focused towards the road centre, when they perform a demanding non-visual task, with the pattern more 'spread' during baseline driving (Victor, Harbluk & Engström). A recent study by Mühlbacher & Krüger (2012) suggests that these improvements in lateral control may be due to the presence of a lead vehicle in such studies. We report on a study which investigated this proposal further, using both visual and non-visual secondary tasks, in different road layouts. The paper will report on how drivers' lateral and longitudinal performance and eye movement pattern was affected by lead car presence and secondary task performance.

25-O: Evaluation of an Adaptive warning system with help of a mini-FOT - A pilot study

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There is a hypothesis that a reduced number of warnings, as a consequence of an adaptive strategy, will increase the drivers' trust for a system. The aim with this work was to evaluate drivers' responses and experiences of an adaptive warning system by using a mini-FOT approach. Questions in focus were: Does an adaptive warning system mean that the driver more often a) experience it as relevant and b) makes a correct counteraction, compared to if it is not adaptive? In the non-adaptive mode (NAM) warnings from four systems (collision, lane departure, distraction, drowsiness) were given independently of each other, while in the adaptive mode (AM) the warnings were adapted to driver status as well as to driving situation. 10 commuters drove an equipped vehicle for one week each with non-adaptive mode (2.5 day) and adaptive mode (2.5 day) used in a balanced order. The participants were instructed to press a "relevant" or "not relevant" button, when given a warning. They were also asked to motivate their arguments for the decision by a short spoken message, which was automatically recorded. In addition they filled out questionnaires and were interviewed twice. On average the drivers received 6.1 warnings/h in the NAM and 1.9 warnings/h in the AM. Drivers reported a higher level of relevant warnings in the NAM (60%) compared to the AM (32%). The reason for this is unknown but may be due to technical problems. The voice recordings helped understanding the drivers' experiences of the warnings. In all situations in both modes the drivers' counteractions when receiving a warning were correct. Generally the drivers were positive to the concept of adaption. Most of the criticisms were related to technical problems of the stand-alone systems. The mini-FOT method worked well and may be a valuable way to evaluate systems before realization of a larger scale FOT.

26-O: The effect of visual and cognitive distraction on the driving performance of older drivers - A driving simulator study

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Driving is a complex task, consisting of several subtasks. Since people have limited capacity to process ongoing activities, distraction during driving may negatively affect driving performance. Especially older drivers, who experience a decline in cognitive capacity, may have difficulty to maintain safe driving while distraction. The aim of this study was to investigate the effect of visual and cognitive distraction on the driving performance of older drivers while taking into account divided attention capacity. In a fixed-based driving simulator, seventeen older drivers (mean age 78 years) drove a ride with and without visual distraction, while thirty-five older drivers (mean age 76 years) drove a ride with and without cognitive distraction. Repeated measures analyses of covariance were conducted to determine the effect of visual and cognitive distraction on several specific driving measures like Standard Deviation of Lateral Position (SDLP). The findings will be discussed.

28-P: Towards understanding mobile device use in Commercial Motor Vehicle Drivers: Do drivers interact as a drowsiness countermeasure?

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This study examined factors associated with mobile device use (MDU) while driving in commercial motor vehicle operations. Analyses were performed on a naturalistic truck driving data set that involved 100 drivers operating a commercial truck that had been instrumented with data collection equipment, including video cameras. The focus of the analysis reported here was twofold. First, how does the MDU recorded in naturalistic driving video compare to the estimates of MDU from the National Occupant Protection Use Survey (NHTSA 2011)? Second, does MDU vary as a function of time-of-day? Regarding the first issue, based on video inspection, it was determined that participants used a hand-held phone approximately 4.3% of the time and a hands-free phone 4.0% of the time (totaling 8.3% of the driving time). When cell phones, Citizen's Band radios, and dispatching devices were included, it was found participants used devices 10.4% of the time. Considering time of day of MDU, one analysis binned the data to match circadian rhythm high (9 a.m. and 7 p.m.) and low (1 p.m. and 2 a.m.) points. Across the four bins, the highest proportion of MDU (accounting for exposure) occurred in the early morning (2 a.m.) bin. Results of additional analyses similarly provide support for the hypothesis that truckers may use a mobile device as a countermeasure to drowsiness.

30-P: Does phone interface type influence the distracting effects of text messaging in tunnels?

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There is clear evidence that text messaging while driving is distracting and can significantly increase the risk of being involved in a collision. However, very little is known about how the type of phone interface might moderate the distracting effects of text messaging. In addition, compared to highway driving, driving in tunnels introduces additional issues such as monotony, fatigue, and more severe consequences of crashing, all of which may serve to exacerbate the effects of distracting activities on driving performance and safety. This study assessed the effect of using a touch screen keyboard versus numeric keypad phone to send and receive text messages on simulated driving performance and eye glance behaviour in a tunnel environment. Twenty-four drivers aged 25 to 55 years ($M=33.4$, $SD=9.9$) drove a 14km route in the MUARC advanced driving simulator. During the drives, participants read and sent text messages using their own mobile phones. Half of the participants used a phone with a numeric keypad, while the other half used phones with a touch screen keyboard interface. Results revealed that, regardless of phone interface type, reading and sending text messages while driving in a tunnel significantly impairs driving performance, eye glance behaviour, and subjective workload measures. There was also evidence that phone interface might moderate the impact of text messaging on some aspects of driver behaviour; although, contrary to expectation, numerical keypad phones appeared to have a more deleterious effect on driver behaviour than touch screen keyboard phones. It was concluded that the relatively larger, higher resolution screens and more familiar keyboard layout of touch screen phones may offset their lack of tactile feedback.

32-P: Effects of Cell Phone Conversations and Device Manipulation on Objective Measures of Driving Performance

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The main purpose of this study is two-fold: first to evaluate how different levels of cell phone use, or engagement, impact driving performance, and second to estimate whether drivers self-regulate the use of cell phones while driving. Naturalistic driving data from the Integrated Vehicle-Based Safety Systems Field Operational Test with 108 drivers were used for identifying cell phone use while driving and corresponding driving performance. Five second clips were selected from the data set when both cell phones were in use (visual-manual task or cell phone conversation) and were not in use (baseline). Three measures of driving performance were used in this analysis, Mean following distance and standard deviation of following distance, Standard deviation of lateral position within the lane. Mixed linear regression models were used. Results suggest that visual-manual tasks, as compared to cell phone conversations and baseline conditions, result in significant degradation in driving performance. Whereas simply engaging in a cell phone conversation had little, or no, effect on driving performance.

33-O: Understanding driver self-regulating behavior: how does phone use influence vehicle control in real world?

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In the last few years, research on driver distraction focused on assessing the extent to which using mobile phones is compatible with safe driving. Many studies employing driving simulators suggested that using a phone while driving is definitely unsafe. Nevertheless, so far, naturalistic studies, as well as aggregate crash statistics, did not match these results, keeping open the debate, and promising guidelines for new countermeasures to distraction alternative to bans and based on understanding driver behavior in the real world.

Naturalistic data collected from 108 drivers in the Integrated Vehicle-Based Safety Systems (IVBSS) program in 2009 and 2010 was employed to determine how drivers change their vehicle control when engaging in a conversation on, or manipulation of, a phone. Drivers were also divided into three age groups 20-30 (young), 40-50 (middle-age), and 60-70 (older) to determine the possible interaction between age and phone use while driving on vehicle control.

Using a phone for calling affected lateral control differently than manipulating a phone (as while dialing or texting). However, no difference was found for longitudinal control. Young drivers used a phone while driving more often than older and middle-age drivers. In addition, young drivers exhibited smaller safety margins while using a phone as well as faster reactions. Finally, the results suggest that drivers tend to interrupt phone interactions when the driving context becomes more complex.

In conclusion, this study suggests that driver self-regulating behavior is the key to assess the net safety effect of using a phone while driving. Consequently, countermeasures able to support the drivers' inherent self-regulating behavior may be a more successful, and more widely adopted solutions, than phone bans toward addressing the potential for distraction posed by phones while driving.

34-O: Different Ways to Compensate Distraction while Using a Hands-Free Telephone in a Vehicle

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Secondary tasks are a main source of distraction while driving in a vehicle. For instance, using a hands-free telephone is known to lead to a worse reaction time in unexpected situations. On the other hand, examinations, especially in simulators, show that driver compensate these disadvantages by driving slower or keeping a larger distance to the car in front.

In this study, data collected in a field operational test (FOT) on navigation systems in the euroFOT project are used to examine the effects of using a hands-free telephone in the car. As the drivers were completely free in using their telephone in the FOT, the study can be considered as a naturalistic driving study (NDS) for the interested aspect. CAN-data of approximately 100 drivers, (40.000 trips, and one million kilometres) are used for the analysis. Results found in the analysis of ND-data are compared to results from experimental examinations e.g. in simulators or on test tracks.

Different aspects of driving while using the hand-free telephone are analysed, like speed and distance behaviour or lane keeping. Additionally, other aspects of potential compensatory behaviour are analysed with the ND-data. For instance, drivers can avoid complex situations while using their telephone (e.g. lane changes) as well as avoid telephoning in demanding driving situations (e.g. at high speeds).

The results give insight into how drivers integrate hands-free telephoning and driving during their daily drives. This enlarges the knowledge about secondary tasks like telephoning in the vehicle and how the drivers handle the distraction connected to these tasks.

35-O: Exposure to Secondary Tasks in Germany: Results from Naturalistic Driving Data

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Especially in the US, data from naturalistic driving studies (NDS) are used to assess the frequency of secondary task interaction in everyday driving. In most published NDS, secondary task interaction is measured based on video analysis.

The presented results are derived from data collected in an FOT on navigation systems in the euroFOT project. For a subsample of 47 drivers, secondary task interaction is analysed with two approaches: CAN-data is used to measure secondary tasks that are related to the vehicle and therefore can be assessed with objective data (e.g. hands-free telephoning). For that analysis, the full data set (about 380 000 km) can be used. For a selected number of drives, video analysis is conducted to get information about the frequency of other secondary tasks like eating or drinking. This data set contains more than 250 hours of driving time (about 20 000 km). Taking both approaches together, results show that in drives with a passenger present, drivers engage in secondary tasks in about 40% of total driving time. Of those 40%, 35% are related to interacting with the passenger, the remaining 5% to other secondary tasks. In drives without a passenger in the car, drivers engage about 25% of driving time with secondary tasks. Of those, the highest proportion (10%) is hands-free telephoning. Secondary tasks related to the vehicle (e.g. inputs via central controller or buttons on the steering wheel) occur during 2.6% of driving time.

The results provide information about the frequency of secondary tasks in daily driving for a German sample. Through combining two different measurement approaches, results refer to a variety of different types of secondary tasks and at the same time are based on a large body of driving data.

37-P: Risk Factors Moderating Driving-related Distraction & Inattention in the Natural Rail Environment

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The signal passed at danger (SPAD) is the rail equivalent of crashes and near-crashes in road. SPADs continue to impact collision risk on railways, despite the prevalence of technology-based countermeasures. This study explored the contribution of task-related distraction and inattention on SPAD-risk. A qualitative methodology was used to collect data from 28 train drivers in eight passenger rail organisations operating in Australia and New Zealand. The approach included focus groups and a scenario Invention Task to determine specific risks and identify amelioration strategies, effectively charactering the experience of distraction and inattention for the driver. Thematic analysis identified four factors that contributed to SPAD-risk. All were task-related, and associated with self-regulatory disconnects in service delivery and in the driver-signal dynamic. Manifest distraction channelled through the factors by assigning primacy to non-safety critical driving goals. The findings are presented in a multifactorial model of distraction linking the risks with mechanisms that induced attentional shift. Three interrelating strategies for ameliorating these SPAD-risk factors were also identified. These were to prioritise goals, remain focused, and remember signal states. The paper conceptualises the driver distraction-inattention relationship in the rail context and considers the taxonomic implications of some subtle yet significant distinctions.

41-O: Deciding to be distracted: Drivers' strategic choices to interact with the mobile phone

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Previous research shows that using a mobile phone while driving can seriously impair the driving performance. Effects are particularly negative when visual-manual distraction is involved in addition to the cognitive distraction provoked by phone use. The developments in mobile technologies hint towards an upwards trend of visual-manual interactions with the phone, induced by the increasing use of mobile applications in addition to dialling a number and writing a text message. Since drivers are generally aware of the risks related to visual-manual secondary tasks, they may choose specific driving situations for this type of interactions so as to mitigate the effects of distraction. Such strategies could include stopping the car and taking advantage of waiting times at a traffic light or in a traffic jam.

A small-scale naturalistic driving study was carried out in order to investigate phone use in everyday driving. Analyses of frequency and context of mobile phone interactions were targeted at detecting whether drivers favour stopping situations and how phone use extends beyond this driving context. In addition, an observation study was conducted at urban crossroads controlled by traffic lights, with the aim to register the drivers' interactions with the mobile phone in a temporary stopping situation as well as its visible effects on the driving behaviour. The results from these studies provide new insights on exposure and strategies related to visual-manual interactions with the mobile phone in a naturalistic setting, complementarily drawing on a longitudinal design with a restricted participant sample and a cross-sectional approach that focuses on a specific setting with an extended sample.

44-P: Effects of Anger and Sadness on the drivers' useful visual field: toward a tunnel vision phenomenon?

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The useful visual field (UVF) is defined as the area around the fixation point from which information is briefly stored and interpreted during a visual task. It corresponds to the part of the peripheral visual field around the fixation point inside which sources of information can be processed without any movement of the eyes or the head. It is generally determined while carrying out a dual task: one with signals in the central part of the visual field, and the other with signals in the peripheral part of the visual field. The UVF is assessed on the basis of the number of signals detected in the peripheral task in which the participant has to detect the presence of a signal located at different eccentricities in his visual field. The drivers' UVF can be influenced by internal factors, such as age, causing a tunnel vision-like phenomenon. Here, the influence of anger and sadness on the UVF is studied. The results revealed a positive effect of anger: better detection in the central task without decreasing the detection in the peripheral task. Secondly, a tunnel vision phenomenon was also observed in sadness. A classification of these emotions in the inattention taxonomy is discussed.

46-O: Modifying the Lane Change Task – How does increased unpredictability of lane changes affect performance?

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The Lane Change Task (LCT) is an established method to assess the distraction caused by various secondary tasks. Thoroughly researched, it has even become an ISO sanctioned procedure. However, despite the fact that the task can claim some face validity as it closely resembles various aspects of driving, it might be argued that in terms of safety relevance, the LCT is not designed perfectly. The initiation of a lane change as a response to the respective sign is supposed to be a form of event detection task. But the signs that command the change of lanes are visible throughout the drive (blank they are, though, until 40m ahead of the sign's position), which makes the “event” (the popping up of information on the sign) rather predictable. While this regular and predictable nature of the LCT might apply to the majority of driving situations, it might not be representative of a situation in which distraction is actually dangerous. As Sheridan (2008) emphasised, the safety relevance of a particular secondary task depends (among other factors), “on unexpected events that occur when attention is not on driving” (p. 593). To investigate how the distraction assessment of secondary tasks might change if lane change events were unexpected (or, at least, less predictable), we implemented the LCT with our driving simulation software, to then manipulate the predictability of the lane change signs. In this experiment, we compared the “classical” LCT to an “unpredictable” version in which signs were not visible permanently, but only popped up 40m ahead of their actual position (just like the information they were presenting). Easy and difficult versions of the SuRT and a counting task were used as visual and cognitive secondary tasks. Results will be presented.

48-O: Influence of psychological flow on the management of cognitive secondary tasks while driving: an approach comparing subjective and objective mental effort measurement

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Driving is a complex activity requiring a good management of attentional resources. Numerous studies try to understand dual task interference wondering whether driver has enough spare capacity to take on additional tasks or whether the amount of mental workload is responsible for driving errors. Thus, it is necessary to better understand how the driving activity is modified when drivers are performing demanding cognitive tasks in order to identify the best measurement tools to be used to evaluate the driver's mental effort.

Our previous preliminary results indicated that two workload regulation strategies exist. If required to resolve cognitive enigmas, some participants seemed more focused on driving. Some others were distracted, felt uncomfortable and were often stressed. In the present study, we hypothesize that their proneness for psychological flow can influence their choices regarding workload regulation strategies. Flow proneness is associated with personality; it may be a state of effortless attention relying on different mechanisms from those involved in attention during mental effort.

Taking into account the driver's psychological flow, this study aims to identify mental effort indicators from three different measurements recorded on a car simulator: cardiac activity, driving performance, and subjective data. An experiment was conducted with 23 participants (mean age 26 years old) comparing simulator driving as the sole task with driving while performing two different cognitive tasks (either resolution of verbal or visuo-spatial enigmas). Flow proneness was evaluated with a French version of the Swedish Flow Proneness Questionnaire. Mental effort was measured with the Driving Activity Load Index and Heart rate variability.

A negative correlation between flow proneness and subjective mental effort was observed. However, flow proneness had no effect on heart rate variability. Moreover, regulation strategies used by the drivers on highway and secondary roads seems different.

50-O: Effects of spatial and non-spatial cognitive distraction on drivers' mental representation of spatial and situational information

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Where numerous studies demonstrate the detrimental effects of distraction on drivers' reaction time, action selection or scanning behaviour, only few studies investigate the causal mechanisms underlying these distraction effects. The aim of the research presented here - as part of a general project to build computational cognitive models of driver behaviour - is to examine the effect of cognitive distraction on the driver's mental representation of situational and spatial information of traffic situations, such as intersection situations. The driving task explicitly demands the driver to process and represent situations in terms of space. Distortions of this mental representation are one of the key factors for the development of driving errors and we assume that cognitive distraction will interfere with the construction and maintenance of such representations. Additionally, by manipulating the kind of cognitive distraction information will be gathered about the nature of the spatial and situational representation and the cognitive structure responsible for maintaining this representation. As existing cognitive architectures are lacking structures and resources especially to process spatial information, these results will provide a first step for modeling drivers' spatial and situational representation, thereby addressing an issue central to the development of cognitive models of driver behaviour. Hence, we set up an experiment that particularly addresses the demands of situation assessment when approaching intersections. Videos of such approach situations were presented to participants and in varying distances to the intersection they had to perform an auditory spatial vs. an auditory non-spatial reaction time task. An effect of the spatial dual task on the dependent measures is expected due to the assumed demands posed by assessing the driving situation in terms of space. Eye tracking, pupil dilation and reaction time data will be presented. The empirical results will be discussed with respect to their evidence for or against spatial processing.

52-P: Effects of cerebral diseases on driver distraction

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The objective of this paper is to review the literature on the ability of individuals having some kind of cerebral disease to drive, especially while being distracted. Driver distraction, defined as the diversion of attention away from activities critical for safe driving toward a competing activity, is found to be an important cause of road accidents. Driver distraction effects may interfere with several cerebral diseases with high prevalence in the general population, such as cerebral incidents, Parkinson's, Alzheimer's, Mild Dementia and Mild Cognitive Impairment. These diseases affect driver's attention and other cognitive functions and cause degradation in driving performance, which might in turn translate into increased accident risk, especially at the presence of additional (external) distractors. Overall, the literature review confirms that the interaction between driver distraction and cerebral diseases downgrades the driving performance. The degree to which these clinical conditions affect accident risk, especially when unexpected incidents take place, and the driver's response, need further investigation

55-P: Impact of mobile phone use and music on driver behaviour and safety by the use of a driving simulator

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This study attempts to investigate the impact of mobile phone use and music on driver behavior and the probability of being involved in an accident. An experimental process on a driving simulator was carried out, in which all the participants drove in a mountainous road with and without mobile phone (handheld mode) and music. Lognormal regression models were developed for driver speed and it appeared that mobile phone use leads to a statistically significant decrease in speed, while music tends to increase it. Moreover, a 'difficult' conversation at the mobile phone leads to an increase in reaction time when it comes to an unexpected event and mobile phone use in general leads to an increase in the distance of the vehicle from the central axis of the road. Through a binary logistic analysis it appeared that the 'difficult' conversation at the mobile phone may bring about a significant increase in the accident probability, in case of an unexpected event activated by the experiment coordinator. Finally, regarding the use of mobile phone with a difficult conversation, as a general conclusion it was noted that the lower speed and the increase of the distance from the central axis of the road cannot compensate for the much greater risk for an accident, in case of an unexpected event, due to increased reaction time

56-P: Impact of Texting on Young Drivers' Behaviour and Safety on Motorways by the Use of a Driving Simulator

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Texting while driving seems to be a widespread behaviour, which has been associated with a non negligible proportion of road accidents, especially among younger drivers. The impairment of the driver's behaviour and the related risks may be increasing on motorways, if we take into consideration the fact that there are high vehicle speeds and the necessary reaction time is decreased.

This research aims to investigate the impact of texting on young drivers' behaviour and safety on motorways. On this purpose, a driving simulator experiment was carried out, in which 34 young participants drove in different driving scenarios. Lognormal regression methods were used to investigate the influence of text messaging as well as various other parameters on the mean speed and the mean headway. Binary logistic methods were used to investigate the influence of texting and other parameters on the probability of an accident. The models' application showed that texting leads to statistically significant decrease of the mean speed and to increased headway in normal and in specific conditions on motorways. Simultaneously, it leads to an increase of accident's probability, probably due to increased reaction time of the driver in case of an incident.

62-O: Dialling, texting, and reading in real world driving: When do drivers choose to use mobile phones?

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Mobile phone use is the most debated and studied form of driver distraction. Naturalistic driving studies have shown that the risk of being involved in a near-crash or crash increases during manual and visual interaction with a mobile phone (e.g., when texting or dialling), while just talking on a mobile phone seems neutral or may even have a protective effect. Previous studies involving focus groups and questionnaires present conflicting results about the strategies that drivers use to decide when to engage in mobile phone use. The aim of this study is to analyse naturalistic driving data to determine when drivers decide to engage or disengage in dialling, texting or reading text messages. Video-, map-, and vehicle-data from approximately 300 passenger car trips, in average 15 minutes long, were searched for sequences involving mobile phone use. All sequences, as well as, driving prior to each initiation of mobile phone use, were coded and analysed. Results show that drivers adapt mobile phone use both to the road characteristics and to the presence of other road users. This adaptation includes both proactive behaviour, such as overtaking prior to dialling a number, and reactive behaviour, such as delaying reading a text message until the vehicle exits a curve and enters a straight road segment.

64-O: Driver Distraction Research and Policy: An update from NHTSA

Chris Monk

The National Highway Traffic Safety Administration (NHTSA), USA

The National Highway Traffic Safety Administration (NHTSA) published its Distraction Research Plan in 2010. As part of that plan, NHTSA developed Distraction Guidelines in attempts to help stem the tide of potentially distracting devices and tasks in the vehicle by encouraging driver-vehicle interfaces (DVIs) that require no more eyes-off-road time than tuning a radio. These guidelines are being developed in three phases: Visual-Manual, Portable Aftermarket Devices, and Voice-based auditory interfaces. In addition, the Human Factors for Connected Vehicles (HFCV) program within the US DOT has substantial research investment in developing design principles to ensure V2x applications do not result in high workload or distraction for drivers. This presentation will provide an update on each of the three Distraction Guidelines stages, as well as the research and design principles product for the HFCV program. Other related NHTSA research programs such as crash warning interface metrics may also be included.

67-P: Drowsy Driving Increases Severity of Safety-Critical Events and Is Decreased by Cell Phone Conversation

Richard A. Young

Wayne State University School of Medicine, USA

A recent study found that drowsy driving prevalence in U.S. national crash databases is substantially higher than previously estimated, especially for fatal crashes. The aims of the current study are to merge this result with a new estimate of the prevalence and odds ratio (OR) of drowsy driving in the 100-Car naturalistic driving study (NDS), and investigate interactions with secondary tasks, particularly cell phone conversation. A 2010 NDS study matched baseline video clips to crash/near-crash video clips for driver demographics, time of day, and GPS location. Using that matched baseline to remove bias from those variables, the current study estimates the drowsy driving OR for crashes to be 63, substantially higher than previous estimates. In addition, observable moderate to severe drowsiness causes an estimated 20% of all crashes, while non-observable microsleeps likely elevate that percentage. A logistic regression analysis on the 100-Car data found no interaction between drowsy driving and secondary tasks as a whole. However, the moderately-difficult task group (which includes cell phone conversation) reduced the drowsy driving crash/near-crash OR, as did cell phone conversation alone. These new NDS analyses provide preliminary evidence that curtailing drowsy driving will reduce more crashes than curtailing secondary tasks while driving.

68-P: Cell Phone Conversation and Automobile Crashes: Relative Risk is Near 1, Not 4

Richard A. Young

Wayne State University School of Medicine, USA

The aim of research into cell phone tasks is to obtain an unbiased estimate of their relative risk (RR) for crashes. This paper re-examines five RR estimates of cellular conversation in automobiles. The Toronto and Australian studies estimated an RR near 4, but used subjective recall to estimate driving times. The OnStar, 100-Car, and a recent naturalistic study used objective measures of driving times and estimated an RR near 1, not 4 – a major discrepancy. Analysis of data from GPS trip studies shows that subjects were in-car only 20% of the time on a previous day, given they were in-car at the same clock time on a subsequent day. Hence, the Toronto estimate of driving time during control windows must be reduced from 10 to 2 min. Given a cell phone call rate about 7 times higher when in-car than out-of-car, and correcting for misclassification of some post-crash calls as pre-crash, the Toronto adjusted RR is 0.61, and the Australian 0.64, agreeing with the OnStar estimate of 0.62. After adjustment for bias, all five RR estimates for cellular conversation while driving in automobiles are near 1, with a pooled RR of 0.61 (95% confidence interval 0.51 to 0.74).

70-O: Modeling Safety of Lane Change Maneuvers Based on Driver Gaze and Vehicle Operation Behavior

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Norihide Kitaoka, and Kazuya Takeda*

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Changing lanes is one of the most common driving maneuvers, and risky lane change behavior is often the cause of accidents. In order to analyze driver behavior during lane change maneuvers and estimate risk levels, we collected driving data from expert and non-expert drivers on expressways while they passed other vehicles using an instrumented vehicle. In order to assess the actual risk level of each lane change scene, we first recruited nine subjects who watched front-view video of each lane change scene, and they rated how risky they felt a scene was on a scale from 1 to 5, with 5 representing the highest risk level. We then assumed that the direction of a driver's gaze could be roughly categorized into one of ten directions, such as "front," "left," "rear-view mirror," "instrument panel," etc., and manually labeled each driver's gaze direction frame by frame using video of the drivers' faces. Vehicle operation behavior was also broken down into discrete acts such as "brake-on," "steady speed," "left-low acceleration," etc., based on amounts of pedal pressure and on longitudinal/lateral acceleration. Next, we modeled safe and risky lane change maneuvers based on gaze directions and discrete acts of vehicle operation behavior using hidden Markov models (HMMs). We found that there were significant differences between the parameters of the HMMs modeling safe and risky behavior. We then estimated risk levels of lane changes using HMMs. Our models could successfully estimate current risk levels of lane change maneuvers, compared to the risk levels assigned by our risk raters, by accumulating HMM likelihood over the previous fifteen minutes.

71-P: A Smart Driving Smartphone Application: Real-World Effects on Driving Performance and Glance Behaviours

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A smart driving Smartphone application – which offers real-time fuel efficiency and safety feedback to the driver in the vehicle – was evaluated in a real-world driving study. Forty participants drove an instrumented vehicle over a 50 minute mixed route driving scenario, with 15 being selected for video data analysis. Two conditions were adopted, one a control, the other with smart driving advice being presented to the driver. Key findings from the study showed a 4.1% improvement in fuel efficiency when using the smart driving system, and an almost 3-fold reduction in time spent travelling closer than 1.5 seconds to the vehicle in front. Glance behavior results showed that drivers spent an average of 4.3% of their time looking at the system, at an average of 0.43 seconds per glance, with no glances of greater than two seconds. In conclusion this study has shown that a smart driving system specifically developed and designed with the drivers' information requirements in mind can lead to significant improvements in real-world driving behaviours, whilst limiting visual distraction, with the task being integrated into normal driving.

72-P: Individual Differences in Driving-Related Multitasking

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We conducted an experiment with 22 participants to investigate the effect of secondary task presentation style on driving-related performance. Prior to the experiment, participants were presented with three cognitive ability tests and answered an online survey consisting of the Domain-Specific Risk-Taking Scale (DOSPERT), the Driver Behaviour Questionnaire (DBQ), and some demographic questions. The participants then performed a 1-D tracking (primary) task which simulated longitudinal control of a car. They also performed a vowel counting secondary task (counting the number of vowels in a list of multiple letters) under a variety of conditions. These conditions combined different modalities (audio/visual), presentation styles (simultaneous/sequential), task complexity (the number of distractors), and list lengths. We discuss the experimental results in terms of the impact of individual differences, in risk tolerance and cognitive ability, on how the tasks were performed.

73-P: Estimating Visual Demands in Road Traffic Environments

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This study investigates methods of estimating visual demands during driving in road traffic environments. Accurate estimation of visual demands is expected to promote the identification of driving situations in which drivers have sufficient capacity to divide their attention to in-vehicle systems without resulting in distraction or inattention. Two experiments were conducted to identify occlusion methods suitable for assessing the visual demand variations derived from traffic conditions and road structures. First, four occlusion methods were compared to estimate visual demands during driving with and without lead vehicles: (1) depression of a switch allowed the road scene to be viewed for 0.6 seconds, (2) depression of a switch blanked out the driver's vision for 1.5 seconds, (3) the driver was allowed to view the road while depressing a switch, and (4) the driver's vision was blanked out while depressing a switch. The results of the first driving simulator experiment suggested that differences in the proportions of viewing time to driving time were higher in occlusion methods 2 and 4. Second, we estimated the visual demands of road structures (straight sections, curves, etc.) using the two occlusion methods identified in the first experiment. The second simulator experiment suggested that drivers viewed the roadway throughout the curve in occlusion method 2, while some drivers occluded the forward scene for a very short time even during the curve in method 4. The findings suggest that the occlusion method in which the scene is invisible for a specific time at the driver's request may contribute to establishing the conditions in which the driver can safely operate in-vehicle systems.

75-P: Development of a Protocol to Classify Drivers' Emotional Conversation

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We present a video data reduction protocol that was developed to classify the type and intensity of emotion expressed by a driver involved in a cell phone conversation. Although there has been substantial research on coding emotion from a person's facial expression, the prescribed methods are significantly detailed and require a hundred hours of training as well as certification. The objective of the current research was to develop a simplified protocol based on the previous research that could be applied to naturalistic driving data by data reductionists in a reasonable amount of time to distill information pertaining to the nature of the driver's cell phone conversation. We present the basis for the protocol and describe how it was applied. In identifying an emotion from a driver's facial expression using naturalistic driving data, it will become possible to compute how often drivers engage in emotional cell phone conversation, the risk of a Safety-Critical Event (SCE) associated with emotional cell phone conversation, as well as the relative risk of emotional cell phone conversation compared to neutral cell phone conversation. In conclusion, we discuss other related applications of the protocol, how the protocol could be developed further and potential synergy with prior research.

76-P: Effect of phone conversations on tactical components of the driving task

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IFSTTAR - TS2 - LESCOT, France

This paper aims at investigating how phone conversations may affect tactical control of the vehicle and decision-making. Twenty-four drivers (16 males and 8 females; mean age = 39.1; SD = 5.5) participated in an on-road experiment. They had to answer to phone calls using a hands-free kit and to maintain conversations while driving on motorway and in urban area. Results on motorway show that, during phone conversations, the drivers were less likely to overtake slower vehicles and stayed longer on the lane before moving back after overtaking manoeuvres. Some changes in speed behaviour were also observed as participants failed in adapting their speed to the limits when they changed. Driving errors were also more frequent while at the phone in urban area. Results on motorway show that while phoning, drivers tend to adapt their driving in a way to compensate for the additional attentional demand of the dual task of phoning and driving, by neglecting driving sub-tasks such as overtaking and adapting speed, etc. However, such behaviour also reveals difficulties to process all needed information to execute complex manoeuvres. Hard braking and errors in urban area occur as a consequence of these difficulties induced by phone communications.

77-P: The DO-IT BEST Feedback Model - Distracted Driver Behaviour Management and Prevention Before, While And After Driving

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Today, there are two main approaches to improve traffic safety through feedback to drivers. One approach is Advanced Driver Assistance Systems (ADAS), which are concurrent feedback systems (i.e. immediate, on-line feedback) that warn the driver in a dangerous situation (e.g. taking the eyes off the road). The other approach, behaviour-based safety management programs (BBS), use deferred feedback (i.e. “offline”, pre- or post-trip feedback) and target, for example, a habit of sending text messages while driving. If both approaches are used, feedback to drivers is provided during different timescales before, while and after driving. Each approach on its own is an effective accident prevention strategy, however they tend to be used independently and would benefit from being integrated into one holistic strategy.

The DO-IT BEST Feedback Model is a holistic model which synthesizes driver behaviour feedback before, while and after driving into one comprehensive accident prevention strategy. The model consists of a closed circuit set of feedback strategies, based on the driver's own behaviour, and ranging from concurrent on-board driver feedback to deferred post-trip feedback. The various feedback sources (e.g. technology- or human-based feedback) are included in the model.

The DO-IT BEST Feedback Model is an eight-step process model which was further developed from the original four-step DO-IT process first introduced by Geller (2001) in industrial working settings. DO-IT BEST is an acronym for Define, Observe, Intervene, and Test targeted at-risk and/or safe behavior as well as to assimilate Behavioural check-ups, Education, Safety benefit analysis and Training on targeted at-risk and/or safe behaviour.

In sum, the DO-IT BEST Feedback Model aims to enhance traffic safety with a short-, medium-, and long-term focus by sustainable and effective driver behaviour management. Applied to driver distraction and inattention prevention/mitigation, this paper expresses an improved, integrated feedback model for how to improve attention allocation. The aim is to provide behavioral feedback before distraction occurs, while it occurs in the vehicle, and after it has occurred.

78-P: Using smart materials to monitor physiological signals of driver's inattention

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The HARKEN project gathers a consortium of European research centres and enterprises that produce vehicle components, smart materials, and sensors for biomonitoring, to create a physiological monitor integrated in the car. This system is in constant contact with the driver's body through the car seat cover and the safety belt, and it monitors the physiological, mechanical activity related to respiration and the cardiac cycle. Redundant measures of vibrations and artefacts that may distort these signals are used to improve their quality by means of adaptive filters, programmed in a signal processing unit.

79-O: The Impact of Typeface Design in a Text-Rich Automotive User Interface on Driver Distraction

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Researchers and policy makers are actively focused on better understanding and regulating driver distraction as it relates to the type of technologies and interactions that should be permitted in the vehicle. More limited investments are being made in the optimization of information that needs to be available to drivers. Past efforts in ISO and SAE standardization of legibility requirements focus largely on the display of “stamped” media (e.g. fixed labels, numbers, and icons). However, modern electronic displays present a number of new characteristics that are not addressed in these standards (e.g. pixilation, reflection, etc.). This talk will focus on recent research on the impact of typeface design on driver attention and how variations in design and presentation of content may have significant impact on reducing driver distraction.

Results from a series of studies assessing the impact of typeface design on glance behavior away from the roadway are considered. During the studies, drivers were asked to interact with a multi-line menu display designed to model a text-rich automotive human machine interface; the HMI screens were implemented using two different typeface designs. Across studies of black text on a white background, among men, a “humanist” typeface resulted in a 10.6% lower visual demand as measured by total glance time as compared to a “square grotesque” typeface. Total response time and number of glances required to complete a response showed similar patterns. Interestingly, the impact of the different typeface styles was either more modest or not apparent for women on these variables across studies. Current efforts have focused on extended these results to a broader set of display characteristics. Overall, this research suggests that optimizing typeface characteristics may be viewed as a relatively simple and effective method of providing a significant reduction in interface demand and associated distractions.

80-O: Examining fatigue and inattention in night shift workers during a two-hour post-shift commute

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Fatigue remains an important traffic safety concern as it can result in insufficient attention to activities critical for safe driving (driver restricted attention; Regan et al., 2011). Night shift workers are at increased risk of drowsiness-related crashes on the drive home from work as the combination of chronic circadian misalignment and high homeostatic sleep pressure results in difficulty to maintain wakefulness and alertness. The current study examined the impact of night shift work on driver state and performance in an instrumented vehicle on a closed test track. Sixteen night shift workers (18-65 years) presented for two 2-hour driving sessions: one following a night of rest (Post-Sleep), and another following a night of shift work (Post-Shift). The driving sessions were divided into 15 minute intervals to further explore effects of fatigue within a session. Objective physiological measurements of drowsiness were monitored continuously throughout the driving sessions, including eye movements and scanning, eyelid movements and blink patterns, polysomnographic recordings of brain activity and ocular muscle movements, and several measures of driving performance and vehicle control.

Compared to the Post-Sleep condition, drivers in the Post-Shift showed as much as double the rate of Theta intrusions in brain and slow eye movements (reflecting that drivers were in the state of micro-sleep). This restricted attention to driving led to greater degradation in lane keeping performance as well as more frequent occurrence of critical driving events (where the in-vehicle experimenter had to activate a secondary brake pedal to prevent a road departure). The Post-Shift condition also resulted in more frequent and longer blinks, less frequent and short fixations, but longer saccades than the Post-Sleep condition. These results confirm that the morning commute following night work carries significant safety concerns. Further, we describe and discuss the implications for fatigue countermeasures.

81-O: When do drivers use their mobile phone?

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SWOV Institute for Road Safety Research, The Netherlands

Mobile phone use, in particular smartphone use, has become increasingly popular over the last decade. The smartphone adoption rate has surpassed that of any other consumer technology in history. Some argue that the 'smartphone revolution' might be related or even responsible for the stabilising or even increasing traffic related fatality and injury rates across countries in Europe. Therefore it is important to better understand how, how often and when drivers use their mobile phone in everyday traffic.

Based on Naturalistic Driving data of 21 participants, this paper presents analyses of frequencies and durations of mobile phone use while driving. A distinction will be made between mobile phone conversations and other manual and visual-manual interactions with the mobile phone. The main focus of the paper will be on the driving context of mobile phone interactions. In what driving contexts do drivers engage in interactions with their mobile phone? The paper will explore if there is a relation between mobile phone interactions and driving context factors. Contextual factors examined will include: road categories, legal speed limits, actual speed, trip length and time driven. The results of this study will be discussed in relation to traffic safety and recommendations for future research.

82-P: The impact of interface modality on police officers' visual behaviour when using an in-vehicle system

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Background: Standard operating procedures state that police officers should not drive while interacting with their mobile data terminal (MDT) which provides in-vehicle information essential to police work. Such interactions do however occur in practice and represent a potential source of driver distraction. The MDT comprises visual output with manual input via touch screen and keyboard. This study investigated the potential for alternative input and output methods to mitigate driver distraction with specific focus on eye movements.

Method: Nineteen experienced drivers of police vehicles (one female) from the NSW Police Force completed four simulated urban drives. Three drives included a concurrent secondary task: imitation licence plate search using an emulated MDT. Three different interface methods were examined: Visual-Manual, Visual-Voice, and Audio-Voice ("Visual" and "Audio" = output modality; "Manual" and "Voice" = input modality). During each drive, eye movements were recorded using FaceLAB™ (Seeing Machines Ltd, Canberra, ACT). Gaze direction and glances on the MDT were assessed.

Results: The Visual-Voice and Visual-Manual interfaces resulted in a significantly greater number of glances towards the MDT than Audio-Voice or Baseline. The Visual-Manual and Visual-Voice interfaces resulted in significantly more glances to the display than Audio-Voice or Baseline. For longer duration glances (>2s and 1-2s) the Visual-Manual interface resulted in significantly more fixations than Baseline or Audio-Voice. The short duration glances (<1s) were significantly greater for both Visual-Voice and Visual-Manual compared with Baseline and Audio-Voice. There were no significant differences between Baseline and Audio-Voice.

Conclusion: An Audio-Voice interface has the greatest potential to decrease visual distraction to police drivers. However, it is acknowledged that an audio output may have limitations for information presentation compared with visual output. The Visual-Voice interface offers an environment where the capacity to present information is sustained, whilst distraction to the driver is reduced (compared to Visual-Manual) by enabling adaptation of fixation behaviour.

87-O: Safer Glances, Driver Inattention, and Crash Risk: An Investigation Using the SHRP 2 Naturalistic Driving Study

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SAFER Vehicle and Traffic Safety Centre at Chalmers, Sweden

This paper presents progress in the SHRP2 Safer Glances analysis project which aims to establish the relationship between crash risk and driver inattention using rear-end crashes and near crashes. Results will pinpoint the most dangerous glances away from the road and show how to change glance behavior to be safer.

The Second Strategic Highway Research Program (SHRP2) is conducting the largest and most comprehensive naturalistic driving study (NDS) ever conducted (see Campbell, 2013; and www.shrp2nds.us). The study has recruited 2,800 volunteer drivers. All of their trips are recorded for one to two years. When complete in early 2014, the NDS data set will contain over 33,000,000 travel miles from over 3,800 vehicle-years of driving – over 4 petabytes of data. The analysis plan is formulated in five analytic steps. Each analytic step is expected to provide better precision and explore different components of the inattention-risk relationship by providing more detail on inattention-risk relationships under different circumstances – relationships to timing with optical parameters, glance characteristics, and relationships with respect to different levels of crash severity.

This research will identify a more precise relationship between glance patterns and their associated risk around a sweet spot, a time when perceptual information is particularly valuable in crash avoidance. Further, it will relate glance behavior to injury severity as defined by new severity scales. This set of functions will indicate crash likelihood and/or injury severity for certain contextual characteristics of the lead-vehicle crash scenario, such as traffic density, road type, and speed. These relationships can be used to show more precisely which glance behaviors are safer than others.

Safer glance strategies for interacting with electronics and the traffic environment can be encouraged in a number of ways including design guidelines, education, and in-vehicle feedback. Likewise, the most dangerous glances can be pinpointed and associated with improvements to appropriate countermeasures like distraction guideline performance criteria and active safety system technology.

90-O: A method for extracting data for quantification of comfort zone boundaries for intersection negotiation from in-vehicle naturalistic data

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Drivers' allocation of attention and their driving behavior is partly driven by their expectations for how events will unfold in the near future (Engström, 2011; Weir & McRuer, 1973). Comfort zone boundaries based on drivers' expectations lead drivers to adapt their behavior to avoid collisions with other road users (Gibson & Crooks, 1938; Ljung Aust & Engström, 2011; Summala, 2007). These boundaries can be empirically defined using a multi-dimensional state space. Dimensions include, but are not limited to, distance and time to other road users and the driver's allocation of attention. Context-specific quantitative descriptions of drivers' comfort zone boundaries for a variety of contexts provides a basis for understanding attention allocation and driving behavior. In this presentation we discuss initial efforts to enable description of comfort zone boundaries for a set of intersection contexts. This study uses three different types of data to address a variety of intersection contexts. The dataset includes 1) naturalistic driving data from the euroFOT project (Benmimoun et al., 2011), 2) on-road experiments with high-fidelity eye-tracking, environment sensing, and gaze allocation data, and 3) test track data. We describe the methodology used to extract information from in-vehicle naturalistic data for location based analysis in intersections and a set of results used to quantify comfort zone boundaries. The method and results are first steps towards an empirical methodology that develops quantitative descriptions of comfort zone boundaries that can inform the design of Advanced Driver Assistance System.

92-P: Analysis of the role of inattention in road crashes based on naturalistic on-board safety monitoring data

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The general objective of the present analysis was to investigate the role of driver inattention in rear-end crashes and crossing path intersection crashes. To this end, a set of 133 naturalistic crashes (70 rear-end and 63 intersection crashes), obtained by means of the DriveCam on-board safety monitoring (OBSM) system, were analyzed based on a novel methodology for assigning and aggregating crash-contributing factors. The analysis focused on rear-end crashes where the OBSM-instrumented vehicle was striking a lead vehicle and crossing-path intersection crashes where the driver of the instrumented vehicle intended to proceed straight through the intersection. It was found that driver inattention, in particular driver distraction involving a diversion of gaze from the forward roadway, was the dominating factor contributing to the rear-end crashes. Although driver inattention also contributed to the intersection crashes, the patterns of contributing factors for this crash type were quite different compared to the rear-end crashes. In particular, in the intersection crashes, visual occlusion and insufficient selection of safety margins were identified as key contributing factors. Cognitively distracting activities that did not involve a diversion of gaze from the forward roadway, such as cell phone conversation, did not contribute frequently to avoidance failures for any of the crash types. The present results show that the role of driver inattention as a crash-contributing factor depends strongly on the type of crash. They also support previous findings from naturalistic driving studies that visual diversion from the forward roadway is the key mechanism by which inattention leads to rear-end crashes.

93-O: The Impact of Hand-Held and Hands-Free Cell Phone Use on Driving Performance and Safety-Critical Event Risk

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Issue: Using a cell phone while driving has been found to increase crash risk (McEvoy et al., 2005; Redelmeier & Tibshirani, 1997). However, newer hands-free technologies may reduce this risk by mitigating visual-manual distraction.

Method: The National Highway Traffic Safety Administration contracted the Virginia Tech Transportation Institute (VTTI) to investigate the effects of distraction from the use of three types of cell phones: 1) hand-held (HH), 2) portable hands-free (PHF), and 3) integrated hands-free (IHF)(Fitch et al., 2013). Through a naturalistic driving study (NDS), 204 drivers were continuously recorded for an average of 31 days each in 2011. The data were collected through a separate contract performed by VTTI and Westat. Only drivers that reported talking on a cell phone while driving at least once per day were recruited. A key feature of this study was that drivers provided their cell phone records for analysis, making this the first NDS to date to combine call and text records with continuous naturalistic driving data.

Results: Drivers talked on a cell phone 10.6% of the time the vehicle was in operation (28% of all calls and 10% of all text messages occurred while the vehicle was being operated). Talking on a cell phone, of any type, while driving was not associated with an increased safety-critical event (SCE) risk. SCEs comprised crashes, near-crashes, and crash-relevant conflicts. Visual-manual (VM) subtasks performed on an HH cell phone, however, were associated with an increased SCE risk. HH cell phone use in general was thus found to be associated with an increased SCE risk. In contrast, PHF and IHF cell phone use, absent of any VM HH cell phone subtasks, were not found to be associated with an increased SCE risk. However, VM HH cell phone subtasks were frequently observed during hands-free cell phone use. Driver performance when using a cell phone was also investigated through a within-subject comparison. VM HH cell phone subtasks were found to significantly increase the percentage of time drivers took their eyes off the forward roadway, while talking on an HH cell phone significantly decreased the percentage of time drivers took their eyes off the forward roadway. The effects of cell phone use on vehicle control were less pronounced.

Conclusion: Visual-manual cell phone subtasks are associated with an increased safety-critical event risk and affect driver performance. Drivers continue to interact with hand-held cell phones despite hands-free technologies and text-messaging bans.

94-O: VisGuard – Distraction Prevention System

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Out of all safety-critical events in traffic it has been estimated that 25-80% are caused by driver inattention. Almost 80 percent of all crashes and 65 percent of all near-crashes involved visual inattention in the largest field study on the topic so far. As a cause of visual inattention by secondary activities in these safety-critical events the use of a mobile device was by far the leading cause by at least 30%. Field studies have shown that drivers are trying to keep diverging glance durations within safe limits but that often their allocation of visual attention is inefficient and unsafe – drivers take a look at a wrong place at a wrong time and/or look at a wrong place for too long given the visual demands of the traffic situation.

VisGuard distraction prevention system warns the driver to focus on the driving task before visual distraction by a mobile device use is realized. When the driver engages in activities with the mobile device, VisGuard immediately starts to track driver's gaze and mentors the driver to turn eyes back on the road when needed.

The system gives the guidance by taking into account the visual demands based on the current driving situation and driver's skills. This will happen automatically as the system runs in the background in the mobile device monitoring the driving situation.

The VisGuard mobile application runs currently on Android devices. The visual demand algorithm behind it is based on data collected from hundreds of drivers in simulator and real traffic environments. Besides mobile devices, the system can be implemented in any in-vehicle device such as dashboard infotainment or navigation systems.

During the upcoming months we will be conducting field tests in different countries with several hundred drivers. Participants will be drivers who use their mobile phones frequently while driving.

NON-PAPER PRESENTATION: WORK-IN-PROGRESS

**95-O: Distraction and driving:
results from the epidemiology task of the ATLAS project:
a casecontrol responsibility study of traffic crash injured
drivers interviewed at the emergency room**

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Objective: To assess the risk associated with diversion of attention due to unexpected events or mind wandering at the wheel.

Design: Responsibility case-control study.

Setting: Adult emergency department of the Bordeaux University Hospital (France) from April 2010 to August 2011.

Participants: 955 injured drivers presenting as a result of motor vehicle crash.

Main outcome measures: The main outcome variable was responsibility for the crash. Exposures were external distraction; internal thoughts, alcohol use, psychotropic medicine use, and sleep deprivation. Potential confounders were sociodemographic and crash characteristics.

Results: Beyond classical risk factor found to be associated with responsibility, results showed that distracting events inside the vehicle (picking up an object), distraction due to driver activity (smoking) and distracting events occurring outside were associated with an increased probability of being at fault. These distraction-related factors accounted for 8% of injurious road crashes. Analysis of self-reported thoughts content showed a strong association between mind wandering and responsibility, leading to an estimated attributable fraction of 9%.

Conclusions: This study provides population-based evidences of the impact of diverted attention, both by external and internal distraction, on the risk of road traffic crash. Our results are supporting recent research efforts to detect periods of driving vulnerability related to inattention.

Notes

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