INATTENTIVE AND DISTRACTED DRIVING

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ACRONYMS	
AAA	Automobile Association of America
AVAS	Advance Driver Assistance Systems
CDS	Crashworthiness Data System (USA)
CEVMS	Commercial Electronic Variable Message Signs
CRE	Crash Relevant Events
CSIR	Council for Scientific and Industrial Research
DAS	Data Acquisition System
DCA	Driver Cursory Attention
DDA	Driver Diverted Attention
DDA-DR	DDA Driving-Related
DDA-NDR	DDA Non-Driving-Related
DIDC	Discovery Insure Driving Challenge
DMPA	Driver Misprioritised Attention
DNA	Driver Neglected Attention
DoA	Decade of Action for Road Safety
DRA	Driver restricted attention
ED	Experienced Driver
ETSC	European Transport Safety Council
EU	European Union
FARS	Fatality Analysis Reporting System
FESTA	Field Operational Test Support Action
fMRI	functional Magnetic Resonance Imaging
FoT	Field Operation Tests
GDP	Gross Domestic Product
GPS	Global Positioning Satellite
ICT	Information and Communication Technology
ITS	Intelligent Transportation Systems
IVIS	In-Vehicle Information Systems
LCT	Lane Changing Task
NCS	National Safety Council (USA)
NDS	Naturalistic Driving Studies

NHTSA	National Highway Traffic Administration (USA)
NMVCCS	National Motor Vehicle Crash Causation Survey
NMT	Non-Motorised Transport
NoD	Novice Driver
LVM	Lead Vehicle Was Moving
LVS	Lead Vehicle Stopping
NDS	Naturalistic Driving Studies
NSC	National Safety Council (USA)
PDA	Personal Digital Assistant
PGWC	Provincial Government of the Western Cape
PrDP	Professional Driver Permit
PRT	Perception-response time
ROR	Run-off-Road
RTMC	Road Traffic Management Corporation
RTMS	Road Traffic Management System
SANS	South African National Standard
SHRPII	Strategic Highway Programme 2
TTC	Time-To-Collision
UDRIVE	European Naturalistic Driving and Riding for Infrastructure & Vehicle safety and Environment
UK	United Kingdom
USA	United States of America
VTTI	Virginia Tech Transportation Institute
WHO	World Health Organisation

EXECUTIVE SUMMARY

In accordance with the Accra Declaration and the 2000 Millennium Development Goals, South Africa undertook to reduce its road crash fatalities by half by 2014. This resolution was again strengthened in 2009 through the Moscow Declaration that led to South Africa also becoming a participant to the Decade of Action for Road Safety 2011 - 2010 (DoA) launched worldwide on 11 May 2011. The Road Traffic Management Corporation (RTMC) as the lead agency in the Country became a member of the United Nations Road Safety Collaboration (UNRSC).

The roles of research in dealing with road crashes remains integral to ensure to that the strategic interventions are supported by data and are responsive. The RTMC is tasked with stimulating research in road traffic matters and effectively utilising resources of existing institutes and research bodies. Human factors and the role they play in road traffic crashes is considered a leading cause of crashes, however, we know very little about human factors in the South African road safety context. By better understanding driver behaviour per se, it becomes possible to make informed decisions regarding law enforcement activities and, for example, to inform campaigns aimed at changing unsafe driving and road user behaviour. With this in mind the RTMC initiated this project as part of a larger research and development plan aimed at facilitating road research in the country.

Internationally a large body of research exists that details different aspects of human factors in road safety. One topic of interest that has greatly expanded over the past decade is the role that inattention and distractions play in crashes and near-crashes. Distraction and driving have been a research topic for many years and ranges from eating and drinking while driving, talking to passengers to using a cellular phone or navigational device while driving. Inattentiveness while driving is associated with a lack of situational awareness, in other words, not being aware of potential risks in your traffic environment and thus being unable to appropriately respond to these risks.

Traditionally, inattention and driver distraction was researched through crash database analysis, self-report and simulator studies. However, simulator studies are considered constricted and does not allow for all variables to be included in experiments simultaneously, while self-report studies are considered less reliable as it is difficult for a human being to provide feedback regarding when, where and why inattentiveness or the distraction while driving occurred. Crash database analyses have been used extensively to identify factors such as inattention or distraction that preceded crashes. However, crash database analyses are dependent on the quality and richness of the data of crash databases.

More recent attempts to study human behaviour used instrumented vehicles to collect human behavioural data within the context of the road, the vehicle and the traffic environment. These methodologies are resource intensive and although there are debates regarding the reliability of the information due to the manner in which drivers respond to the instruments in the vehicle, there seems to be some consensus that these methodologies do provide rich contextualised data and aiding a better understanding of the type of behaviours that precede a crash or near-crash.

A naturalistic driving study (NDS) was conducted in 2014 in which four drivers (two male and two female, two novices and two experienced) participated in research aimed at investigating the differences between novice and experienced drivers in South Africa. Approximately 200 hours of driving data was collected over a six month period. In this RTMC research project, this NDS data is further interrogated to determine the measure to which drivers are inclined to engage in secondary or distracting activities can be identified and quantified.

The literature review provides an overview of international research pertaining to inattentive and distracted driving. Driver distraction is generally viewed as a specific form of driver inattention. For purpose of clarity, definitions for inattentive driving and distracted driving are provided. The review provides an overview of the different types of driver distraction, the consequences associated with distracted driving and considered recommendations to address distracted driving practices. In addition, the literature review provides the basis for the development of the methodology for the study of distracted driving.

Based on the literature review, a set of vehicle and behavioural parameters were identified that could potentially highlight distracted driving practices based on the vehicle data that was collected. However, this strategy did not yield the desired results and a new data selection strategy was required. The second week of driving data for each of the four drivers was selected. The reasoning was that by the second week of driving with the instrumented vehicles, the drivers should have been more comfortable with the equipment in the vehicle and their behaviour should have returned to normal.

The selected imagery was transcribed and analysed in qualitative analysis software. A predefined coding scheme (based on the selected parameters) was used for the analysis of activities related to in-vehicle distractions. This analysis was then matched to the vehicle data that was collected for the corresponding driving periods. Approximately 7.4 hours of data was analysed.

Indications are that the drivers did engage in secondary activities while driving. However, the frequency and the extent to which they engaged differed. Passenger related distractions constituted the largest proportion of the total driving time. In other words, looking at, talking to or listening to a passenger was the activity that on average took the longest for all the drivers. Other secondary activities observed include using electronic devices, grooming, dining and person or object related distractions. The important question to answer is what constitutes normal driving in South Africa and is it possible that driving distracted has become the norm rather than the exception?

The dataset of the small sample of drivers inhibits the making of inferences towards the general driving population. However, this study of four drivers with different profiles shows a clear tendency that these drivers at a significant level engage in secondary activities while driving. This may be construed as indicative of a high level of disassociation with the driving environment or an elevated risk of non-avoidance of potentially avoidable incidents with crash potential. The study shows that distracted driving can be quantified scientifically with the NDS methodology. To determine the significance of this behaviour as an attribute of the general driver population, it’s advisable to undertake a larger and more representative study to determine the extent, magnitude and impact that distracted driving has on road safety performance in South Africa.

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CHAPTER 1: BACKGROUND

1.1. Road safety in South Africa

The road safety picture in South Africa remains grim. According to the RTMC 2013/2014 calendar year report road traffic crashes resulted in an increase of deaths rising from 11 844 in 2013 to 12 702 in 2014 (RTMC Calendar Year Report, 2014). In 2010, the costs of road traffic crashes and fatalities were estimated to be R100 billion (Arrive Alive, 2010). In 2013, the costs of road traffic crashes and fatalities quadrupled o R306 billion (Ensor, 2013). The International Traffic Safety Data and Analysis Group (IRTAD) indicated that in 2011, 27.6 per 100 000 people died in SA as a result of traffic crashes (IRTAD, 2013). At the time of this report South Africa ranked amongst the worst in the world (37/37) with 26.7 people killed per 100 000 population (IRTAD, 2013). This report also argued that rapid urbanisation and motorisation contribute to high levels of fatal crashes. The main causes cited in this report include impaired driving, speed, incorrect or no use of seatbelts and helmets as well as distracted driving (IRTAD, 2013).

In accordance with the Accra Declaration and the 2000 Millennium Development Goals, South Africa undertook to reduce by 50 per cent its road crash fatalities by 2014 (WHO Economic Commission for Africa, 2007; WHO, 2011). This resolution was strengthened in 2009 through the Moscow Declaration that led to South Africa also becoming a signatory to the Decade of Action for Road Safety 2011 - 2020 (DoA) launched worldwide 11 May 2011 (WHO, 2011).

South Africa as a signatory to the DoA has the responsibility to align research programmes and interventions for road safety that focuses on the institutional management, safer road use, safer vehicles, safer roads and better “post care” after crashes. As part of its mandate, the RTMC is responsible for addressing road safety in the Country by introducing interventions and programmes to reduce the high levels of road traffic crashes and associated fatalities and injuries on South African roads.

1.2. Human factors research in South Africa

Developed countries, with already low road casualty rates in comparison to South Africa, have on-going intensive efforts and interventions that include addressing human factors in road safety in order to facilitate further dramatic reductions in road related causalities (IRTAD, 2013).

In South Africa this is an area of road safety research that needs vigorous attention. Government has in the past expressed a grave concern regarding road user behaviour on South African roads (SA Government, 2015). Human factors are said to account for 80 to 90 per cent of fatal road traffic crashes in South Africa (Botha, 2005; Gainewe et al., 2010). However, limited research has been conducted in South Africa. Human factors previously monitored by the RTMC on a national level include: speed offences, barrier line violations, and seatbelt, alcohol and traffic offences (Gainewe et al., 2010). These indicators provided a glimpse into the lawlessness on South African road.

Other recent scientific road safety research publications in South Africa include research related to impaired driving (Sukhai et al., 2005; Meel, 2006; Ramsoomar et al., 2012), occupant protection (Olukoga et al., 2005; Sinclair 2013; Van Hoving et al., 2014), speeding behaviour (Bester et al., 2007; Chrisholm et al., 2012; Parkinson et al., 2013) as well as hazard perception in novice drivers (Venter and Sinclair, 2015).

1.3. Motivation for and significance of the study

By better understanding driver behaviour per se, it becomes possible to make informed decisions regarding law enforcement activities and, for example, to inform behavioural campaigns aimed at changing unsafe driving and road user behaviour.

Internationally, distracted driving has been a research topic for many years and ranges from eating and drinking while driving, talking to passengers, using a cellular phone or navigational devices while driving. Inattentiveness while driving is associated with situational awareness, in other words being aware of potential risks in your traffic environment and having the ability to correctly respond to these risks.

Topics such as speed, in-vehicle restraints and driving under the influence of substances have been researched extensively by academics within the South African context. However, distraction and inattentiveness while driving, have not received the same level of interest.

CHAPTER 2: INTRODUCTION

2.1. Purpose of this project

In support of human factor research in South Africa, the RTMC approached the Council for Scientific and Industrial Research (CSIR) in June 2015 to conduct a three month pilot study to determine whether inattentive and distracted driving as part of everyday driving in South Africa can be quantified.

The CSIR had to the avail of the RTMC a naturalistic driving study (NDS) dataset from a research project in 2014 where a sample of four (4) drivers were monitored over a period of 6 months. The purpose of this study was thus to develop a methodology to interrogate this NDS dataset intending to identify and quantify inattentive and distracted driving behaviours.

2.2. Research Objective

The investigation of inattentive and distracted driving is a commencement of research aimed at exploring the potential extraction of useful information from available NDS data. The results of the investigation will lead to the scoping of an expanded representational driving study for research of various driver behavioural themes on a larger scale in South Africa.

2.3. Research Questions

The following two overarching questions are explored:

- What types of inattentive and distracted driving behaviours can be observed and quantified in the NDS dataset?
- What is the significance of prevalent inattentive and distracted driving behaviour thereof?

2.4. Additional considerations

2.4.1. Research scope

Selected data from 2014 NDS study was used in the analysis. The original dataset was too small to make any inferences to a general South African population. In addition only a fraction of the data collected in the previous study has been analysed. Although the NDS methodology is effective in understanding road safety behaviour in the context of the driver, the vehicle and the environment is the methodology is very resource intensive as the image material selected needs to be transcribed, visually interrogated, coded and then analysed. In addition the vehicle data then need to be matched with the image material before being analysed and interpreted. This is a time consuming process requiring diligence and man hours

2.4.2. Research Ethics

This work entails a study of human subjects and is therefore subject to research ethics considerations. Signed consent was obtained from all participants during the previous study. Participation in the study was voluntary and all personal information pertaining to the participants is kept confidential.

2.5. Overview of chapters

This document describes the research that was undertaken to investigate the prevalence of inattentive and distracted driving in a South African context making use of existing naturalistic driving data that was collected previously. The document is arranged as follows:

- Chapter 1: Background to the project
- Chapter 2: Introduction to the project
- Chapter 3: Overview of inattentive and distracted driving
- Chapter 3: Methodology and analysis
- Chapter 4: Findings
- Chapter 5: (Placeholder1) Conclusions and recommendations

CHAPTER 3: LITERATURE REVIEW

3.1. Overview

The literature review had a dual purpose:

a) To provide an overview of international research pertaining to inattention and distracted driving. The review defines distraction within the context of driver inattention as driver distraction is considered a specific form of driver inattention. It provides an overview of the different types of driver distraction, as well as to identify the consequences associated with distracted. It considers recommendations to address distracted driving practices.

b) The second section of the review was aimed at identifying vehicle and behavioural parameters that informed the development of the methodology for application in this pilot project.

3.2. Background

3.2.1. International research

Internationally, distracted driving research has expanded exponentially since more wireless communication, entertainment (infotainment) and driver assistance systems became available in the vehicle market (Young et al., 2007). With these technologies becoming more and more prevalent, the incidence of distraction-related crashes is expected to escalate (Young et al., 2007). Driver inattention according to the National Highway Traffic Safety Administration (NHTSA) is the leading factor in most crashes and near-crashes (NHTSA, 2014). In the United States of America (USA) nearly 80 per cent of crashes and 65 per cent of near-crashes involved some form of driver inattention within three seconds before the event (NHTSA, 2014).

In 2011 the WHO and NHTSA indicated that worldwide the proportion of drivers making use of mobile phones while driving has increased from 1 per cent to 11 per cent in the last five to ten years (Burton, 2011).

Table 1 below provide an overview of distracted driving crashes in the USA in 2013. The table illustrates that distraction was a contributory factor in 10 per cent of all fatal crashes, in 7 per cent of driver fatalities and in 10 per cent of fatalities. Mobile phone use was evident in 14 per cent of all these fatal crashes associated with driver distraction.

Table 1: Distracted driving cited as a cause in 2013 USA crashes. (Insurance Information Institute 2015)

	Crashes	Drivers	Fatalities
Total fatal crashes	30057	44574	32719
Distracted fatal crashes	2910	2959	3154
% of total crashes related to distraction	10%	7%	10%
Mobile phone use in fatal distracted crashes	411	427	445
% of fatal crashes where a mobile phone was used	14%	14%	14%

In Australia, a study that examined the role of self-reported driver distraction in serious road crashes that resulted in hospital attendance, found that distraction was a contributing factor in 14 per cent of crashes (Beanland et al., 2013). In New Zealand, estimates are that distraction contributes to at least 10 per cent of fatal crashes and 9 per cent of injury crashes (WHO and NHTSA, 2011). In the Netherlands reports indicate that mobile phone usage was the cause of 8.3 per cent crashes resulting in fatalities (SWOV factsheet, 2012). In Spain, 37 per cent of crashes were caused by distracted driving (WHO and NHTSA, 2011). National Canadian data analysed for the period 2003-2007 showed that distracted driving was the cause in 10.7 per cent of fatal crashes where drivers were killed (WHO and NHTSA, 2011).. For the same period in the US, distraction was the cause in 11 per cent of all national reported crashes (WHO and NHTSA, 2011). In Columbia, insurance data showed that distraction was a cause in 9 per cent of all crashes and in crashes where pedestrians were killed, distraction played a role in 21 per cent of those crashes (WHO and NHTSA, 2011).. In Great Britain, distraction is believed to have played a role in 2 per cent of crashes (Burton, 2011). Petzoldt (2010) indicated that a survey conducted by the German Dekra testing authority revealed that 22 per cent of the drivers interviewed made use of a mobile handheld phone while driving. This is illegal in Germany and when questioned as to why they engage in this illegal behaviour, 58 per cent indicated that they did not care if this was illegal.

Previous methodologies to study distraction included in-depth crash analysis, observations and simulator studies however, with recent technological developments and improvements in in-vehicle technologies; it has become possible to study driver behaviour more comprehensively (Van Schagen et al., 2012). In-vehicle technologies such as the use of camera and computer equipment in vehicles make it possible to explore traffic system components, the driver, environment, road and vehicle, holistically (Van Schagen et al., 2012). Where previous studies had to make use of crash data, self-reports or observations, in-vehicle technologies provide researchers with a glimpse of driver behaviour in a drivers' natural setting (Van Schagen et al., 2012).

The first NDS study was conducted in 2001 by the Virginia Tech Transportation Institute (VTTI) under the auspices of the United States Strategic Highway Programme 2 (SHRP II). In 2006, Klauer et al. made use of crash and near-crash information collected during the 100-car study to conduct research that provided insight into the role that distraction play in the causation of traffic crashes. The study found that drivers who engaged in secondary tasks were three-times more likely to be in a near-crash or a crash than drivers who are attentive. This finding renewed the interest in the role that driver distraction plays in crashes and provides researchers with a better understanding of behaviour prior to crashes or near-crashes that can be addressed (Klauer et al., 2006).

3.2.2. Distracted driving and the South African context

South Africa is no exception to technology developments and according to Nielsen Southern Africa (2011), more people in South Africa has access to mobile phones than access to drinking water. Figure 1 below illustrates the dominance of mobile phones above other technologies in South Africa (Hutton, 2011).

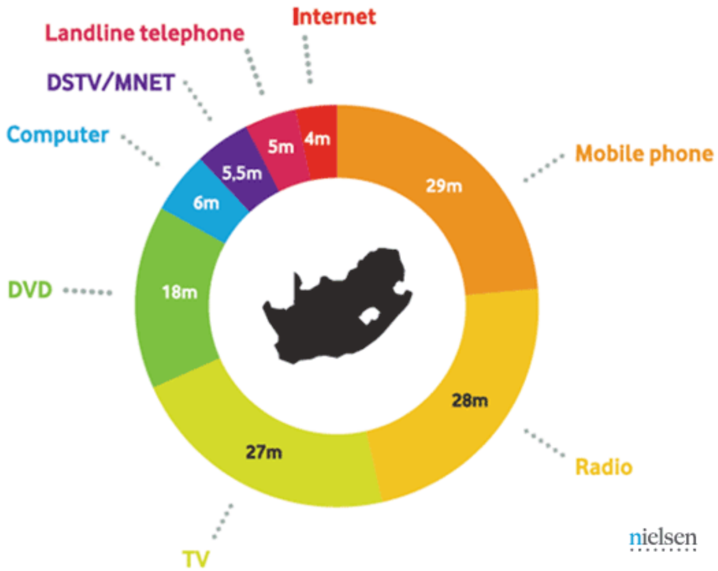

Figure 1: Mobile phones compared to other technology in South Africa

Despite MYBroadband (My Broadband 2015) reporting that 25 per cent of crashes in South Africa are related to the use of mobile phones, little formal research related to the prevalence of distracted driving has been published. Indications from the private sector are that distracted driving is probably a major problem in South Africa (MyBroadband, 2015). Discovery Insure indicated that through its Discovery Insure Driving Challenge (DIDC) programme, the data collected shows that on average a single instance of mobile phone usage in South Africa represents approximately of 52 seconds of distracted driving (MyBroadband, 2015). The Company indicated that when driving at 60 km/h this few seconds is equivalent to driving blind and makes crashes four times more likely to occur. In addition, the research found that the worst 20 per cent of offending South African drivers use their phones for an average of three minutes per trip (My Broadband, 2015).

The 2013 Goodyear third annual Road Safety Survey investigated distracted driving among young drivers globally (Goodyear EMEA, 2013). According to the report, 6 400 drivers under the age of 25 were surveyed in 15 European countries as well as South Africa. Findings indicated that South African young drivers were much more distracted compared to European young drivers (IOL Motoring 2013). Sixty one (61) per cent of young South African drivers use mobile phones without headsets compared to European young drivers (44 per cent). Other distracted driving practices included drinking (75 per cent compared to global average of 58 per cent), eating (71 per cent compared to the global average of 45 per cent), looking at a map, changing navigation settings, grooming and kissing (33 per cent).

In an IOL Motoring a market study surveying 14 160 South African drivers found that up to 41 per cent of the participants admitted to texting, emailing and using social media while driving (IOL motoring, 2014).

The National Road Traffic Act, Act 93 of 1996, Regulation 308A and 308B, prohibits drivers from using communication and electronic devices such as in-vehicle televisions while driving. Regulation 308A states that no person shall drive a vehicle on a public road while:

- holding a cellular or mobile telephone or any other communication device in one or both hands or with any other part of the body;
- while using or operating a cellular or mobile telephone or other communication device unless such a cellular or mobile telephone or other communication device is affixed to the vehicle or is part of the fixture in the vehicle and remains so affixed while being used or operated;
- This device needs to be adapted or designed to be affixed to the person of the driver as headgear, and is so used, to enable such driver to use or operate such telephone or communication device without holding it as such that the driver need to hold it with one or both ands or any other part of the body.

The Provincial Government of the Western Cape (PGWC) has been enforcing this law through its Safely Home campaign. This campaign has been strict in enforcing laws to reduce the use of mobile phones while driving in the Province with drivers being fined and their phones confiscated for 24 hours (Western Cape Department of Transport and Public Works, 2015).

The Road Traffic Management System (RTMS) is an accredited South African National Standard (SANS 1395) and a voluntary programme where through self-regulation road transport consignees, consignors and transport operators are encouraged to implement a vehicle management system that preserves road infrastructure, improves road safety and increases the productivity of the logistics value chain. Part of this system is driver management that encourages initiatives by logistic companies to have policies in place for the management of driver behaviour and wellness (RTMS, 2009; Nordengen 2014). These policies include guidelines and restrictions on mobile phone use while driving, fatigue management and hours of driving.

3.3. Definition of concepts

Driving is a safety critical task where the attention, visual and motor skills of the driver is essential (Cheong, 2010). Without these critical tasks a driver runs the risk of being involved in a crash, resulting in property damage, related health care costs, litigation expenses, insurance administration, lost work time, and other adverse consequences (Lissy et al., 2000).

The primary driving task is defined as the actual driving task. The primary driving task involves keeping the vehicle on the road while obeying the traffic regulations and being thoughtful towards other road users (Peissner et al., 2011. The primary task includes physical actions such as braking, pressing down on the accelerator, operating the transmission, controlling the speed and steering the vehicle (Peissner et al., 2011).

Drivers need to constantly allocate their attentional and physical resources to the driving task at hand (Young et al., 2007). Primary tasks becomes more habitual in nature as driving experience grow (Peissner et al., 2011). With experience the driving task tend to become automated which provide drivers with the opportunity to become more practiced at dividing their attention between the driving tasks and secondary activities in most instances without serious consequences such as being involved in a crash (Young et al., 2007). However, distraction occur when these secondary activities become the focus and due to the high task demands, attention is diverted away from the primary driving task, which can have catastrophic consequences (Young et al., 2007).

Secondary tasks are not part of the natural driving response, but function to please the comfort- and entertainment needs of the driver in a vehicle (Peissner et al., 2011). This includes talking to passengers, selecting music from a radio, hand-held or hands-free music player, receiving and indicating a call, entering data into the navigation system, or regulating the air conditioning. Secondary tasks might divert the driver’s attention away from the (primary) driving task (Peissner et al., 2011) and indications are that performing primarily perceptual-motor tasks while driving (e.g. dialling/texting on a mobile phone) can significantly impair driver performance (Salvucci, 2002).

In addition to needing specific sets of skills to physically drive a motor vehicle; drivers are also required to have mental abilities which will ensure that they engage safely with traffic. Situational awareness is essential as environmental information need to be integrated into a drivers’ mental model of the situation and the driver then has to use that mental representation to predict and react to future events (Kass et al., 2007). Situational awareness therefore refers to the driver being mentally alert in order to scan the road environment for immediate threats, the ability to anticipate hazardous situations, deciding on the correct action to effectively execute an action that will mitigate the risk (Fisher et al., 2014). Research has shown that driver performance deteriorates as a result of cognitive and other distractions as it hampers the drivers’ ability to detect (situation awareness) and react to hazards within the road environment (Kass et al., 2007).

The National Safety Council (NSC) in the USA associates distracted driving with multi-tasking. Lee (2014) highlights the fact that multi-tasking impairs driving performance because the brain experiences increases in workload which results in slower processing of information. The brain handles tasks sequentially as illustrated in figure 2. By switching from one task to another, it makes it difficult for the brain to recognise and respond safely and effectively to hazards in the road environment (National Safety Council, 2012).

Figure 2: Sequences followed to complete a task (National Safety Council, 2012).

Despite the large body of research that has emerged on inattentive and distracted driving in the last decade, there are still no universal definitions agreed upon (Young et al., 2007; Stelling,et al., 2012). However the generally accepted categories for distracted driving are visual, cognitive, auditory and physical distractions. Some additional research has since been conducted to develop taxonomies in order to clarify and operationalise the concepts and definitions for research purposes (Regan et al., 2011; Hanowski, 2011; Regan et al., 2014).

3.3.1. Driver inattention

Inattention is defined as failure to pay attention or to take notice. Regan et al (2011) state that inattention in the context of driving refers to: *"diminished attention to activities critical for safe driving in the absence of a competing activity"* (Regan et al., 2011: 1772). Previously inattention was defined as "any point in time that a driver engages in a secondary task, exhibits symptoms of moderate to severe drowsiness, or looks away from the forward roadway" (Klauer et al., 2006, pp. 21). Primary causes of driver inattention are activities, such as mobile phone use, talking to a passenger, as well as fatigue and drowsiness (Klauer et al., 2006; Dong et al., 2011).

3.3.2. Driver distraction

Driver distraction is a specific type of driver inattention (NHTSA, 2014). Distraction occurs when a triggering event induces an attentional shift away from the primary task, in this case driving (Horberry et al., 2006). Driver distraction can be described as anything that diverts the driver's attention away from the primary task of navigating the vehicle (NHTSA, 2010). Salvuci (2002) refers to driver distraction as multi-tasking and performing secondary tasks while driving.

Regan et al. (2011) state that driver inattention means insufficient or no attention to activities critical for safe driving. Other types of inattention may occur because of physical or biological factors ('driver restricted attention'), because of too much focus is placed on one aspect of the driving task (driver wrongly prioritised attention), or because of neglecting to pay attention to critical driving activities ('driver neglected attention') or because of too cursory or hurried attention to critical driving activities ('driver cursory attention') (DaCoTA, 2012). Concentration loss is considered an internal source of distraction when the competing task for driving is thinking about other things or daydreaming without being fatigued (DaCota, 2012).

Figure 3 below illustrates the different aspects of distracted driving in terms of visual, auditory, physical and cognitive distractions which will be discussed below (Automobile Association of America, 2013).

Figure 3: What constitutes distracted driving (AAA, 2013)

3.3.3. Reframing driver inattention and distraction

Regan et al (2011) developed a classification to redefine driver distraction in order to distinguish it from other types of driver inattention. The authors argue that the current definitions used in literature vary in meaning and are (as indicated earlier) not necessarily suitable for operational use when for example coding behavioural data from observational studies. There is a need for a precise definition that is used consistently across research studies which will ease comparisons and ensure consistency across different scientific studies (Regan et al., 2011; Hanowski, 2011).

Accordingly, driver inattention is defined as five different types of sub-categories (Table 2). The authors highlight that the last type of inattention (Driver Diverted Attention) is most applicable to distraction and distinguishes between non-driving activities and driving activities that divert the drivers' attention.

In addition the authors differentiate between voluntary and involuntary selection of information (Regan et al., 2011). *Involuntary selection* of information refers to things difficult or impossible to ignore, and generally which are not initiated by the driver. These triggers cause diversion of attention involuntarily (e.g. roadside advertising, flashing bill boards, warning lights in the vehicle, etc.) *Voluntary selection* of inattention refers to activities where the driver intentionally diverts his attention away from the driving task (e.g. dialling and texting on a mobile phone, adjusting the volume control on the radio, etc.). Beanland et al. (2013) applied the 2011 coding scheme by Regan et al. to the in-depth analysis of the Australian crash data. From the findings it can be derived that "most showed evidence of driver inattention (57.6 per cent) or possible inattention (5.9 per cent). Furthermore that 70 per cent of distractions were voluntary and potentially preventable.

Table 2: Categories describing driver inattention (Regan et al., 2011)	
Insufficient or no attention to activities critical for safe driving due to:	
Driver restricted attention (DRA)	Something that physically prevents (due to biological factors) the driver from detecting (and hence from attending to) information critical for safe driving (e.g. micro sleeps).
Driver Misprioritised Attention (DMPA)	Brought about by the driver focusing attention on one aspect of driving to the exclusion of another, which is more critical for safe driving (E.g. driver looks over shoulder while merging and misses a lead vehicle braking).
Driver Neglected Attention (DNA)	Driver neglecting to attend to activities critical for safe driving (E.g. driver who neglects to scan for trains at a railway level crossing (because they are rarely or never seen).
Driver Cursory Attention (DCA)	Driver giving cursory or hurried attention to activities critical for safe driving. (E.g. driver is in a hurry and does not complete a full head check when merging–and-ends up colliding with a merging car).
Driver Diverted Attention (DDA)	Diversion of attention from safe driving toward a competing activity. Refers to "internal" and "external" distractions; that is, competing activities that derive from inside the vehicle (e.g., conversing with a passenger) or from outside the vehicle (e.g., looking at a pedestrian).
DDA non-driving-related (DDA-NDR)	The diversion of attention away from activities critical for safe driving toward a competing non driving-related activity.
DDA driving-related (DDA-DR)	Driver diverts attention away from activities critical for safe driving toward a competing activity that is driving-related (e.g. attending to a low fuel warning)

3.4. Types of distractions

As indicated earlier, driving is a complex task, requiring the driver to simultaneously perform various cognitive, physical, sensory and psychomotor skills (Young et al., 2007). Despite these complexities, it is not unusual to observe drivers engaging in various non driving-related activities while driving including conversing with passengers, listening to the radio, applying make-up and even reading (Young et al., 2007). NHTSA (2014) highlights the fact that research related to distraction has mostly focused on mobile phone use while driving; however, distracted driving also includes activities such as eating, talking to other passengers, or adjusting the radio or climate controls, responding to in-vehicle devices and so forth (NHTSA, 2014).

Activities that impact on a driver's ability to focus on the road vary from visual distractions inside and outside the vehicle, to cognitive and physical distractions within the vehicle. Driver distraction leads to a breakdown or failure in task timing, switching tasks and prioritisation of tasks (Lee et al., 2014). Pulling drivers' visual attention away from the road and the driving task, dilute the drivers' ability to maintain a safe driving position and to react to potential hazards within the road environment. Liang (2009) describes visual distraction as "eye-off-road", and cognitive distraction as "mind off-road".

The sources of driver distraction can reside inside or outside the vehicle, be technology-related or otherwise traffic-related, can be self-initiated or imposed upon by the situation or circumstances (DaCoTA, 2012).

Lee et al (2005) stipulates that any secondary task can have combinations of manual, visual, and cognitive components at different levels. With a visual task, the lowest level requires drivers to take their eyes off of the road, the next level requires them to turn their head, and the highest level requires them to shift their entire body. On the other hand, the lowest level of a manual task requires drivers to take a hand off the wheel. Secondly to move their entire arm while the highest level requires them to move/turn their body. The cognitive component of a task also has varying levels ranging from no thought to simply listening and comprehending to selecting a response based on incoming and recalled information (Lee et al., 2005).

Strayer et al (2011) highlights two important factors that should be considered when discussing driver distraction and crash risk. The first revolves around the duration of the activity and the second around the exposure rate of the distracting activity. In the first instances, drivers might engage in secondary activities because they feel it is safe to do so. The longer they engage in the secondary task, the less they become able to respond to traffic demands and potential hazards in the environment. The second important factor is the exposure rate, in other words how often the driver engages in this specific secondary task. The more a driver engages in secondary tasks the bigger the threat of being in a crash.

Table 3 below provide an overview of the sources and type of distractions (DaCota, 2012).

Table 3: Sources and types of distraction (adapted from DaCota, 2012)

Source of distraction	Type of distraction
Phone	Auditory-Cognitive
Passenger	Visual-Auditory-Cognitive
Music	Auditory-Perhaps Cognitive
Texting	Visual-Cognitive-Physical
Navigation system use	Visual-Cognitive-Physical
Follow navigation system instructions	Visual-Auditory-Cognitive
Reacting to warnings	Visual-Auditory-Cognitive
Looking at advertisements	Visual-Cognitive
Eat/drink; grooming or reach for object	Visual- Physical
Daydreaming	Cognitive

3.4.1. Visual distractions

Visual distraction can be categorised into situations where (a) the driver's visual field is blocked and prevents the perception of relevant information, (b) the driver neglects to look at relevant areas, focusing instead on another visual target, and (c) the driver is inattentive, often described as the "looked-but-failed-to-see" phenomenon (Petzold, 2011).

Frequency and duration of in-vehicle glances to infotainment systems are important influences with regards to visual distraction. The higher the frequency of glances off the road the bigger the threat to be involved in a danger situation while driving. Visual distraction of more than two seconds is considered to be a critical time of visual absence which can potentially result in higher crash risk (Klauer et al., 2006). Novice drivers for example have been found are far less likely to initiate texts (write) than to read them while driving (Goodwin et al., 2014).

3.4.2. Cognitive distractions

Cognition refers to the mental functions of human understanding and information processing such as perception, learning, thinking, and remembering (Peissner et al., 2011).

The use of in-vehicle information systems (IVIS) contributes increasingly to driver distraction (Liang, 2009). Two types of technologies can distract drivers. Firstly, built in technologies such as advance driver assistance systems (AVAS) with built in Global Positioning Satellite (GPS) and secondly technology such as mobile phones, IPod and other wireless devices (Ministry of Public Safety and Solicitor General, 2009).

The most popular cited in-vehicle distraction is mobile phone usage (Horberry et al, 2006). The use of a mobile phone while driving reduces driving precision and this becomes worse with increases in age. On average, drivers using mobile phones while driving were 50 per cent more at risk than drivers not using a mobile phone (Burns, Parkes, Burton, Smith, and Burch, 2002). Drivers engaging in mobile phone conversations had slower reaction times and their speed control was poorer. Interestingly, drivers found it easier to perform driving tasks when driving drunk than to perform the same driving tasks while talking on a hand-held device (Burns et al., 2002; Leung et al., 2012). Furthermore it was found that the more emotionally intense the conversation is the greater the driving impairment (Leung et al., 2012; Sterkenberg, 2015). Engaging in non-driving cognitive activities, such as being lost in thought or thinking about personal or financial problems may also cause a driver to lose focus (Singh, 2010).

3.4.3. Physical distractions

Physical distractions revolve around distractions that cause the driver to physically have to use hands to adjust something instead of concentrating on the physical task of driving that requires hands on the steering wheel or on gears for changing (ETSC, 2010). This includes talking on a mobile phone, texting while driving or engaging in secondary activities such as eating and drinking as well as grooming (NHTSA, 2012).

3.4.4. Auditory distraction

Auditory distraction occurs when drivers momentarily or continually focus their attention on sounds or auditory signals rather than on the road environment. This can occur when the driver listens to e.g. the radio or when holding a conversation with a passenger, but is most pronounced when using a mobile phone (ETSC, 2010).

3.5. Measuring inattentive and distracted driving

Traditionally, the most popular methods included self-report studies, simulator studies and crash database analysis to investigate the effect of distraction on driving as well as the prevalence of distracted driving crashes in crash data. More recently instrumented vehicles are used to investigate driver distraction and inattention.

3.5.1. Traditional approaches

3.5.1.1. Self-reported studies

Although a number of previous studies have made use of self-reports to investigate distracted driving behaviour, Goodwin et al (2014) state that data from these studies are rarely specific enough to be of any research value because drivers cannot report accurately about how often, how long, or the proportion of time that they drove distracted.

3.5.1.2. Crash database analysis

Stutts et al. (2001) made use of the NHTSA Crashworthiness Data System (CDS) to analyse police crash reports between 1995 and 1999 to investigate the role distraction played in crashes. The database contains mainly passenger vehicle crashes and the authors specifically looked at serious crashes. This database includes detail such as "Driver's Distraction/Inattention to Driving" variable (added to the database in 1995) which need to be completed. However, the issue of under-reporting or incorrect reporting was highlighted as a key concern that impact on the validity of the data. In terms of frequently reported distracted behaviour these included: events occurring outside the vehicle, adjusting radio/cassette/CD controls, and interactions with other occupants inside the vehicle. Less frequently reported distractions included moving objects in the vehicle, other objects brought into the vehicle, adjusting vehicle or climate controls, eating and drinking, using a mobile phone, and smoking. Due to the aforementioned issues with the data the authors concluded that it is difficult to assign relative risk associated with distracted driving (Stutts et al., 2001).

Eby et al (2003) reviewed a number of crash databases (the National Automotive Sampling System General Estimates System; The National Automotive Sampling System Crashworthiness Data System; the Fatality Analysis Reporting System; the Highway Safety Information System; and regional geographic information system databases), with the aim of comparing these databases and making recommendations toward how these can be used to determine distraction-related crash scenarios. Eby et al (2003) focused on distraction information (inside and outside the vehicle), inattention information (driver physical or mental condition at the time of the crash for determining the driver's level of attention to the driving task) and driver demand information (including roadway, traffic, and environmental conditions at the time of the crash). They concluded that not one single database included all the factors desired for identifying distraction scenarios and estimating their magnitude nationally.

Singh (2010) reports on findings from the NHTSA National Motor Vehicle Crash Causation Survey (NMVCCS) which collected on-scene information on several crash factors, including factors related to driver inattention. The NMVCCS data studied two facets of distracted driving, namely distraction from sources within the vehicle and non-driving cognitive activities, as associated factors. Findings from this study indicated that among the crash-involved drivers, distraction from internal sources was more common than distraction due to non-driving cognitive activities. The findings showed that talking to a passenger was the most common internal distraction. Inattentiveness due to thoughts was the most prevalent factor among the non-driving cognitive activities.

In the Australian National Crash In-Depth Study, serious casualty crashes (856 crashes) from 2000 to 2011 were used to investigate the role of driver distraction in Australian crashes (Beanland et al., 2013). Criteria for inclusion in the study required that at least one party was admitted to hospital due to crash-related injuries. However according to the findings 45 per cent of crashes could not be coded according to distraction definitions as the information in the database was insufficient and in 15 per cent of the records the driver indicated the “other driver was at fault” without specifying whether inattention was involved. In the remaining 340 crashes inattention was highlighted cause in 57.6 per cent and as a possible cause in 5.9 per cent of crashes (Beanland et al., 2013).

3.5.1.3. Simulator studies

Previously simulator studies were considered a safe manner in which to study human factors for road safety. A simulated environment is safe, allows for experimental control and the manipulation of variables and through the years a large number of different driving measures have been studied using simulators (Young et al., 2003). However, simulator studies could potentially be questioned in terms of the validity of results as a simulator needs to represent the real world as closely as possible.

The influences of information and communication technology (ICT) systems on driving performance can be demonstrated by measuring longer reaction and response times, and by detecting problems with lane keeping and variations in following distances. Often large variances in lane position are considered as the most serious sign of influences on driving performance when using an ICT system while driving. Therefore, Kun et al (2007) recorded three measures of driving performance when investigating the effect of different accuracy levels of speech recognition: the lane position, the steering wheel angle, and the velocity of the participants when operating with different systems. They found significantly reduced driving performance for lower speech recognition levels. Using a reliable driving simulator with a 180 degree field of view, twenty participants needed to follow a leading vehicle at a constant distance without departing from the lane. The Lane Change Task (LCT) is considered a well-established experimental paradigm for assessing driver distraction. In the LCT simulation, the driver had to follow a straight three-lane road for about three minutes at a constant maximum speed of 60 km/h. During one trial, eighteen signs along the track indicate that the driver has to change the lane as soon as possible. On the basis of measuring the longitudinal and lateral position, the speed, and the steering angle, the deviation of the actual driving performance from a normative (baseline performance) was calculated and served as an indicator for the distraction caused by a secondary task (Kun et al., 2007).

Beede et al (2006) investigated college students' with more than six years of driving experience cognitive distraction according to various measures of driving performance through the use of a simulator. The participants were subjected to the completion of a questionnaire and the completion of four simulated driving scenarios. The distraction tasks consisted of responding to a signal detection task while engaging in a simulated mobile phone conversation. Driving performance was measured in terms of traffic violations (e.g., speeding, running stop signs, etc.), driving maintenance (e.g., standard deviation of lane position), attention lapses (e.g., stops at green lights, failure to visually scan for intersection traffic, etc.), and response time (e.g., time to step on brake in response to a an event, etc.). Kass et al (2007) also made use of a simulator study to investigate the differences in distraction between novice and experienced drivers. The experiment measured the number of driving violations that were committed while talking on a mobile phone while having to follow direction instructions. In both of these studies findings indicated that driving performance deteriorates and driver error as well as violations increase when the driver engaged in secondary tasks.

3.5.2. Instrumented vehicles

3.5.2.1. Naturalistic Driving Studies

The USA has possibly one of the largest bodies of research related to inattention and distraction while driving. Topics under consideration from US research include investigations into general driver characteristics and effects of distracted driving, mental workload as well as the impact that wireless communication devices have on safe driving behaviour (NHTSA, 2014).

The SHRP II NDS project was the largest and most comprehensive study undertaken to study the role of driver behaviour, the vehicle and environmental performance. The study revolved around an investigation of how the driver interacts and adapts to the vehicle, the traffic environment, roadway characteristics, traffic control devices, and other environmental features through the use of instrumented vehicles. One of the first concepts to be explored was driver distraction and inattention within the context of real world crashes and near-crashes (Victor et al., 2015).

In 2006, the 100-Car NDS conducted by the VTTI examined data from 69 crashes and 761 near-crashes in conjunction with baseline data from 20 000 randomly selected, uneventful driving segments. The study revealed that distraction resulting from a secondary task was reported in 33 per cent of crashes and 27 per cent of near crashes. Using this data to calculate the relative risk of crashing, researchers concluded that performing a complex secondary task (e.g., reaching for a moving object, applying makeup or dialling) exposed drivers to approximately three times the risk of being involved in a crash or near-crash. Moderate secondary tasks (talking/ listening, eating, inserting a CD) were approximately twice the risk, and for simple secondary tasks (e.g., drinking, smoking) there was no significant increase in crash or near-crash risk (Klauer et al. 2006). It was noted that there are limitations to this study. Most importantly, only a small number of crashes were studied, and many of the distraction-related crashes involved minor damage that may not necessarily be investigated by the police or included in a transportation department's collision data (Ranney et al., 2008).

3.5.2.2. Field Operation Tests

European research initially revolved around Field Operations Tests (FoTs). FoTs are used to evaluate driver support systems (IVIS and AVAS). FoT therefore refers to the methodology used by vehicle manufacturers, researchers and practitioners in Europe to test ICT along with Intelligent Transportation Systems (ITS) solutions for better driving and traffic management. FoTs focus on the effect that vehicle technologies have on driver behaviours and investigate the possible uses of advanced technologies to make vehicles as safe as possible (Barnard et al., 2010). These studies were deemed extremely valuable as they validate the impact that advances technologies have on real-world driving performance. The Field Operational Test Support Action or FESTA methodology is used on a European level to plan, prepare, execute and report on a FoT. In Europe, large FoTs have been underway for a number of years. These field studies mostly involve equipping vehicles with instrumentation to determine the influence and impact that in vehicle-instrumentation such as park-distance control, voice controls and so forth have on driver behaviours (Dingus et al., 2006; Bekarias, 2011).

The Prologue project (Promoting real life observations for gaining and understanding of road user behaviour in Europe) was a feasibility study that focused on potential benefits that a ND study could have for Europe (Bekarias, 2011; Van Schagen et al., 2012).

With FoT studies the focus is on the interaction between the driver and the vehicle systems while in NDS the focus is on driver behaviour within the context of the vehicle and the environment. Building on the FESTA methodology and Prologue projects, the UDrive project will take place in seven EU Member States where road user behaviour will be studied with a focus on both safety and environment (Eenink et al., 2014). In both of the projects mentioned above, driver distraction and inattention is considered key research topics.

Table 4 below provide a summary of research methodologies used to investigate inattention and distracted driving behaviour.

Table 4: Methodologies used to investigate inattention and driver distraction		
	Type	**Description**
Traditional approaches	Self-reported studies	Studies are not specific enough to be of research value because drivers cannot report accurately about how often, how long, or the proportion of time that they drove distracted Goodwin et al (2014).
	Crash data analysis	Under-reporting or incorrect reporting was highlighted as a key concern that impact on the validity of the data – makes it difficult to assign risk (Stutts et al., 2001). Not one single database included all the factors desired for identifying distraction scenarios and estimating their magnitude on a national level (Eby and Kostyniuk, 2003) Difficulty in coding distracted crashes in national crash databases crashes (Beanland et al., 2013).
	Simulator studies	Safe and relevant results, but potentially be questioned in terms of the validity of results as a simulator needs to represent the real world as closely as possible (Kun et al, 2007; Beede et al., 2006; Kass et al., 2007)
Instrumented vehicles	Naturalistic Driving Studies	SHRP II NDS large study the role of driver behaviour, the vehicle and environmental performance (NHTSA, 2014). Driver distraction and inattention within the context of real world crashes and near-crashes – but crashes are rare events (Victor et al., 2015; Klauer et al., 2006; Ranney et al., 2008).
	Field Operation Tests	FOTs are used to evaluate driver support systems (IVIS and AVAS) and more recently distraction in the context of these systems (Dingus et al., 2006; Bekarias, 2011).

3.6. Factors associated and contributing to driver distraction

3.6.1. Overview

Driver distraction impacts driving performance negatively. The level of impact is dependent driver characteristics, driving task demand, competing task demand and the ability of the driver to self–regulate in response to the competing activity. Factors influencing driving task demand include traffic conditions, weather conditions, road conditions, the number and type of vehicle occupants, in-vehicle design, and vehicle speed. The lower the driving demand the greater the residual attention available to attend to competing activities (Young et al., 2008; Singh, 2010).

Table 5 below provides an overview of the internal sources of distraction and non-driving cognitive activities associated with distraction.

Table 5: Sources of distraction (Singh, 2010)

Internal sources of distraction	Non-driving cognitive activities that causes distraction
• Internal sources of distraction include • Looking at movement/actions of other occupants • Dialling/hanging up phone • Adjusting radio/CD player • Adjusting other vehicle controls • Retrieving object from floor and/or seat • Retrieving object from other location • Eating or drinking • Smoking • Reading map/directions/newspaper, etc. • Focused on other internal object • Conversing with passenger • Driver talking on phone • Text messaging • Talking on CB radio	• Inattentive, thought focus unknown • Future event (vacation, wedding, etc.) • Preceding argument • Financial problems • Family problems • Personal problems

Singh (2010) indicated that from the NMVCCS analysis, almost 17 per cent of drivers involved in crashes were distracted from at least one internal source. The type of distraction at the time of the crash varied although 57 per cent of these drivers were conversing with a passenger in the pre-crash phase, about 11 per cent were engaged in phone use. In addition, 11 per cent of drivers were focused on internal objects compared to 7.4 per cent who were looking at movements or actions of other occupants. Eating or drinking was more frequently (5.7 per cent) recorded as an associated factor than smoking (1.6 per cent). More drivers (6.8 per cent) were assessed as retrieving objects from the floor or seat than 2.5 per cent of the drivers who retrieved objects from other locations; and adjusting the radio or CD was 4 per cent more common than adjusting other vehicle controls (1.2 per cent).

In 2012, the SWOV Institute for Road Safety Research in the Netherlands indicated that the number of fines for drivers holding their mobile phones have increased from 55 000 in 2003 to 140 000 in 2010 (SWOV Factsheet, 2012).

Singh (2010) found that approximately 7.9 per cent of the drivers involved in a crash were inattentive due to being engaged in one of the six cognitive activities listed in Table 5 above. In addition the level to which distracted behaviour influences crash risk is dependent on a decrease in driving competence; the frequency with which the distraction occurs; and duration of the distracted behaviour (Foss et al., 2014).

Driver distraction and the risk of being in a crash also increase according to vehicle type. Table 6 illustrates the level of risk associated with distracted driving (compared to non-distracted driving) and how the level of risk increases with certain vehicle types. Table 5 below, illustrates that heavy vehicle drivers engaging in distracted driving activities have a much higher crash risk than light vehicle drivers when driving distracted.

Table 6: Risk associated with distractions according to vehicle type

	Dialling	Talking/ Listening	Reaching for object/electronic device use	Texting
Light vehicle	2.8 X	1.3 X	1.4 X	No information
Heavy vehicles	5.9 X	1 X	6.7 X	23.2 X

3.6.2. Driver demographics influencing distraction

3.6.2.1. Age and experience

Most novice drivers have not yet achieved driving experience and that distractions such as that posed by passengers make this even worse (Foss et al., 2014). The research found that the presence of passengers influenced the frequency with which, novice drivers engaged in other types of distracted behaviour (Foss et al., 2014).

Victor (2000) indicated that novice and experienced drivers adopt different glance strategies and indicated that in-car single glances will increase with age. Older drivers with more experience though seem to have slower reaction times when driving distracted. In 2001 Stutts et al. found that young drivers (under 20 years of age) were the most likely to be involved in distraction-related crashes. This notion is supported by Singh (2010) who indicated that according to the NMVCCS analysis of distracted drivers involved in crashes, the under 16 age group had the highest frequency (36.8 per cent) of engaging in at least one distraction activity, while drivers 65 and older had the lowest percentage (12.3 per cent).

In contrast to other findings, a study conducted by Stavrinos et al. (2011) indicated that younger drivers tend to be more distracted than experienced drivers, but found no significant differences between age groups. Therefore, these results suggested that all drivers, regardless of age, may drive in a manner that impacts traffic negatively when distracted (Stavrinos et al., 2011). Earlier reference was made to driving becoming automated or a habit as driving experience increases. However, even though experienced drivers are able to do more than one thing at a time, studies show that performing a secondary task degrades driving performance (Brace et al., 2007; Just et al., 2008).

Also in terms of age, Singh (2010) found that distraction from internal sources decreased as a person gets older. The highest incidence of distracted driving from internal sources was found among the 16 year old group who were thinking about personal problems.

3.6.2.2. Gender

Research has found that female drivers tend to be more distracted while talking on a phone and driving than males. On the other hand, male drivers were more distracted while conversing with passengers while driving. The research also found that female drivers tend to make more driving errors when driving distracted compared to male drivers (Irwin et al., 2011; Singh, 2010). Internal sources were the main type of distraction for especially male drivers 16 to 25 years of age when compared to other gender/age groups (Singh, 2010).

Ronis (2012) also found that US female drivers tended to more easily make use of mobile phones while driving than teen males. In addition the research found that females were also twice as likely as males to use other electronic devices. Overall, Ronis (2012) indicated that females were 10 per cent more likely to engage in other types of distracting behaviour than males. These included reaching for objects in the vehicle (50 per cent more likely than males) and eating/drinking (25 per cent more likely than males). Teen males however on the other hand were more likely to turn around in their seats while driving as well as communicating with outside people (Ronis, 2012).

3.6.2.3. Social norms and influences

Atchley et al (2012) argues that in order to successfully address distracted driving practices through education and awareness campaigns, there needs to be an understanding of the influences that culture and social norms have on these behaviours. In their experiment young drivers were asked to assign responsibility to drivers in various crash scenarios (due to drunk driving and texting). The participants assigned higher responsibility to the drunk drivers causing crashes than to the drivers causing crashes while texting. Despite the fact that the participants did view driving and texting as dangerous and illegal behaviour, they still indicated that drunk driving was a more serious offence. One of the explanations for this was the fact that for many years, campaigns against the dangers of drunk driving have been implemented while distracted driving campaigns have not had that much exposure and those drivers might think it is in order to do so as their exposure to the consequences have not been that much. The authors concluded from their experiment that it is not only the perceived risk that influences a driver to engage in a specific type of driving behaviour but also the underlying social norms as to what is acceptable and what not.

Similarly, Li (2013) conducted a study that investigated the influence of culture on distracted driving found that drivers who frequently drive distracted are less likely to view distracted driving as a serious safety concern compared to other drivers (Li, 2013).

3.6.2.4. Driving task demands

Hazard perception is defined as the process of identifying hazards and quantifying their potential for danger. It is considered a complex task that takes decades to develop (Whelan et al., 2000). Hazard perception is classified into two types of skill needed to identify hazards in traffic, namely, performance based skills and cognitive/visual search skills (see Figure 4 below).

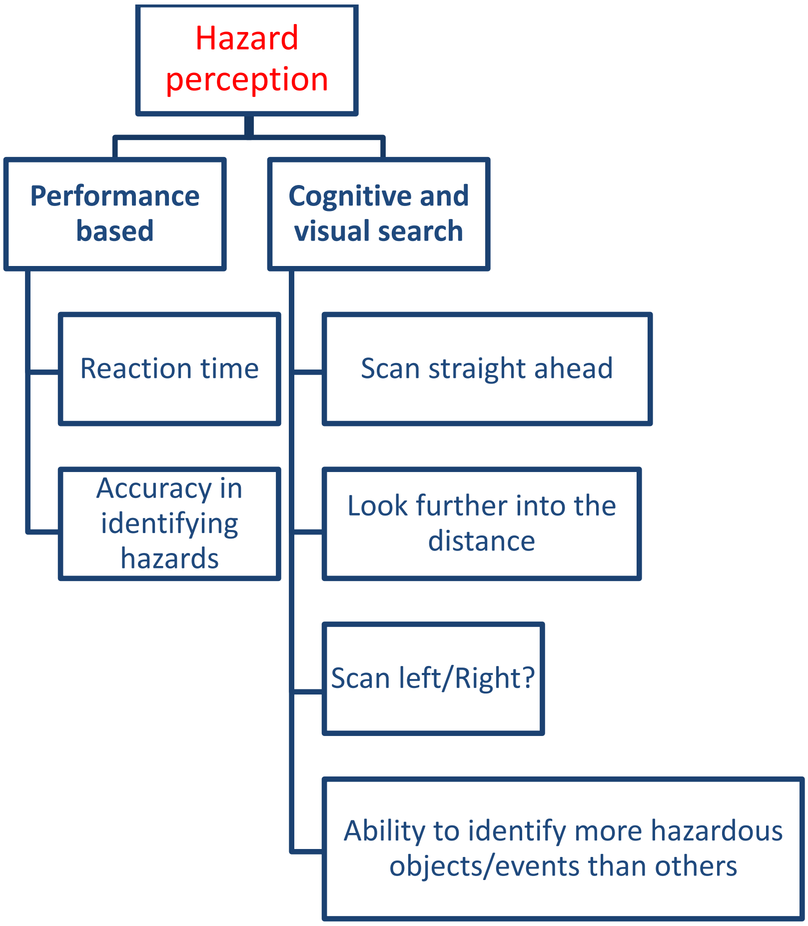

Figure 4: Hazard perception skills (Whelan et al., 2000)

Performance based skills refer to the ability of the driver to correctly identify hazards and to take appropriate action to mittigate the associated risk. Cognitive and visual skills are associated with the ability to scan the environment effectively to such an extend that the driver can anticipate possible dangerous situations and then react to those safely.

Parkes and Hooijmeijer (2000) state that poor situation awareness and poor driving performance has been associated with distracted driving practices. Situation awareness is defined as 'a person's perception of the elements in the environment within a specific time and space, the comprehension of the meaning of these elements and the projection of their status in the near future' (Endsley, 1993).

In a test track study drivers' adaptation to an in-vehicle reading task were measured. Drivers were able to control when to perform the secondary tasks in an effort to make the experiment more realistic. Drivers mostly initiated the secondary task before they came to a difficult road environment that would require concertation but were not discouraged if they could not complete the reading task before they got to that section. This implied that although drivers might seek to be safe when engaging in distracting activities such as reading a text message, it did not discourage them from doing so in more difficult road traffic environments (Liang et al., 2014).

3.6.3. In-vehicle distractions

Stutts et al (2003) recorded and analysed three hours of driving time of seventy test subjects. The research found that all the participants were observed to manipulate vehicle controls (such as air conditioning or window controls) and reaching for objects inside their vehicle as well as manipulating music or audio controls, and had their attention drawn to something outside the vehicle (external distraction). Furthermore, 75 per cent of the participants were observed eating or drinking while and talking to a passenger. Approximately 50 per cent of the drivers engaged in grooming activities, as well as reading or writing. Approximately 33 per cent of the participants used a cell phone while driving (Stutts et al., 2003). In-vehicle distraction, such as texting, adjusting the radio, talking to passengers or working with in-vehicle systems also influences driving performance negatively (Horberry et al., 2006).

3.6.3.1. Hands-free devices

McCallum et al (2004) investigated the cognitive workload when using a Personal Digital Assistant (PDA) while driving. Two different conditions (Speech PDA, and Manual PDA) and a control condition (No PDA) were compared. Twenty four participants were tested in a stationary vehicle which included a display with the driving environment, simulation control and data collection modules. The results indicated that while driving, manual PDA operations produced a significantly higher cognitive workload than speech-based operations (Peissner, 2011). Similarly, research has found that selecting music from a portable music player (e.g. Apple Ipod) while driving deteriorated driving performance as the driver has difficulty to maintain his lane position, following distance and drove significantly slower in order to correct deviance from the lane (Salvucci et al., 2007).

Different types of studies have also shown that the negative effects on driving task performance such as increases in reaction time and narrower visual focus. The effects of distraction were found to be the same for both handheld and hands-free use of the phone (Horrey et al., 2004; DaCota, 2012). Even though hands-free devices are aimed at reducing physical distraction research, it causes the driver to divert his attention away from the driving task and instead focuses on the conversation (Caird et al., 2005; Breen, 2009). Breen (2009) indicate that adverse consequences are associated with use of a car telephone while driving, whether hand-held or hands-free. The author highlights the fact that cars have become the new office, especially considering the availability of internet access, mobile phone technology that allows the visual display of information and so forth.

3.6.3.2. Texting

In terms of texting while driving it has been established that braking reaction times are slower, lane position varies more, the time drivers spend not looking at the road is higher, they miss more lane changes, and the following distances to lead vehicles varies more than that of normal baseline driving (Leung et al., 2012).

Texting while driving in turn also has a negative effect on safety-critical driving tasks such as hazard detection and the detection and appropriate response to traffic signs as the driver need to physically divert his attention away from the road in order to attend to the texting task (Breen, 2009).

Hosking et al (2009) examined the impact of text messaging on the mean frequency of in-vehicle glances as well as on the mean duration of in-vehicle glances. In this experiment, 20 young novice drivers were tested in an advanced driving simulator at the Monash University Accident Research Centre. The findings show that text messaging results in more and longer in-vehicle glances than driving in respective control conditions without text messaging. Both, retrieving and sending text messages negatively affect the driving performance (Peissner et al., 2011). The driver's eyes were focusing significantly less on the road during the activity of messaging compared to the control condition (no text messaging) (Peissner et al., 2011).

In dual-task conditions drivers responded more slowly to the onset of braking lights in front of them while they were texting. In addition researchers found that texting drivers show impairments in forward and lateral control compared with a driving-only condition. Interestingly, participants increased their following distance in the dual-task condition; this may have been a conscious or unconscious attempt to create a safety buffer with the leading car to reduce crash likelihood (Petzold, 2011).

3.6.3.3. Talking on a telephone

Using a mobile phone while driving can distract drivers visually, physically and cognitively. Research indicates that distraction while talking on a mobile phone impairs a driver's ability to maintain an appropriate speed, control over the vehicle and lane maintenance (Brace 2007). In addition when talking on a mobile phone the driver is required to steer with only one hand. Brace et al. (2007) also state that driver performance in terms of reaction time is reduced by fifty per cent when conversing on either a handheld or hands free phone.

Caird et al., (2005) considered 16 epidemiological studies and 22 performance studies of mobile phone use while driving. The meta-analysis found that no matter how small, in all of the studies there was indications that mobile phone use while driving had a deteriorating effect on driver performance. The negative impact of mobile phone usage was however larger for critical events (avoiding a collision) than for vehicular control.

When talking on a mobile phone, drivers are looking out the windshield, but do not process everything in the roadway environment. This means that drivers miss critical information on potential hazard in their surroundings and are then not able to respond to unexpected situations (Peissner et al., 2011).

Strayer et al (2007) found that even when participants looked directly at objects in the driving environment, they were less likely to create a durable memory of those objects if they were conversing on a mobile phone. This pattern was obtained for objects of both high and low relevance, suggesting that very little semantic analysis of the objects occurs outside the restricted focus of attention. Moreover, in-vehicle passenger conversations do not interfere with driving as much as mobile phone conversations do, because drivers are better able to synchronize the processing demands of driving with in-vehicle conversations than with cell-phone conversations. Together, the data support an inattention-blindness interpretation wherein the disruptive effects of mobile phone conversations on driving are due in large part to the diversion of attention from driving to the phone conversation (Strayer et al., 2007).

In a Canadian study involving both novice and experienced drivers using mobile phones it was found that both types of drivers restricted their visual scanning while using a phone. Experienced drivers however slowed down while using the phone, but novice drivers maintained the same speed whether on or off the phone. Novice drivers also wandered more in their lane when on the phone (Mayhew et al., 2013).

An interesting concept put forward by Brace et al. (2007) is the impact that size and characteristics of the mobile phone have on the level of distraction experienced. The size of the phone could for example impact on the mental workload that is required to dial small numbers, diverting concentration away from the road and directing it at the dialling task.

According to the findings from Burn et al. (2002) distracted drivers had significantly poorer speed control when using a mobile phone compared to other distractions. Driver reaction times (Breen, 2009) are 30 per cent slower when telephoning while driving than driving with BAC levels of 80mg/100ml and 50 per cent slower than under normal driving conditions. Similarly, Burns et al found that alcohol had the opposite effect than talking on a mobile phone in that drivers drove faster than normal when under the influence of alcohol.

The degree to which the telephone distracts a driver is a function of the level of distraction brought along by the phone as well as the amount of time (exposure) used. The extent to which distraction influences safe driving behaviour is also dependent on the complexity of both the conversation and the driving situation (Breen, 2009). Conversation tasks however were found to show greater costs to performance than did information-processing tasks (Horrey et al., 2004).

3.6.3.4. Talking to passengers

The effects on driving task performance whether talking to a passenger or talking on a phone seems to be similar (UMTRI Research Review, 2006). Just et al (2008) employed functional magnetic resonance imaging (fMRI) to investigate the impact of concurrent auditory language comprehension on the brain activity while the driver performed a simulated driving task. The researchers found that a secondary task such as talking to passengers (language comprehension) diverted the mental resources away from the driving task which reduced driving performance. According to the findings from the NMVCCS data analysis, talking to a passenger was the top factor listed among non-driving activities that caused a crash. This was true irrespective of driver age and gender, or driving conditions (Singh, 2010).

The DaCota review (2012) also indicates that when engaging in conversation drivers tend to reduce speed, increase following distance, display longer reaction times and have more trouble with keeping a vehicle on course.

Driver errors were higher when drivers engaged in mobile phone conversations and that reaction time is slower when talking on a phone in comparison to talking with a passenger (Drews et al., 2008).

Contrary to the findings above, Regan et al. (2007) suggests that passengers often provide support for task performance of drivers and that they interrupt the conversation when the task demands of driving increase for the driver. Drews et al. (2008) was found that a passenger is more conscious of the driving situation which leads to both driver and passenger being more situationally aware. In other words, passengers can support the driver by pointing out hazards.

3.6.3.5. Eating, drinking and grooming

Activities such as eating and drinking influence the driving task (Stutts et al., 2003; DaCota, 2012). Eating and drinking lead to greater deviations from lateral position, lower speed and more crashes and near crashes. Drivers look away from the road more frequently while eating and drinking (Stutts et al., 2003).

3.6.3.6. Listening to music

Ünal et al (2012) found that listening to music increased mental effort while driving, irrespective of the driving situation being complex or monotonous. The effects of listening to music on driving performance seems to be dependent on the on the type of music (DaCota, 2012). Brodsky et al (2013) found that in-cabin listening by novice drivers provided optimal conditions for distraction that can result in driver miscalculation, inaccuracy, driver error, traffic violations, and driver aggressiveness. However the researchers indicated that certain music (listened to by choice by novice drivers might actually increase better driving performance. During previous research, Brodsky (2001) found that high paced or high tempo music affected speed and perception of speed. When the tempo of the music increased the speed of the driver increased, regardless of whether or not he realised it. In addition the research found that higher tempo music was associated with higher levels of traffic violations. Similarly than listening to music, singing while driving have also been found to influence a driver's ability to perceive hazards negatively (Hughes et al., 2013).

3.6.3.7. In-vehicle navigation systems

In-vehicle technologies are becoming part of everyday modern vehicles. The driver needs to safely interact with these devices in order to minimise distraction for the devices to be used successfully. "In-Vehicle Telematics" refers to devices incorporating wireless communications technologies in order to provide information services, vehicle automation and other functions (Road Safety and Motor Vehicle Regulations Directorate, 2003).

Victor (2000) highlights that approximately 90-95 per cent of all driver's fixations have been calculated to be less than or equal to 8 degrees from the centre or expansion and predicted that changes visual scanning patterns and gaze fixations will occur with the introduction of IVIS. Additionally there seems to be correlations between risk-taking behaviour and average glance duration.

Zang et al. (2012) investigated the safety effects of using voice controlled navigation systems (which is considered less distracting) compared to navigation systems which require the driver to provide manual input into the system in different traffic environments. The research found that in traffic environments where a high cognitive mental workload (such as on a curve in the road) were imposed on the driver, drivers made less errors when having to manually input information into the system. An explanation put forward by the researcher was that the drivers needed to take their eyes of the road more frequently which resulted in them being more aware of the danger of this situation. Similarly in a more recent study Morris et al. (2015) found that when glancing at in-vehicle navigation systems and a green driving (eco) advisory device, driver glances were below NHTSA limit of two (2) seconds (Klauer et al., 2006). The study found that although most glances away from the road was towards the navigation device, the average time spent per glance were approximately 0.76 seconds compared to general glancing to other areas inside and outside of the vehicle which ranges between 0.2 seconds and 0.6 seconds. Despite the research results indicating that the off-road glances were "safe" considering the NHTSA guidelines, the authors caution that any glance away from the road is potentially dangerous.

3.3.6.8. Advanced Driver Assistance Systems

AVAS include collision warning, adaptive cruise control, lane departure warning, lane change aids, and parking aids. According to Transport Canada (2003) it is becoming more and more difficult to distinguish between the two IVIS and AVAS systems. Transport Canada acknowledges that although IVIS is seen as the more distracting of the two, AVAS also contributes to driver distraction.

3.6.4. Outside distractions

Stutts et al. (2001) indicated that in their analysis of 5 000 police-reported crash data from the CDS, it was found that outside distractions were a leading cause in 29.4 per cent of crashes.

3.6.4.1. Road side advertising

Roadside advertising and information billboards are intended to draw the driver's attention, which may cause diminished attention to the current traffic situation. Information signs at the roadside serve a different purpose as these signs are intended to increase road safety by providing the driver with critical information. However, in both cases the driver's diminished attention could result in more crashes in their vicinity. A number of studies, simulator studies or field experiments, have shown that roadside advertising can influence driving behaviour negatively (Beijer et al., 2004; Crundall et al., 2006; Chattington et al., 2009; Young et al., 2007). In the UK for example Young and Mahoud (2007) found that road side advertising was the contributory factor in at least 10 per cent of distracted driving crashes.

Moving billboards and billboards positioned in the central field of vision or at street level (rather than at a raised level) are considered particularly distracting (Crundall et al., 2006; Megias et al., 2011).

Roadside advertising can also impact on driving performance via inappropriate visual fixation, which normally occurs away from the forward roadway. Roberts et al.(2013) states that even if the driver is able to process the information and maintain his driving performance, the driver is still not looking in the correct direction to safely negotiate the road and other traffic especially if there are sudden changes in the traffic environment (Roberts et al., 2013).

Klauer et al. (2006), in an analysis of the 100-Car Naturalistic Driving Study, found that glances away from the forward roadway for more than two seconds doubled the near-crash and crash risk compared to baseline. In a study conducted by Decker et al. (2015) the research found that in 10-20 per cent of glances at active/digital billboards, those glances took longer than 75 seconds. Roberts et al. (2013) also stipulates that increased visual clutter (defined as driving irrelevant stimuli) in the road environment can contribute to a decreased ability to locate critical information. Young et al (2007) found that road side advertising caused drivers to swerve more and to make lane changing errors.

3.6.4.2. Environmental factors

Research has mostly focused on in-vehicle distractions although some research was done to highlight the differences in distractions of novice and experienced drivers. External sources of distraction include: driver dazzled due to the sun or another vehicles' headlights, checking for traffic and other road users, trying to find a location, scenery and looking at people or animals (Baird et al., 2011). Mayhew et al (2011) found that despite the fact that experienced drivers slowed down when talking on a mobile phone, outside distractions such as pedestrians also affected reaction and response times negatively. Gautam (2013) found that external distractions affect all drivers and not just novice drivers. Experienced drivers' ability to maintain the vehicle on the roadway as well as their ability to perceive and react to hazards in this roadway is also compromised by external distractions. This finding was true for drivers of all age groups. External distractions cause's drivers to take long glances at what is happening outside the vehicle and drivers were found not to adequately scan their environment.

Stimpson et al (2013) reviewed the information related to distract driving crashes involving non-motorised transport (NMT) users in the Fatality Analysis Reporting System (FARS) database from 2005 to 2010. The research found that the rate of fatalities per 10 billion vehicle miles travelled increased from 116.1 in 2005 to 168.6 in 2010 for pedestrians and from 18.7 in 2005 to 24.6 in 2010 for bicyclists. Pedestrian victims of distracted driving crashes were male, between the age of 25–64 years of age, and non-Hispanic white. Pedestrians were mostly killed at night time and struck by a distracted driver outside of a marked crosswalk, in a metropolitan location. Fatal cycling crashes due to distracted drivers were also male, non-Hispanic white, and struck by a distracted driver outside of a crosswalk. In contrast to pedestrians, cyclists were less likely to be involved in a crash during night time (Stimpson et al., 2013).

3.6.5. Behavioural adaptation to driving distractions

Peng et al (2015) investigated the adaptation of drivers to distractions such as in-vehicle devices. The researchers' highlight that previous studies (Strayer et al., 2011) show that over time, drivers can improve lane keeping and speed control while talking on a mobile phone or improve reaction times to hazardous event. Key findings from the Peng et al. study were that high risk drivers (e.g. novice drivers) stay high risk drivers and do not adapt safely to IVIS. It was found that high risk drivers had their eyes of the road for much longer during the entry of text into the system than low risk drivers. In addition it was found that off road glances occurred more while drivers were entering information into the IVIS than when reading from the IVIS and that glance behaviour changed over time and for different traffic conditions. Despite drivers feeling that entering and reading information from the IVIS the perceived risk did not prevent them from doing so. Similarly, Musicant et al (2015) conducted an Israeli study among drivers that owned smartphones in order to understand patterns of smartphone usage while driving and its motivation along with understanding what drivers perceive the risk to be and whether they would try an application that will block the use of a mobile phone while driving. In line with the findings from Peng et al. (2015) Israeli drivers perceive texting and driving as dangerous but continue to do so while driving because they feel the need to. However, half of the respondents are willing to consider trying an application that would block usage while driving.

3.7. The impact of distraction on driving performance

3.7.1. Overview

Distraction affects essential aspects of road users' performance (Stelling et al., 2012). Research has shown that distraction causes variations in lane position which indicate a reduced vehicle control. Reaction times to changes in the road and traffic environment increase and more errors are committed. Distraction also leads to slower driving speeds and larger following distances. Stelling et al (2012) highlights that distracted drivers fail to see visual information and cues when they take their eyes of the road or their minds of the road.

In the Netherlands Vlakveld et al (2006) investigated absentmindedness when driving and found that these drivers tend to look straight ahead for longer time periods; do not consider their immediate (peripheral) environment often enough; looks at the dashboard and in the mirrors less frequently and the drivers' reaction times increase along with displays of late and abrupt braking (Vlakveld et al., 2006).

Stelling et al (2012) highlights that although many studies have been conducted, the findings from different studies are often not unambiguous. According to the authors this is especially true for research related to the effect of distraction on the crash rate. Most studies agree that distraction causes a higher risk of a crash but there seems to be little agreement about the exact size of the effect.

3.7.2. Type of crashes associated with distracted driving

Eby et al (2003) compared the different available crash databases in the USA and found five types of crashes associated with distracted driving.

- *Single-vehicle-run-off-the-road crashes* represented 23 per cent of the US national (all) databases. The research found that the pre-crash manoeuvring involved "losing control", "negotiating a curve", departing road edge" for freeways and "going straight and departing the road edge" or "negating a curve and departing a road edge" for urban roads.
- *Rear-end crashes* represented the largest proportion of distracted driving crashes (30 per cent of all crashes in all databases). Crashes included rear-end crash where lead vehicle was moving (LVM), and crashing into the back of a stationary vehicle.
- *Intersection/crossing-path crashes* where distraction played a role were represented in 18 per cent of all crashes.
- *Lane-change/merge crashes* represented 9 per cent of the national crashes with approximately 5.4 per cent of these crashes associated with distraction.
- *Head-on* crashes represented 3 per cent of the national crashes with approximately 7 per cent of these associated with distraction.

At the time of the research however the authors indicated that too little is known from the data to make conclusions regarding the role of distraction in intersection, lane changing/merging and head-on crashes (Eby et al., 2003).

3.7.2.1. Single-vehicle-run-off-the-road crashes

A run-off-road (ROR) crash occurs when a moving vehicle leaves the road and crashes with a stationary object or overturns (Liu et al., 2011). Fatigue contributes to inattention and plays a role in “driving without awareness”, “inattention in driving”, “looked-but-failed-to-see” type crashes (Morrow et al., 2004). Vigilance, reduced alert or awareness, drowsiness and fatigue are all concepts considered to contribute to causation of ROR crashes (Sagberg et al, 2004).

Crash data from the FARS in the USA (Liu et al., 2009) and the NMVCCS collected at crash scenes between 1991 and 2007 were analysed with the intent to identify contributory factors to ROR crashes (Liu et al., 2011). The research found that in more than 95 per cent of instances, driver-related factors caused the crashes. Distraction and inattention played a role in almost 20 per cent of the recorded ROR crashes. Internal distraction (the driver failed to correctly recognize the pre-crash situation), accounted for 15 per cent of crashes and external distractions for 2.7 per cent of crashes.

3.7.2.2. Rear-end crashes and driver distraction

Neyens et al (2007) found that novice drivers distracted by passengers at an intersection were more likely to be involved in rear-end crash while in-vehicle distractions resulted in a greater likelihood crashing into a fixed object.

Lee et al. (2007) used the 100-Car study pre-crash data to overcome limitations of police reports and to identify possible countermeasures for preventing rear-ends crashes. The goal of the research was to understand the type of driver behaviour that contributes to rear-end events, the vehicle kinematics that influence the event, and the potential of enhanced rear-signalling systems to alert following drivers or provide additional cues regarding lead vehicle dynamics (Lee et al., 2007).

Rear-end crashes, near-crashes, and incidents were investigated (7024 events) and in 80 per cent of these conflicts with a lead vehicle were recorded. Of the 7024 observed rear-end events:

- 45 % involved a decelerating lead vehicle,
- 38 % involved a stopped lead vehicle
- 2 % involved a slower moving lead vehicle
- 15 % under various other situations.

The crashes were characterised with scenarios where the lead vehicle was stopped, while near-crashes and incidents were evenly distributed across instances of both stopped and decelerating lead vehicles.

Behavioural parameters for investigating near-rear-end crashes included visual behaviour and brake reaction times (Lee et al., 2007).

3.7.2.3. Intersection/crossing-path crashes

Crashes occur at intersections because these are the locations where two or more roads cross each other and activities such as turning left, crossing over, and turning right have the potential for conflicts resulting in crashes (Choi, 2010). In an analysis of the NMVCSS crashes, intersection-related crashes was categorised as crashes that have pre-crash events coded as turning left, crossing over, or turning right at an intersection. According to the analyses 36 per cent of NMVCSS crashes were intersection-related crashes. Of these 96 per cent were attributed to drivers, while the vehicle- or environment was a contributory factor in less than three (3) per cent of these crashes. For intersection crashes inadequate surveillance (44.1 per cent), false assumption of other's action (8.4 per cent), turned with obstructed view (7.8 per cent), illegal manoeuvre (6.8 per cent), internal distraction (5.7 per cent), and misjudgement of gap or other's speed (5.5 per cent) were the most prominent contributory factors. Internal distraction was mostly cited for intersection crashes involving young female drivers under the age of 24 years (Choi, 2010).

3.7.3. Performance indicators associated with distracted driving

Aust (2013) identified crash relevant elements (CREs) and surrogates within NDS and FoT studies. Four approaches were highlighted namely:

- Driver response identification
- Function response identification
- Driving context based identification
- Driving history based identification

Driver response identification builds on the assumption that drivers will not subject themselves to drastic manoeuvres unless necessary. Therefore sudden and rapid changes in velocity and changes in direction are considered out of the ordinary. This could include hard accelerations /decelerations and/or rapid steering. These behaviours could indicate an urgent and unplanned response to something within the driving environment. **Function response identification** refers assessing the impact of one or more active safety functions, and then a very natural approach to CRE identification is to use the function itself to detect CREs.

Driving context based identification refers to the identification of situations (driving contexts) where the risk of a crash is so high due to the environment, that any small mistake or error might result in a crash. **Driving history based identification** entails an investigation into unusual driving events within the driving history of either an individual or a group. The underlying assumption is that unusual events in a driving history are there because drivers in fact try to avoid such events. These incidents therefore represent situations could potentially unsafe situations. The frequency with which drivers commit traffic offences such as "running a red light" or not stopping at a stop street or intersection could potentially indicate driver distraction (Kass et al., 2007).

3.7.3.1. Driver indicators

a) Visual or gaze behaviour

Weller et al (2010) indicated that gaze parameters change with distraction and are related to driving performance and according to the authors influenced by road geometry.

Rear-end crashes are considered a result of distraction, specifically improper allocation of visual attention. According to the research normal safe driving means a driver is able to respond to a decelerating lead vehicle by braking within approximately two (2) seconds. Lee et al (2007) found that in 70 per cent of near rear-end crashes the drivers were looking forward when the lead vehicle started braking where visual attention were diverted away from the roadway, it was found that the following driver had longer brake reaction times (average of 600 milliseconds longer) compared to drivers who were looking forward (for incidents). Glances longer than two (2) seconds away from the roadway also played a role 64 per cent of the rear-end crashes.

b) Following distance

Rosenbloom (2006) found that the following distance between the leading and following vehicle decreased when drivers in the following vehicle used mobile phones while driving. Rosenbloom stipulates that the drivers were not significantly aware of this occurrence while engaged in secondary tasks when driving (Rosenbloom, 2006).

Australian research has identified, rear-end crashes at especially intersections as a concern (Beck, 2015). Intersections were highlighted because the speed of vehicles in intersections varies and there is more interaction between slow moving and faster moving traffic. The research considered the road environment, vehicle and driver characteristics were considered as potential crash contributory factors. Distracted, young male drivers were identified as at greater risk of being the striking driver in a rear-end crash. One of the key findings attributed to human behaviour was that the drivers did not maintain a following distance of 2 to 3 seconds which resulted in in rear-end crashes (Beck, 2015).

c) Reaction time

Parameters of baseline braking events were identified to as events that lasted at least three (3) seconds. A deceleration threshold of 0.4 G and above was indicated as a viable triggering criterion for the onset of braking behaviour to avoid a crash (Lee et al., 2007).

Anderson et al (2012) investigated the influence of audio and visual distractions on driver reaction times. The authors state that in situations where for example a braking response is required, the reaction time of the driver is not simply a one step process, but rather a sequence of complex reactions. The braking response involves mental processing time, movement time, and device response time. Mental processing time consists of four subsequent components: sensation, perception/recognition, situational awareness, and response selection. Movement time is dependent on the physical action where the muscles is used to perform the action and device response time refers to the time it takes the mechanical device to engage and perform the desired action, such as the time lapse from the time the brakes are applied to when the vehicle comes to a stop. According to the research increases in reaction time were found especially when participants were texting while driving followed by followed by conversation and then listening to music (Anderson et al, 2012).

d) Speed

Burns et al (2002) found that distracted drivers slowed down when talking on either hand-held or hands-free phones, even when they were specifically instructed to maintain a set speed.

Tasmania Government in Australia compiled a table (Table 7) that illustrates the travel distance from the moment a driver takes his eyes of the road to the time it takes to bring a vehicle to a stop. It also illustrates that the additional distraction more than double the risk of a crash according to the speed that the vehicle was travelling (Gavlik, 2013).

Table 7: Break down of stopping distance, allowing for distraction and reaction time (Galvik, 2013)

Travel Speed	Distraction time	Distance travelled (meters)	Reaction time	Distance travelled (meters)	Braking distance (meters)	Total distance
40 km/h	2 seconds	22.22	2 seconds	22.22	7.86	52.3
50 km/h	2 seconds	27.78	2 seconds	27.78	12.29	67.85
60 km/h	2 seconds	33.33	2 seconds	33.33	17.70	84.36
80 km/h	2 seconds	44.44	2 seconds	44.44	31.46	120.34
100 km/h	2 seconds	55.56	2 seconds	55.56	49.17	160.29

The report further emphasises that when the driver takes his eyes of the road for two (2) seconds, it could take approximately four (4) seconds before the driver can react to a critical event (Gavlik, 2013).

Haque and Washington (2013) investigated stopping and speed of drivers on approach to a pedestrian crossing. The research indicates that distracted drivers, reduce their speed earlier compared to non-distracted drivers which according to the authors may suggest that distracted drivers know they are taking a risk and compensate for the risk by driving slower.

e) Lane change behaviour

In a simulated highway driving experiment Cooper et al (2008) found that when drivers are talking on a mobile phone, they change lanes less and travel at overall lower speeds that increased travel time significantly (Cooper et al., 2008).

f) Hazard perception and situational awareness

Perception-response time (PRT) corresponds to the time required by the driver to detect, orient, recognize, decide, move, and take appropriate action (Caird et al., 2005). Parkes et al (2000) investigated choice reaction time, braking profile, lateral position, speed, and situation awareness in a simulated environment when drivers were talking on mobile phones (hand-held and hands-free). The study found that although the drivers were able to maintain the vehicle in a lateral position as well as the speed, significant differences were found in reaction time and situation awareness especially at the beginning of the telephone conversations.

Burns et al (2002) found that distracted drivers missed much more potential traffic hazards when they were using a phone compared to those intoxicated by alcohol. The phone distracted drivers also responded more to wrong hazards or warnings compared to drunk drivers.

3.7.3.2. Vehicle indicators

Burns et al (2002) found that on average a driver engaging in a conversation over a mobile phone while driving, drove slower even when they were specifically instructed to maintain a set speed. The research showed that drivers had significantly poorer speed control and reaction times when using a hand-held phone than during the other driving conditions.

Simulators measure cognitive skills important for driving that include tracking ability, vigilance, divided attention and reaction time (RT) (Leung et al., 2012). Indicators to measure driving deviations include (Leung et al., 2012; Burns et al., 2002):

- Velocity deviation: Deviation from the defined safe speed zone of 60 to 80 km/h. Higher scores represent larger deviation from the prescribed speed and decreased vigilance.
- Lateral lane position deviation: Deviation from the median lane position during the drive (averaged every 40 milliseconds). Higher scores indicate larger deviations from the mean lane position and decreased vigilance.
- Number of crashes: Crashes were registered where off-road events, collisions with a truck, or when remaining stationary for more than ten (10) seconds occurred.

Table 8 below provides a summary of the different vehicle parameters used as possible identifiers of distracted driving behaviour.

Table 8: Dependent variables used as event triggers.

Trigger type	Depended variables used as triggers.
Lateral acceleration	Lateral motion equal to or greater than 0.7 *g*. (Klauer et al., 2006)
Longitudinal acceleration	Acceleration or deceleration equal to or greater than 0.6 *g*. Acceleration or deceleration equal to or greater than 0.5 *g* coupled with a forward time to collision (TTC) of 4 seconds or less. All longitudinal decelerations between 0.4 *g* and 0.5 *g* coupled with a forward TTC value of ≤ 4 seconds and that the corresponding forward range value at the minimum TTC is not greater than 100 ft (30.48 m) (Klauer et al., 2006).
Forward time to-collision	Acceleration or deceleration equal to or greater than 0.5 *g* coupled with a forward TTC of 4 seconds or less. All longitudinal decelerations between 0.4 *g* and 0.5 *g* coupled with a forward TTC value of ≤ 4 seconds and that the corresponding forward range value at the minimum TTC is not greater than 100 ft (30.48 m).
Rear time-to-collision	Any rear TTC trigger value of 2 seconds or less that also has a corresponding rear range distance of ≤ 50 feet and any rear TTC trigger value in which the absolute acceleration of the following vehicle is greater than 0.3 *g.*
Yaw rate	Any value greater than or equal to a plus and minus 4 degree change in heading (i.e., vehicle must return to the same general direction of

	travel) within a 3 second window of time.
Glances away from road	Glances totalling more than 2 seconds for any purpose increase near-crash/crash risk by at least two times that of normal, baseline driving (Klauer et al., 2006).
Vehicle stopping or moving	Variable most closely associated with distracting driving - is whether the vehicle was stopped or moving at the time (Stutts et al., 2005).
Vehicle speed	Deviation from the defined safe speed zone of 60 to 80 km/h. Time spent speeding (over or under respectively 60 km/h 80 km/h) (Burns et al., 2002; Leung et al., 2012).
Lateral lane position deviation	Deviation from the median lane position during the drive on averaged every 40 milliseconds (Burns et al., 2002; Leung et al., 2012).
Mean reaction time for braking episodes	2 second response to a decelerating lead vehicle by braking within approximately Lee et al (2007) A deceleration threshold of 0.4 g and above was indicated as a viable triggering criterion for the onset of braking behaviour to avoid a crash (Lee et al., 2007).

Goodwin et al (2014) however caution against the use of only vehicle and kinematic data in NDS studies. The authors state that although there is a correlation between g-force events and serious incidents due to distracted driving, information regarding the context in which these events took place are essential. In other words, visual evidence is needed to substantiate the g-force data.

3.7.3.2. Environmental indicators

a) Traffic flow and congestion

The complexity and density of the traffic environment influences the level of distraction that drivers can experience. The more complex the driving situation, the less cognition is available for engaging in secondary tasks, which contributes to making the situation safer (Brace et al., 2007). Distraction happens when the collective demands from different tasks exceeds the driver's capacity. According to Lee et al. (2003) drivers can manage this demand to some degree by driving slower or maintaining greater headway.

Driver inefficiency contributes to congestion in urban areas. In a study conducted by Cooper et al. (2009) distracted novice drivers were found to be less likely to change lanes and more likely to drive at slower speeds, independent of traffic flow while engaging in a distracting activity such as talking on a mobile phone. When changing lanes the distracted drivers left less space between their own and surrounding vehicles and spent more time tailgating other vehicles compared to non-distracted drivers. The authors concluded that distracted driving has a negative impact on traffic flow (Cooper et al., 2009). The research indicated that driver distraction and traffic congestion significantly affect lane change frequency, mean speed, and the likelihood of remaining behind a slower-moving lead vehicle all of which contributes to traffic congestion (Cooper et al., 2009).

Stavrinos et al (2011) states that the impact of driver distraction is not only limited to safety but should be considered from a wider transportation perspective. The research identified greater driver inefficiencies when distracted including navigating at slower speeds, leaving larger intervals between their own vehicle and the vehicle in front of them, and reduced reaction times. It was found that text messaging had the largest impact on traffic flow as speed fluctuated more when texting, suggesting that the texting driver were attempting to keep up with the traffic in front of them which resulted in the distracted drivers possibly obstructing the traffic flow (Stavrinos et al., 2011).

Xiao et al (2015) through a simulated study investigated the impact that phone use while driving has on traffic flow with reference to both traffic efficiency and safety. The results showed that traffic flow rate was significantly reduced where drivers made use of a phone, compared to traffic flow where no drivers used a phone. Flow rate and velocity decreased as the proportion of drivers using a phone increased. The study showed that when there are distracted drivers the traffic flow rate decreased by as much as five (5) per cent. In low density traffic situations, traffic risk first decreased and then started to increase as more and more drivers were distracted by their phones. Figure 5 below illustrates the level of risk associated with using a phone while driving in different traffic densities.

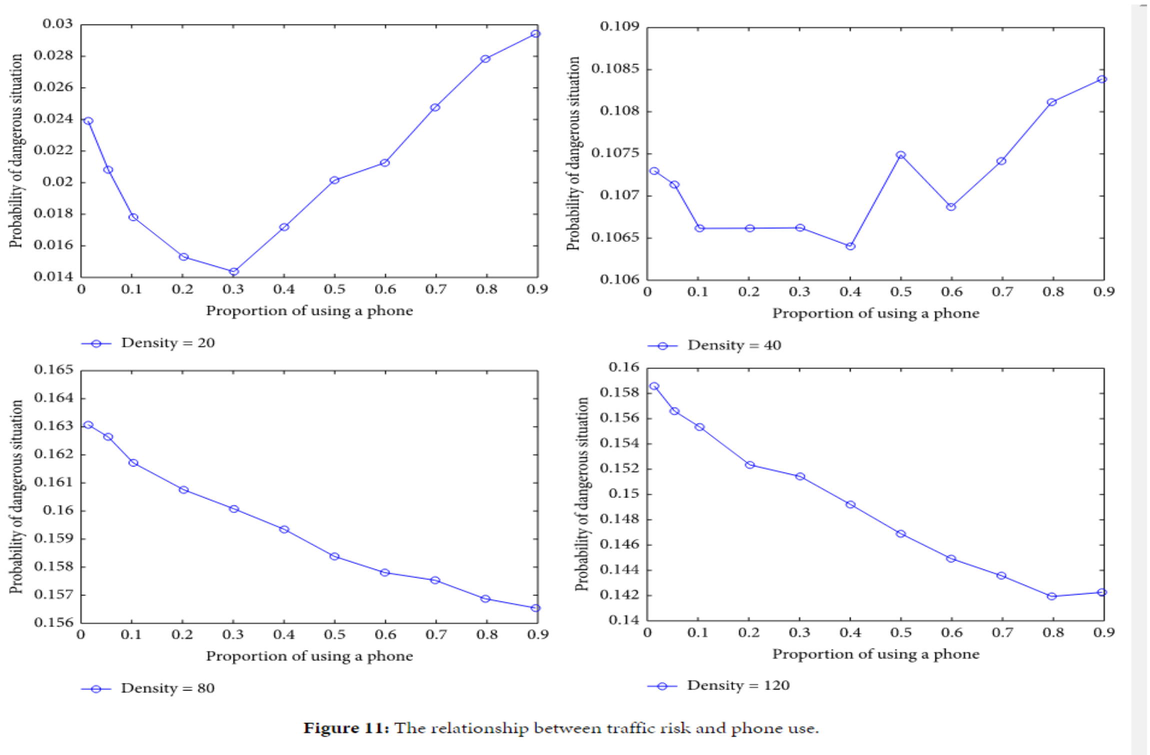

Figure 5: Risk associated with the proportion of drivers using mobile phones while driving according to traffic density (Xiao et al., 2015)

b) Road geometry

Weller et al (2010) and Dong et al (2011) investigated gaze behaviour in the context of the physical driving environment and found that gaze information is related to the vehicle state (steering, lane position, speed, and state of IVIS) as well as the road scenario (e.g., the type of road, weather conditions, and traffic density). The researchers highlighted the findings from Klauer et al (2006) which stipulated that engaging in complex driving tasks along with distracted driving increased crash risk by three times. This was particularly true for drivers that engaged in complex secondary driving tasks at dusk or night time, when it is raining, on divided/ straight roads or curved roads. The researchers concluded that the context of the road is important to identify the level of risk that distracted driving could pose on that road because different road environments requires different levels of situational awareness and attention.

Table 9 below provides an overview and summary of the different distractions and the different influences on driver performance.

Table 9: Summary of the effect that distraction has on various driving performance indicators (adapted from DaCota, 2012)							
<u>Performance indicator</u> Decrease ↓ Increase ↑ no effect X	**Talking on phone**	**Talking to passenger**	**Listening to music**	**Texting**	**Navigation system use**	**Navigation instructions follow**	**Reacting to warnings**
Speed	↓	↓	X ↑	↓	↓	↑	↓
Deviation from lane position	↑	X	X ↑	↑	↑	↓	
Following distance	↑		X	↑			
Conflicts	↑			↑			↓
Errors	↑	X	↑				
Reaction times	↑	↑	↓ X ↑				↓
Visual behaviour							
Glancing at relevant traffic information	↓						↑
Missed objects	↑						
Looking away from road	↑	X		↑	↑	↓	
Looking inside/device/advertisements				↑			
Attentiveness	↑	↑	↓ ↑				
Risk perception				↑		↓	↑

3.8. Countermeasures

3.8.1. Overview

Burton (2011) states that the research related to inattentive and distracted driving are used in a number of countries to address the risk factors associated with distracted driving. These measures that potentially could assist with reducing distracted driving crashes include technological solutions (e.g. applications that detect when the phone is in a moving car and direct in-coming calls to a voice messaging service) and company policies that regulate employees' use of mobile phones while driving. In addition, the most popular traditional means of reducing distracted driving crashes remain education as well as legislation and enforcement. Knowledge about distraction is important for determining the extent of the problem and the mechanisms underlying distraction. This knowledge can assist in the development of countermeasures but it is possible that the different sources of distraction do not require the same types of measures (Stelling et al., 2012).

3.8.2. Legislation and enforcement

Research indicates that evidence of the threat that mobile phone use while driving holds to road safety is great enough to ban mobile phone use all together (Young et al., 2007). A wide range of laws are being adopted and implemented in a number of countries. These laws and regulations have specific target audiences, focus for example on particular high-risk groups, such as young drivers, while others have applied an all-out ban on the use of all mobile phones (Burton, 2011). In the USA, bans are place for talking on a mobile phone as well as texting as well (NHTSA, 2014).

Some countries have also adopted strict legislation on the placement of billboards and advertising campaigns too close to the road (DaCota, 2012).

3.8.3. Education and awareness

Being aware of the consequences of driver distraction may influence drivers' decisions or their willingness to engage in distracting activities while on the road (Horrey et al., 2008). Horrey et al. (2008) state that drivers might not realise the danger of driving distracted, or may feel over confident in their skills that they can do so safely. The researchers indicate that by understanding perceptions of distracted driving it becomes possible to tailor-make public education and awareness campaigns.

Regan et al (2007) state that licensing processes need to incorporate training that highlights the dangers of distracted driving. According to the researchers, the handbooks for learner licensing, for example, should include a section that deals with distracted driving. In other countries where graduated licensing schemes are in place, it is possible to place restrictions on new drivers that prohibit new drivers from using mobile phones.

Public education and awareness campaigns need to be strengthened not only around the use of mobile phones but other distracting behaviour as well. Prevention strategies need to be coupled with corporate policies as well as high visibility enforcement and serious consequences for transgressors (National Safety Council, 2012).

Baird et al. (2011) investigated the effect that distracted driving education and awareness campaigns have on community attitudes toward the behaviour. Their research found that awareness campaigns at least in South Australia are successful as the participants indicated that these campaigns have through the years, raised awareness and made the general driving population more are of the risks associated with such behaviour.

3.8.4. Employee road safety programmes and policies

Road traffic crashes are a leading cause of occupation injuries (Burton, 2011). Employers can address distracted driving practices within fleets by implementing strict company policies that prohibit the use mobile phones while driving.

3.8.5. Technology interventions

Technology in vehicles could be changed or adapted to assist with the warning in events such as drifting across lanes, following to close and so forth (DaCota, 2012). Although some manufacturers are incorporating these in-vehicle systems, it is the exception rather than the norm. Transport Canada (Standards Research and Development Branch Road Safety and Motor Vehicle Regulations Directorate, 2003) has gone the route of forming MOUs with vehicle manufacturers where the manufacturers agree to follow leading human factor standards for the design of in-vehicle systems and the implementation of design processes for telematics device integration.

3.9. Conclusion

Driver distraction and the role that it plays in crash causation is clearly a source of international concern. Although definitions for the different types of distractions exist, it seems that defining inattention has been more difficult.

Many different methodologies have been used to investigate driver distraction with crash database analysis and simulator studies being the most popular traditional methods. However these methodologies are dependent on data and it has been found that data related to driver distraction and especially inattention is not readily available. More recent methodologies used include ND and FoT studies. The literature describes the different types of driving distractions and provides an overview of how these impacts on the risk, safety and performance of the driver. These are described in terms of driver groups (novice and experience) according to demographics (gender and age) as well as cultural aspects.

In-vehicle distractions are mostly associated mobile phone use, dining, grooming, AVAS and IVIS as well as passenger related distractions. Outside distractions refer to the impact that road side advertising, bill boards and even other road users could potentially have on diverting a driver’s attention away from his or her primary driving tasks.

The literature also indicate that there are specific risks associated with specific distracting activities which could potentially not only have an impact on the safety and crash risk of the driver but also other consequences for traffic flow and congestion.

CHAPTER 4: METHODOLOGY

4.1. Overview

The investigation aims to answer two overarching questions:

- What types of inattentive and distracted driving behaviours can be observed and quantified in the NDS dataset?
- What is the significance of prevalent inattentive and distracted driving behaviour?

4.2. NDS methodology

4.2.1. Description

NDS refer to the discreet observation of driving behaviour where the driver is observed in a natural driving setting or environment. It is a novel approach to the way that road safety research can be conducted in South Africa as the methodology enables researchers to study driver behaviour in the context of the driving task and road environment as well as inform driver actions preceding crashes or near crash events. The underlying assumption of this approach is that driver behaviour will not be significantly altered by being observed over the long term and that such studies therefore reflect natural driver behaviour over time.

The vehicle is fitted with a Data Acquisition System (DAS) consisting of with cameras (in this instance three cameras; one facing the driver and two facing the outside of the vehicle) and a data logger (Figure 6). Video material is thus collected along with vehicle information such as GPS coordinates, speed acceleration and deceleration information. The vehicle information is stored on an on-board computer (data logger).

Figure 6: Data Acquisition System

The data was collected weekly or bi-weekly and analysed with both quantitative and qualitative methods.

4.2.2. CSIR's involvement with NDS

The CSIR TSO research group started experimenting with in-vehicle technologies and specifically the NDS methodology in 2008 (Pallet et al., 2010). In 2010 a small pilot project was launched in collaboration with the University of Stellenbosch to investigate the feasibility of using the methodology in a South African context (Venter, 2010). The results were favourable and the methodology was expanded and used on a larger scale to investigate differences in hazard perception and particularly scanning behaviour differences between novice and experienced drivers (Venter and Sinclair, 2014).

As indicated earlier, this methodology collects hundreds of hours of driving behaviour which can be used to understand driving behaviour in the context of the South African road environment as well as the vehicle.

4.2.3. Experimental design of previous ND research

4.2.3.1. Participants

In the 2011 experiment, the driver was male, in his mid-20s, and a professional driver with a professional driver permit (PrDP). At the time of the experiment the driver had been employed by and driving for the company for eight years. Duties of the driver include the delivery and transfer of court and legal documents to clients, attorneys and court houses within the Gauteng province of South Africa - the main hub of economic activity (Venter, 2012).

The second experiment consisted of four primary drivers. Two parent/child combinations participated (mother and son; father and daughter). The Novice Driver (NoD) 2 was a twenty-year old male whom at the beginning of the experiment had a driving licence for approximately six months. NoD1 stayed in an urban setting. His mother, Experienced Driver (ED1), was a 41 year old female who has been driving for more than twenty years.

The second set of participants consisted of a father and daughter. NoD1 was a nineteen year old female who at the time of the interview had been licensed for four months. NoD1 lived in a rural setting/farm. Experienced Driver (ED2) was 53 year old male and has previously been in one crash. He was the driver at the time and sustained minor injuries when another vehicle ignored a traffic signal and collided with him as he was turning on the green signal. ED2 has more than 30 years of driving experience (Venter and Sinclair, 2014).

4.2.3.2. Description of data collection

NDS data has been collected on two previous occasions for South African drivers. The first data collected took place during the years 2011 and 2013. In 2011 ND data was collected for a pilot project from a company driver. Test drives were conducted on three occasions. The first test drives took place in January 2011. Three driving experiments (of which only two was used) were completed by the same company driver. Imagery and data collected from the sensors were downloaded and stored for future analysis (Venter, 2012).

In the second study, four primary drivers participated in an experiment to investigate the differences between novice and experience drivers in South Africa. This experiment collected data over a six month period.

4.2.3.4. Previous analysis and selection of scenarios

In the first experiment the driver was asked to drive specific routes while being observed for distracted driving behaviour (Venter, 2012). In the second study selected scenarios from the primary drivers were chosen based on the type of driving environments (containing intersections with stop, traffic signal and mini-circle controls) in order to investigate the differences in scanning behaviour among novice and experienced drivers.

4.3. Current methodology

4.3.1. Research design

Figure 7 below provides an overview of the methodology followed.

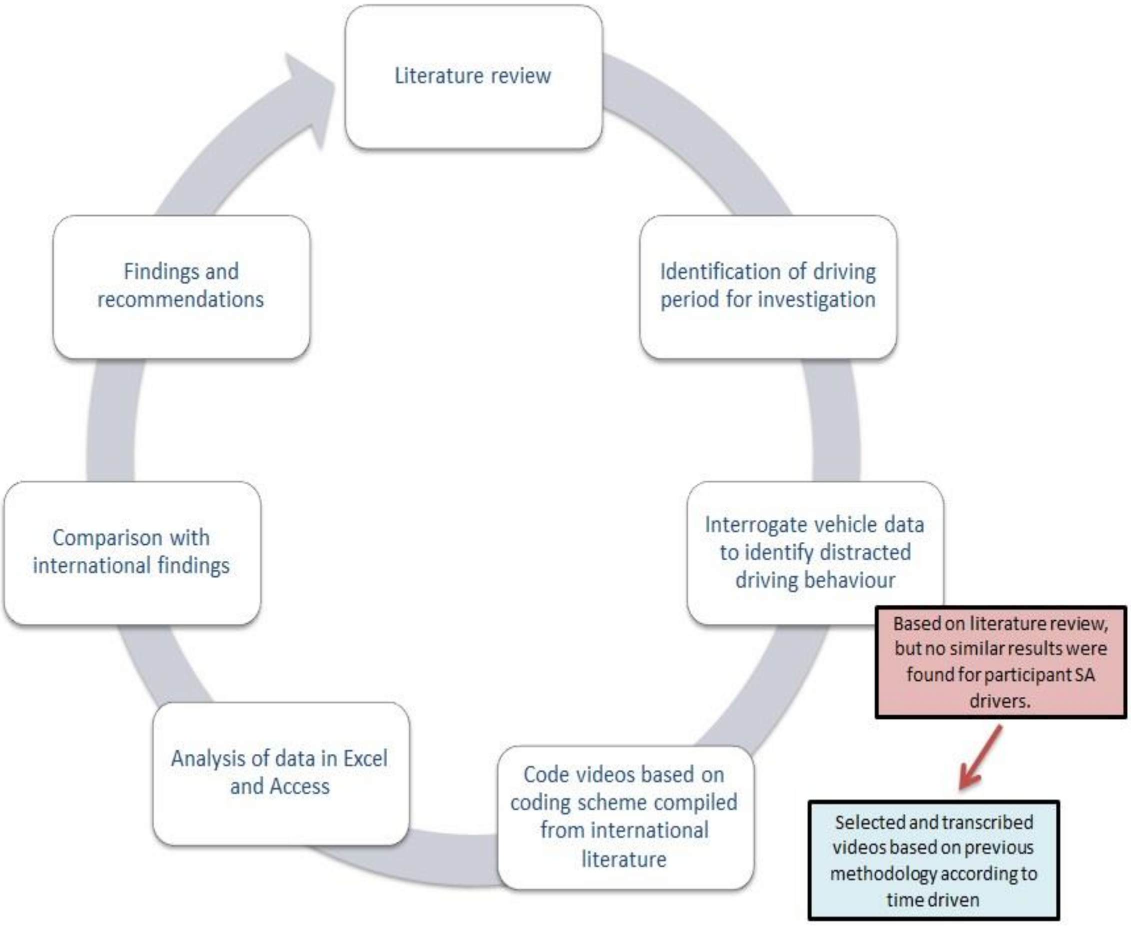

Figure 7: Methodology followed

4.3.2. Data interrogation

4.3.2.1. Parameters

This study intended to select data based on pre-identified vehicle parameters, which have been found to be associated with distracted driving internationally. The literature review provides an overview of the impact of driver distraction on driving performance. One of the key issues associated with performance is lateral deviation, speed of the vehicle and glance behaviour. Based on the literature review the following parameters were selected to interrogate the vehicle data (Table 10).

Table 10: Dependent variables for event triggers possibly indicating distracted driving

Trigger type	Depended variables used as triggers.
Lateral acceleration	• Lateral motion equal to or greater than 0.7 *g*. (Klauer et al., 2006)
Longitudinal acceleration	• Acceleration or deceleration equal to or greater than 0.5 *g* / 0.6 *g* (Klauer et al., 2006)
Glances away from road	• Glances totalling more than 2 seconds for any purpose increase near-crash/crash risk by at least two times that of normal, baseline driving (Klauer et al., 2006)
Vehicle stopping or moving	• Whether the vehicle was stopped or moving at the time (Stutts et al., 2005)
Vehicle speed	• Deviation from the defined safe speed zone of 60 to 80 km/h. • Time spent speeding (over or under 60km/h 80 km/h) (Leung et al., 2012; Burns et al., 2002)
Mean reaction time for braking episodes	• 2 s response to a decelerating lead vehicle by braking within approximately Lee et al (2007) • A deceleration threshold of 0.4 g and above was indicated as a viable triggering criterion for the onset of braking behaviour to avoid a crash (Lee et al., 2007).

No actual crashes have been observed in the data sets. The initial study approach entailed the finding of situations in the data set by isolating events where a g-force of equal or greater than 0.5 g - 0.6 g was observed (Perez et al., 2013) This initial analysis yielded little results and the search strategy was expanded to include driving scenarios where the driver drove slower than 60 km/h or more than 120 km/h.

4.3.2.2. Data search and selection strategy

The initial strategy proved to be inefficient as the parameters in the existing data was not similar to that of the parameters highlighted in the literature. This necessitated a revision of the search strategy. The parameters were applied to the vehicle data but again did not yield results that were comparable with the parameters from the literature.

It was decided to select specific videos that were then coded from beginning to end. Table 11 below provide an overview of the data selected. Due to time restrictions videos were selected from the second week because by the second week of driving the drivers are typically used to the equipment in the vehicle and no feedback regarding road safety issues (e.g., seatbelt usage) had been given to the drivers. The exception was experienced driver 2 who was hospitalised during the second week of data collection and Week 3 was therefore used to compile the data.

For the novice drivers (who drove much less than the experienced drivers), videos from the second week were transcribed in which the novice drivers drove for more than 10 minutes. For experienced drivers videos from the second week were selected where they drove for longer than 15 minutes. Only daylight videos were coded because the clarity of the imagery collected under poor light conditions was poor. In future this will need to be addressed.

The videos were transcribed using the BX4000 system into .avi files at eight frames per second. In addition the log files containing vehicle information from each corresponding video were transcribed into Microsoft Excel files for quantitative analysis.

Table 11: Data selection and analysis

	Driver 1 (NoD 1)	Driver 2 (NoD 2)	Driver 3 (ED 1)	Driver 4 (ED 2)	Total
Number of videos selected	9	6	7	6	28
Summary of driving time analysed (minutes)	173.26	69.56	107.92	95.06	444.8
Hours analysed	2.9	1.2	1.8	1.6	7.4

4.3.3. Coding scheme

4.3.3.1. Preparation of a coding scheme

Coding refers to the practice of assigning codes to segments of texts or imagery. Hanowsi (2011) states that it in order for researchers to code the naturalistic driving data, valid taxonomies are needed to define the sources of distraction, code the data collected and accurately quantify impact on driving performance and safety of different sources of distraction.

This study made use of a predefined coding scheme (based on the international literature review) along with in-vivo coding. The coding scheme used was adapted from Hanowski [1] (Foss et al., 2014) and Stutts et al (2005).

Some activities are, however, classified as distracted driving activities but are also essential in completing the driving task safely (e.g. mirror checking). In these instances it might be needed to classify the task according to frequency and duration (Foss et al., 2014).

Stutts et al. (2005) incorporated a variety of contextual variables to described additional conditions under which drivers engage in various distracting activities. These included:

- Whether driving with one hand, two hands, or neither hand was on the steering wheel;
- Whether the driver's eyes were directed outside the vehicle or inside the vehicle;

[1] Annexure A: Hanowski (2011) coding scheme

- Whether the vehicle was swerving or wandering within the travel lane, crossing into another travel lane, or stopping from sudden braking (Stutts et al., 2005).

Based on the literature review, the following coding scheme was adapted and applied in the analysis (Table 12). The main themes used in the present analysis included inside distractions, external distractions along with classification of the type of distracted driving that was used to indicate whether or not distractions or inattention were prevalent in the scenarios.

4.3.3.2. Application of the coding scheme

For the purpose of this project qualitative analysis software was used to code and analyse the data. The coding was conducted for each of the selected videos from beginning to end in an attempt to provide a description of the context in which the behaviour occurs.

Table 12: Coding scheme developed (based on literature review)			
	Groups	**Codes**	**Description**
In-vehicle distractions	Normal driving	Normal	Coded in terms of the driver looking ahead, with both hands on the steering wheel. Included actions where: the driver/s were stationary (e.g. at a toll plaza, take-away drive through or waiting for someone somewhere); waiting in traffic/waiting to turn and reversing the vehicle. It also included the "looking-up" behaviour after attention has been diverted elsewhere.
		Stationary	
		Waiting in traffic	
		Looking up after activity	
		Reverse	
	Grooming	Adjust clothing	Grooming refers to behaviour such as fidgeting with hair, sunglasses etc. Grooming might distract the driver or be a potential indicator of inattention.
		Adjust sunglasses	
		Fidget with hair	
		Put cream on	
	Person/object	Put something away	Person or object related refers to the driver directing his attention to something within the vehicle that was not clearly identifiable put still distracted the drivers' attention away from the driving task. This included reaching for things, putting things away, putting things into/taking it out of the mouth (e.g. credit card, pen) or looking down at something i.e. eyes clearly averted downwards.
		Look down (eyes not on the road)	
		Put something into/out mouth other than food	
		Reach for something	
		Look to the back of the vehicle	
	Dining	Eating	Dining refers to any action that included eating and drinking while driving.
		Drinking	
		Throw gum out	

		Unwrap food	
	Electronic devices	Texting while stationary Texting while driving Reach for cell phone to use Hands-free on /adjust Talk on cell phone Talk on hands-free	The use of electronic devices was coded in terms of reaching for, adjusting and using the devices while driving (talk/dial/text). This was only coded if the device could be seen.
	Smoking	Light Smoke Extinguish Reach for cigarettes	Smoking behaviour was observed for only one driver. Smoking behaviour included reaching for, lighting the cigarette, smoking and extinguishing the cigarette.
	Vehicle related	Adjust controls Both hands of steering wheel One hand on steering wheel	Vehicle related included, adjusting vehicle controls (including the gears, radio etc.). Behaviour was also coded if it could be seen that one or both hands were not on the steering wheel.
	Passenger related	Talk to /distracted by /look at	The literature review did not list passenger distraction as a separate in-vehicle activity. However for the purpose of this study, passenger related activities was coded separately and included behaviour where the driver can be seen looking at, talking to and handing a passenger something
	Other	No seatbelt Reach for and put seatbelt on Unfasten seatbelt	Wearing of a seatbelt is not a distraction per se but the action of realising one is not wearing a seatbelt during the course of the trip and then reaching and putting the seatbelt on or unfastening the seatbelt for some reason was considered a distracting activity as well an activity that could potentially show inattention.
Outside distraction	Outside distraction	Outside	Outside distractions were coded when the drivers' head turned approximately 45 degrees to look at something outside or in events where drivers spoke to someone outside the vehicle.

5. ANALYSIS, FINDINGS AND COMPARISON WITH INTERNATIONAL TRENDS.

5.1. Research Approach

5.1.1. Overview

The investigation intended to answer two overarching questions:

- What types of inattentive and distracted driving behaviours can be observed and quantified in the NDS dataset?
- What is the significance of prevalent inattentive and distracted driving behaviour thereof?

The data was analysed according to the type of driver (experienced *vs.* to novice drivers) as well as per potential distracted driving activity. Distracting activities are described in terms of the proportion of time that is allocated to it, the frequency with which it occurs along with the driving context. The findings are then compared with international trends.

After establishing that secondary activities are indeed present the next step was to identify the behaviour and then to understand the significance of the prevalent behaviour. The activities coded were therefore counted for each driver in order to understand how frequently they engage in specific secondary activities as well as to understand the average duration thereof. These findings were compared with international research in an attempt to benchmark the distraction. Furthermore in an attempt to generalise the findings the all the activities were clustered to represent a proportion of the total driving time.

As indicated earlier, no baseline information related to normal driving behaviour exists. Therefore the average speed of each driver over the total driving time was used as a baseline measure against which the other secondary activities was compared according to international findings.

5.1.2. Comparison between driver groups

In order to determine whether or not there were differences between the distracted driving behaviour of experienced and novice drivers, t-tests were applied to the mean time spent on each distracted activity. A *t* test was used because the sample size is small.

Previous research (Stutts et al., 2005; Perez et al., 2013) analysed each category of driver distraction in relation to the time spent on the activity in order to compare the levels of distraction to the absence of the distraction (normal driving). Stutts et al. provided for a 95 per cent confidence interval and proportion were estimated for each category and then compared in order to highlight the differences between proportions for distracting events that were statistically significant (identified at the .01 and .05 confidence levels). Perez et al. estimated significance, using a Type I error of 0.05. A similar approach was followed in this study and confidence intervals were estimated at $p<0.01$, $p<0.05$ and $p<0.1$.

In addition, the proportion of time spent on similar distracted activities was calculated for the different driver groups.

5.1.3. Comparison between activities

Not all drivers displayed the same distracting behaviour. However a particular distraction displayed by a driver could still potentially contribute to the level of risk of being involved in a crash and was therefore still represented in the analysis. Activities were compared in terms of prevalence and significance of contributing to risk according to individual drivers, driver groups as well as different distracting activities. The findings were compared to international research as cited in the literature review.

5.2. General findings

5.2.1. Study observations

Normal driving behaviour (no distracting activities) was observed most of the time for all of the drivers (84.67 per cent)[2]. The time was measured in seconds and included all the videos coded for the driving week. Table 13 below provide an overview of the average time spent on normal driving per driver as well as per activity.

Table 13: Proportion of time spent on normal driving activities

Average %	NoD 1	NoD 2	ED 1	ED 2
Normal	73.32	91.12	71.86	76.54
Stationary	2.95	2.83	2.48	4.79
Waiting in traffic	3.14	0.73	1.78	2.02
Looking up after activity	0.33	0.51	1.62	2.49
Reverse	0.17	0.00	0.00	0.00
% of time	79.91	95.20	77.75	85.84

5.2.2. Normal vs. distracted driving

In accordance with the literature review, any activity that takes the attention away from the primary driving task is considered a distraction (Horberry et al., 2006; NHTSA, 2010).

In this study distracted driving activities were observed for all four sample drivers. A total of 956 activities were coded. Normal driving was coded 484 times. Instances where only one activity (including normal driving) was coded constituted 653 entries while activities where more than one distracting activity (also co-occurring with normal driving) were coded , constituted 303 entries (Table 14).

Table 14: Activities coded for all drivers

	Total activities coded	Normal	Only 1 activity	Instances >1 activity
NoD 2	123	67	85	38
ED1	284	127	205	79

[2] Annexure B & C provides an overview of the coding matrixes and the weight of each coded activity in accordance to the driving activities and total time

NoD1	328	184	270	58
ED 2	221	106	93	128
Total	**956**	**484**	**653**	**303**

Multi-tasking or engagement in more than one secondary activity at one time was present in approximately a third of the data analysed.

Secondary activities which could potentially be distracting were therefore observed for all drivers. These activities included in-vehicle distractions as well as outside distractions. In-vehicle distractions included dining, grooming, person or object related activities, possible distractions due to controls of the vehicle as well as passengers (Figure 8).

Other distractions that was observed to a lesser extend included adjusting of the seatbelt (fasten/unfasten) as well as smoking behaviour which was only observed for one experienced driver.

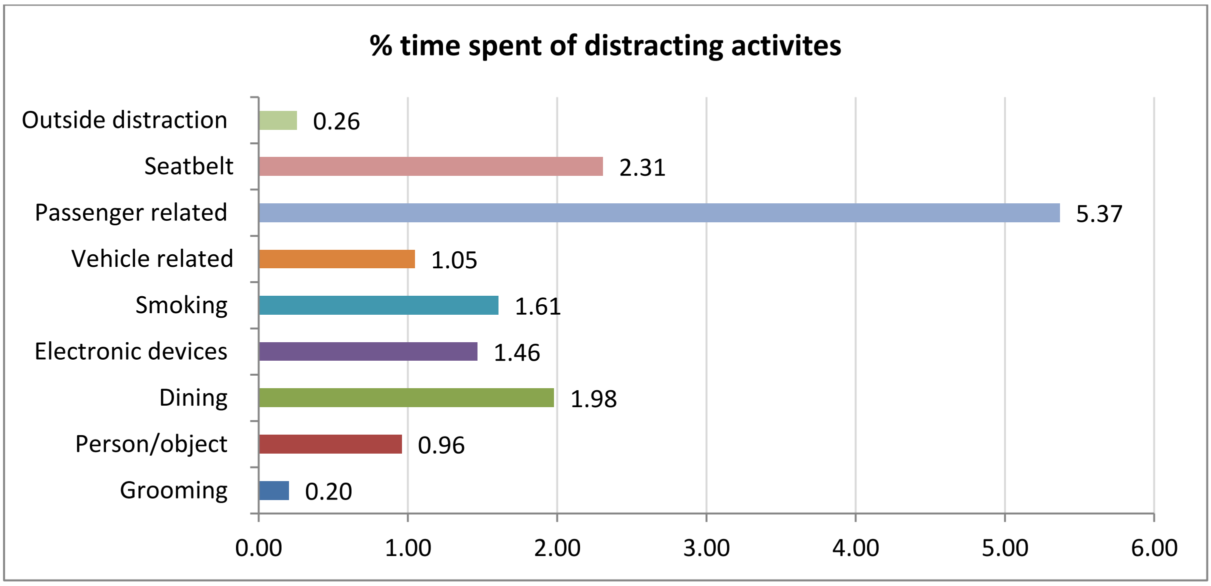

Figure 8: Average proportion of time spent on distracted driving activities.

It is important to note that not all of the drivers engaged in the same secondary activities and even if they did, the manner in which they did so, differed. For example, as indicated above, only one of the drivers smoked and two of the drivers engaged in dining activities more frequently than the other two drivers.

The rest of this section describes the secondary activities that were observed for the drivers. Each activity is described in terms of the number of times it occurred as well as the average duration thereof. The secondary activities are also expressed as a proportion of the driving time in order to illustrate the amount of time that was allocated to the different activities by all the drivers. The average and maximum speed at which activities occurred was included in an attempt to benchmark the willingness of the drivers to engage in secondary activities as perceived safe or unsafe speeds.

Due to the scope of this project only selected data and a limited amount of driving time that could be analysed, conclusions on whether or not the activities drivers engage in whilst driving would be distracting to the extent that crash risks levels are elevated cannot be drawn with scientific significance. However, by comparing these findings with internationally reported crash risk associations with driver distractions, some indication of the risk levels drivers is exposed to be demonstrated in the South African context.

5.2.3. Demographics

In terms of total time spent on distracting activities the research found that novice drivers spent more time on “normal” driving behaviour than the experienced drivers. Previous research has established that with more experience, driving becomes automated and that even though experienced drivers are able to do more than one thing at a time, performing a secondary task degrades driving performance (Brace et al., 2007; Just et al., 2008).

Although some research has indicated that novice drivers tend to be more distracted than experienced drivers (Victor, 2000; Stutts et al, 2005) this research did not substantiate this finding for all distracted driving activities.

T-tests were conducted for each of the secondary activities observed. The findings from this research concurred with that of Stavrinos et al (2011) that the drivers, regardless of age and experience, were all distracted in one way or another by engaging in secondary activities. Differences in the manner in which the driver groups engaged in secondary activities were found for activities related to the driver (person) or objects in the vehicle, passenger related distractions and seatbelt behaviour.

5.3. Distracted driving activities observed

5.3.1. Grooming

5.3.1.1. Study findings

Grooming was observed for all of the drivers, although the frequency with which drivers engaged in the behaviour differed. The proportion of time spent on grooming was 0.2 per cent of the total driving time.

Grooming activities included adjusting clothes, hair, sunglasses or putting cream onto hands. Adjusting clothing and fidgeting with hair was the most common grooming related activities observed for most drivers.

Fidgeting with hair and adjusting clothing were more frequently observed for the female drivers (NoD1 and ED 1) than the male drivers and on average also took longer. The only grooming activity that NoD1 engaged in, was putting on cream, this on average took half a minute and coincided with one hand or both hands off the steering wheel.

Table 15 illustrates the number of incidences coded as well as the average duration of the activity.

Table 15: Count of grooming activity and average duration								
	NoD1	*Ave time (s)*	**NoD2**	*Ave time (s)*	**ED1**	*Ave time (s)*	**ED4**	*Ave time (s)*
Adjust clothing	2	*2*	0	*0*	2	*22.95*	1	*5*
Adjust sunglasses	2	*2.04*	0	*0*	0	*0*	0	*0*
Fidget with hair	1	*4.7*	0	*0*	4	*12.9*	2	*12.5*
Put cream on	0	*0*	2	*31.2*	0	*0*	0	*0*

5.3.1.2. International comparison

Grooming activities are considered a physical distraction (NHTSA, 2012). In this study the most prominent grooming activities were adjusting clothes and fidgeting with hair. Adjusting clothes and fidgeting with hair on average took the longest. Grooming activities might also coincide with other secondary activities such as steering with one hand or looking down to adjust clothing.

Stutts et al (2003) found that 50 per cent of the study participants engaged in grooming activities. Drivers were found to look away from the road more frequently while eating and drinking. Similarly the 2013 Goodyear third annual Road Safety Survey found that compared to its European counterparts, 33 per cent of South African young drivers surveyed engaged in grooming activities while driving (Goodyear EMEA, 2013).

5.3.2. Person or object related

5.3.2.1 Study findings

All four drivers were engaged in secondary activities within the vehicle that was object or person related (Table 16). This include looking down at something, putting something away, reaching for something in the vehicle and putting something into or taking it out of their mouth (e.g. credit card, pen).

In terms of the total driving time analysed, drivers were engaged in secondary activities within the vehicle that was object or person related for 0.96 per cent of the total driving time. The t-test comparing the means of the novice and experience drivers indicated that the manner in which the two driver groups engage in person or object related secondary activities while driving was significant at 90 per cent (P= 0.07328).

Looking down at something (unidentified) was the activity that occurred most for all drivers. Reaching for something in the vehicle was the second most frequent activity in this category. Average time spent on reaching for something in the vehicle was between 9 and 25 seconds.

Table 16: Count of object/person related activities and average duration								
	NoD 1	*Ave time (s)*	**NoD 2**	*Ave time (s)*	**ED 1**	*Ave time (s)*	**ED 2**	*Ave time (s)*
Put something away	13	3.01	6	1.09	6	2.97	10	*1.65*
Look down (eyes not on the road)	99	18.63	28	10.06	77	33.19	80	*49.27*
Put something into/out mouth other than food	4	0.24	0	0.00	0	0.00	0	*1.35*
Reach for something	31	9.28	5	4.96	14	5.21	43	*24.77*

The highest average percentage of time was spent looking down at something in the vehicle and reaching for something in the vehicle (Figure 9).

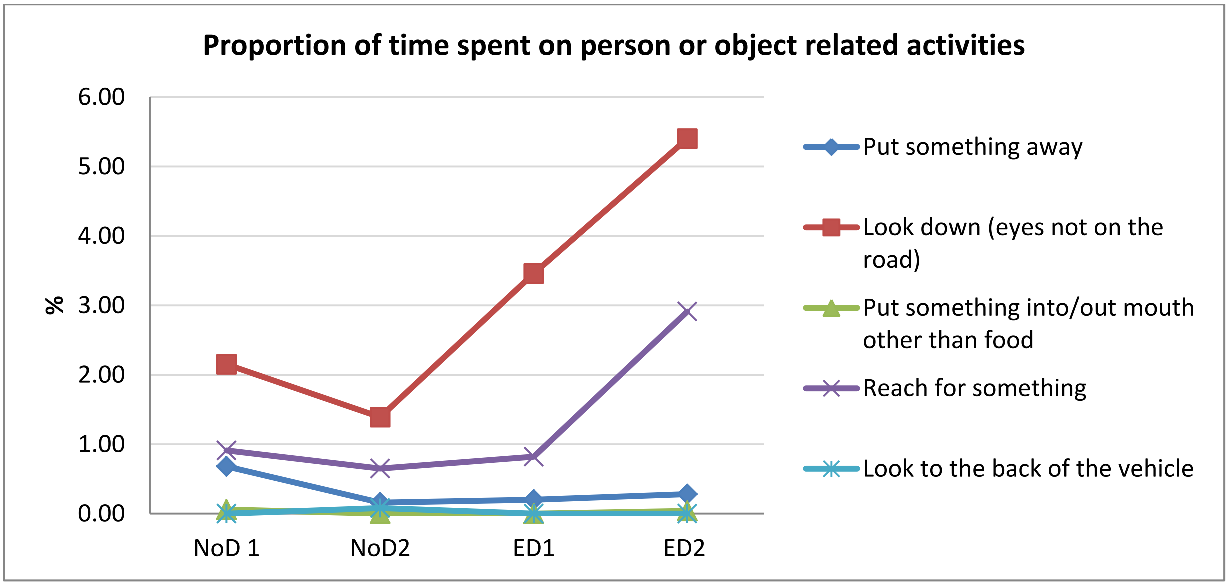

Figure 9: Average percentage of time Individual drivers spent on person or object related activities within the vehicle.

5.3.2.2. International comparison

This category referred to the driver engaging with any activity that diverts his eyes downward or diverted his attention elsewhere in the vehicle in order to reach something or to put something away. Behaviour was coded accordingly when the object or reason for looking down could not be established by the coder but there was evidence that the attention of the driver were being diverted elsewhere in the vehicle. The cause of the distraction could therefore be visual (changes on the control panel; looking down at a text message); auditory (hearing the phone ring or indicate that a text message has arrived) and physical (reaching for cigarettes, documents, cell phone).

In an analysis of NMVCCS crash database, Singh (2010) found that in 11 per cent of the crashes analysed, the drivers were focused on internal objects within the vehicle. In 6.8 per cent of the crashes drivers attempted to retrieve something from the floor of the vehicle and 2.5 per cent from somewhere else within the vehicle.

Klauer et al. (2006), in an analysis of the 100-Car NDS, found that glances away from the forward roadway for more than two seconds doubled the near-crash and crash risk compared to baseline. In this study all drivers looking down at something in the vehicle were coded for all the drivers. The average time for which a driver did not look at the road ranged between 10 seconds and almost 1 minute (49.27 seconds) which is significantly more than the 2 seconds prescribed by Stutts et al in 2005.

5.3.3. Dining

5.3.3.1. Study findings

Dining was observed in 1.98 per cent of the total driving time. Dining was observed for three drivers. Drivers engaging in this activity took on average between 3 and almost 5 minutes to complete eating. Drinking was the second most prevalent dining activity and drivers on average to between 2 and 24 seconds to complete the action (Table 17).

Most of the activities coded were related to dining specifically for NoD 1 and ED 2 (Parent/NoD combination)

Table 17: Count of object/person related activities and average duration

	Driver 1 (NoD 1)	Ave time (s)	Driver 2 (NoD 2)	Ave time (s)	Driver 3 (ED 1)	Ave time (s)	Driver 4 (ED 2)	Ave time (s)
Eating	12.00	274.20	0.00	0.00	2.00	1.86	9.00	173.33
Drinking	11.00	6.70	0.00	0.00	2.00	0.00	5.00	23.62
Throw gum out	0.00	0.00	0.00	0.00	1.00	10.00	0.00	0.00
Unwrap food	0.00	0.00	0.00	0.00	0.00	0.00	1.00	10.00

5.3.3.2. International comparison

Dining constitutes a visual and physical distraction that requires one or both hands to not be on the steering wheel (Stutts et al., 2003; Singh 2010).

Eating is considered moderate secondary tasks that according to Klauer et al. (2006) double crash risk. Stutts et al. (2003) found that eating and drinking lead to greater deviations from lateral position, lower speed and more crashes and near crashes. Drivers look away from the road more frequently while eating and drinking. Ronis (2012) indicated that females tend to be more prone to eating and drinking while driving. On average, ED 2 spent approximately 5.62 per cent of the total driving time on dining activities compared to 2.25 per cent for NoD 1 and 0.05 per cent for ED1.

Although there was evidence of both a male (ED2) and female (ED 2 and NoD1) drivers participating in dining related activities the sample size is too small to draw any meaningful comparisons. However in this study the female driver engaged in eating on average took much longer and participated in the activity much more frequently than the male driver. The female driver also engaged in drinking activities more frequently than the male driver but the average time spent on the activity was much less.

5.3.4. Electronic devices

5.3.4.1. Study findings

Electronic devices were used by drivers in 1.46 per cent of the total driving time. Table 18 shows the number of events coded along with the average duration of each activity.

Table 18: Count of Electronic device usage and average duration

	Driver 1 NoD 1	Ave time (s)	Driver 2 NoD 2	Ave time (s)	Driver 3 ED 1	Ave time (s)	Driver 4 ED 2	Ave time (s)
Texting while stationary	1	39	0	0	0	0	0	0
Texting	0	0	9	6.7	2	13.2	2	9.77
Reach for cell phone to use	0	0	0	0	2	1.92	1	1
Hands-free on /adjust	0	0	0	0	2	3.12	0	0
Talk on cell phone	0	0	0	0	2	734	0	0
Talk on hands-free	0	0	0	0	6	42.29	5	98.23

Talking on a hands-free set was the most prominent (4.21 per cent) followed by talking on a cell phone while driving (3.57 per cent). Adjusting the hands-free accounted for 0.06 per cent of the driving time, reaching for a cell phone, 0.08 per cent of the driving time and texting while driving for 0.77 per cent and texting while stationary for 0.09 per cent of the total driving time.

Means compared between novice and experienced drivers engaging in electronic device use were not significantly different (p=0.49667).

Novice drivers' texting spent a maximum of 21.2 seconds texting while driving compared to experienced drivers whom spent a maximum of 64 seconds. Only experienced drivers made use of a hands free device and took a maximum of 16.4 seconds to adjust the device and a maximum of eight minutes (477.7 seconds) talking on the hands-free set. The maximum time that was spent talking on a cell phone while driving was approximately twelve minutes.

5.3.4.2. International comparison

Electronic device distractions can be considered as physical as well as visual and auditory distractions (NHTSA2012).

Using a mobile phone while driving reduces the ability to drive safely (Caird et al., 2005; Strayer et al., 2007; Mayhew et al., 2013). Research also indicates that risk related to talking on a cell phone (handheld) and using a hands free set are not different (Brace et al., 2007).

Talking on a hand held cell phone was observed twice, for only one driver (ED 1) and the average duration was 734 seconds. Horberry et al. (2006) indicate that talking on a cell phone while driving reduces driver performance and that this deterioration of performance increases with age.

The average speed for talking on a handheld cell phone was 62km/h compared to talking on a hands-free set (65 km/h). Talking on a hands-free set was observed eleven times but only for the experienced drivers. Average time talking on the hands-free set ranged between 42 and 82 seconds. Burn et al. (2002) and Breen (2009) have indicated that drivers talking on mobile phones have much poorer reaction times than under normal driving circumstances. The degree to which the telephone distracts a driver is a function of the level of distraction brought along by the phone as well as the amount of time (exposure) used. The extent to which distraction influences safe driving behaviour is also dependent on the complexity of both the conversation and the driving situation (Breen, 2009).

Texting was observed for all drivers, however, NoD2 engaged in the activity more frequently than the other drivers. The average time spent on texting by the novice driver was however much less than the experienced drivers. Research related to the negative impact that texting while driving has on safety performance is well documented and include slower braking times (Leung et al., 2012), poorer vehicle control (Petzoldt, 2011) and poor hazard perception and reaction times (Hosking et al., 2009; Leung et al., 2012; Peissner et al., 2011).

5.3.5. Vehicle related

5.3.5.1. Study findings

Vehicle related distractions included adjusting controls (radio, gears etc.) as well as instances where it was possible to identify to whether the driver had one or two hands on the steering wheel. Vehicle related distractions accounted for 1.05 per cent of the total driving time. Table 19 provides an overview of the number of incidents coded, and the average duration for each activity.

Table 19: Count of vehicle related distractions and average duration								
	NoD 1	**Ave time (s)**	**NoD 2**	**Ave time (s)**	**ED 1**	**Ave time (s)**	**ED 2**	**Ave time (s)**
Adjust controls	3	3.9	1	173.1	0	0	0	0
Both hands of steering wheel	0	0	3	22.8	1	29	2	10.17
One hand on steering wheel	0	0	2	1.45	0	0	4	111.15

5.3.5.2. International comparison

Vehicle related distractions are associated with physical distractions. In this study the distractions observed included adjusting vehicle controls (e.g. gear changes), or driving with only one or no hands on the steering wheel (ETSC, 2010). Activities internationally associated with this include talking on a cell phone, dining and grooming (NHTSA, 2012).

For the purpose of this study the associated activities were coded separately in an attempt to distinguish between the type and frequency of the activities. Therefore the incidents coded in this category were coded when observed in absence of other secondary activities. However this behaviour could co-occur with other secondary activities such as grooming, eating drinking and so forth.

Although these events were coded as distracted behaviour, the behaviour is also associated with normal driver behaviour. These events were evident in 1.05 per cent of the total driving time. Steering with only one hand represented the largest proportion (1.84 per cent) of the vehicle related distracted behaviour coded. Evidence of driving with both hands off the steering wheel was evident in 0.61 per cent of the time and adjusting controls 0.69 per cent of the time. The highest average time observed where a driver did not have both hands on the steering wheel was approximately 23 seconds and with one hand on the steering wheel 111 seconds.

5.3.6. Passenger related distractions

5.3.6.1. Study findings

All drivers had scenarios in which they were interacting with passengers. This included talking to, looking at and handing a passenger something. Passenger related distractions constitute the largest proportion of the driving time (5.37 per cent).

Table 20 provide an overview of the number of incidents coded and the average time spent on the activity.

Table 20: Count of passenger related distractions and average duration								
	NoD1	**Average (s)**	**NoD 2**	**Average (s)**	**ED1**	**Average (s)**	**ED2**	**Average (s)**
Passenger related	3	155.8	4	201.31	3	379.37	2	659.10

5.3.6.2. International comparison

Passengers mostly constitute an auditory distraction (ETSC, 2010). For the purpose of this study however, this distraction was also coded in terms of looking at a passenger (physical distraction) and talking to a passenger (cognitive distraction). DaCota (2012) considers passenger related distractions as Visual-Auditory-Cognitive. This has been confirmed by Singh (2010) whom stated that in an analysis of the NHTSA NMVCCS talking to a passenger was the most common internal distraction (57 per cent) occurring before a crash. However, similar to vehicle related distractions, although it could potentially be distracting, driving with passengers is also part of everyday driving.

The t-test performed for this secondary activity indicated that there was a significant difference (at 99 per cent p=0.00017) in the manner in which novice and experienced drivers engaged in passenger related activities. Foss et al., (2014) indicated that most novice drivers have not yet achieved driving experience and that distractions such as that posed by passengers make this even worse. For this study, experienced drivers engaged in distracting passenger related activities more and for longer than the novice drivers. No significant difference was found in terms of gender where international research has found that female drivers are more distracted when driving with passengers than males (Irwin et al., 2011; Singh, 2010).

Passenger related activities constituted 4.8 per cent of the total driving time and was by far the activity that drivers allocated most of their time to however highlights the fact that passenger distractions do not interfere with driving as much as mobile phone conversations do, because drivers are better able to synchronize the processing demands of driving with in-vehicle conversations than with cell-phone conversations (Strayer et al., 2007; Drews et al., 2008). One reason cited for this (Regan et al., 2007) is that passengers might be more conscious of the driving situation and are often an extra pair of eyes and ears for the driver, which makes the driver more aware of the driving situation.

Rather than only being considered a distraction, talking to a passenger is also considered a primary cause of driver inattention (Klauer et al., 2006; Dong et al., 2011). According to Regan et al (2011) talking to a passenger is an example of driver diverted attention (DDA) which implies that the driver has to deal with competing activities (driving task vs. talking). This influences driving performance negatively.

5.3.7. Other types of secondary activities

5.3.7.1. Study findings

Outside distractions accounted for 0.26 per cent of the driving time. Outside distractions was coded for all drivers and the average duration spent on looking outside the vehicle was 10 seconds, mostly while stationary.

Drivers were observed not wearing a seatbelt in 6.63 per cent of the driving time. Seatbelts being either unfastened or fastened while driving accounted for 0.14 per cent of the total driving time. Three of the drivers (the two experienced drivers and one novice driver) tended to only fasten their seatbelt during the journey, while driving.

Seatbelts being fastened was observed once for ED1 and ND2 and three times for ED2. On average it took approximately 10 seconds to reach for, and fasten the seatbelt. Unfastening of the seatbelts while driving was observed for both novice and experienced drivers.

Smoking related activities were observed for only one driver but constituted approximately 1.61 per cent of the driving time.

Table 21 provide an overview of the average time spent per activity.

Table 21: Smoking behaviour

	Activity	Proportion of time
Smoking behaviour	Light	0.28%
	Smoke	4.48%
	Extinguish	0.60%
	Reach for cigarettes	1.08%

5.3.7.2. International comparison

The focus of this research was in-vehicle distractions but outside distractions were coded when the driver turned his or her neck to physically look at something outside of the vehicle. External sources of distraction include: driver dazzled due to the sun or another vehicles' headlights, checking for traffic and other road users, trying to find a location, scenery and looking at people or animals (Baird et al., 2011). International research has found that external distractions such as road side advertising, moving billboards especially those situated in the central field of vision has been associated with distracted driver crashes (Beijer et al., 2004; Crundall et al., 2006; Chattington et al., 2009).

Seatbelt behaviour was coded in-vivo as observed but no international research could be found to draw comparisons.

Smoking behaviour was observed for only one of the experienced drivers. Smoking behaviour however constituted 1.61 per cent of the drivers' total driving time. Smoking also seems to be one of the less reported distracting activities internationally (Stutts et al., 2001; Singh, 2010). Klauer et al. stated that smoking while driving seems to be less risky (within no significant increase in crash risk) than other secondary activities.

Smoking was coded in terms of reaching for cigarettes, lighting, smoking and extinguishing. The average time spent smoking was 207 seconds. Although international research has not found a significant increase in crash risk associated with smoking as an action while driving, this research suggests that the average time spent on reaching for cigarettes (27.1 seconds) and lighting cigarettes (14.08 seconds) might be indicative of other distraction behaviours such as looking down or removing hands from the steering wheel which in previous discussions have been highlighted as factors that increases crash risk.

5.4. Secondary activities and driving contexts

5.4.1. Description of driving contexts

Drivers from both participant groups were observed driving on the freeway as well as in urban settings. The exception was NoD2 who only drove within urban areas. Participant group 2 (ED2 and NoD1) stayed in a rural setting where the trips started and ended. All of the drivers were observed to be driving with passengers in the vehicle during at least one trip.

Average speeds during the trips varied between drivers. Table 22 however indicate that the average speed for the driver groups (ED1/NoD2 and ED2/NoD1) was similar. Being parent child combinations might be indicative of how the novice drivers follow the examples of parents (Table 22).

Table 22: Average speeds

	Average speed (Km/h)	Average Maximum Speed (Km/h)
ED1	46.28	99.63
NoD2	40.73	93.43
ED2	68.17	135.67
NoD1	62.68	137.78

5.4.2. Grooming

The average speed for engaging in grooming behaviour is shown in figure 10 below.

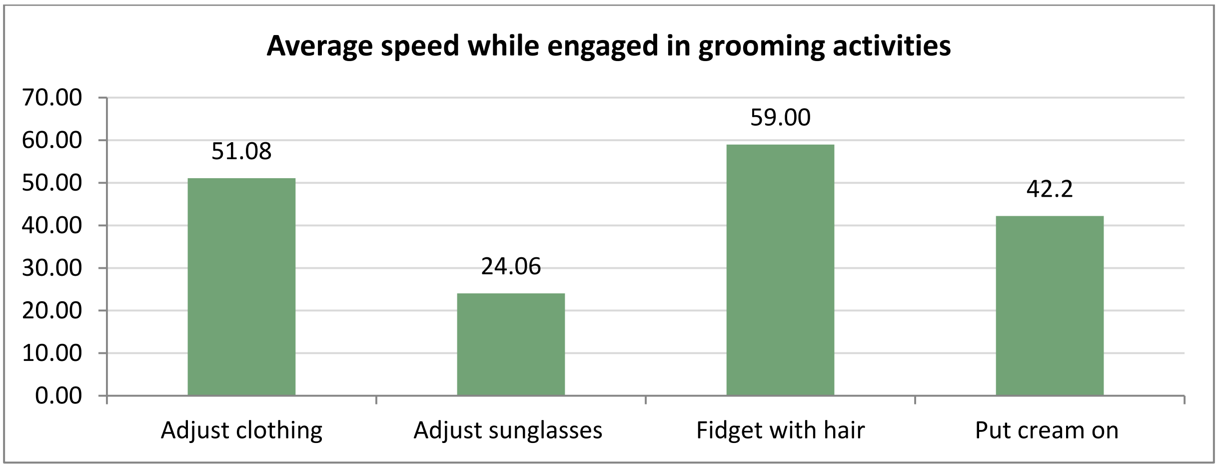

Figure 10: Average speed while grooming

Figure 10 illustrates the average speed measured for all drivers while engaged in grooming activities. Average speeds according to driver engaged in grooming activities are displayed in Figure 11. Figure 11 indicates that the speeds for adjusting clothes and hair differed between the experienced drivers and the novice drivers.

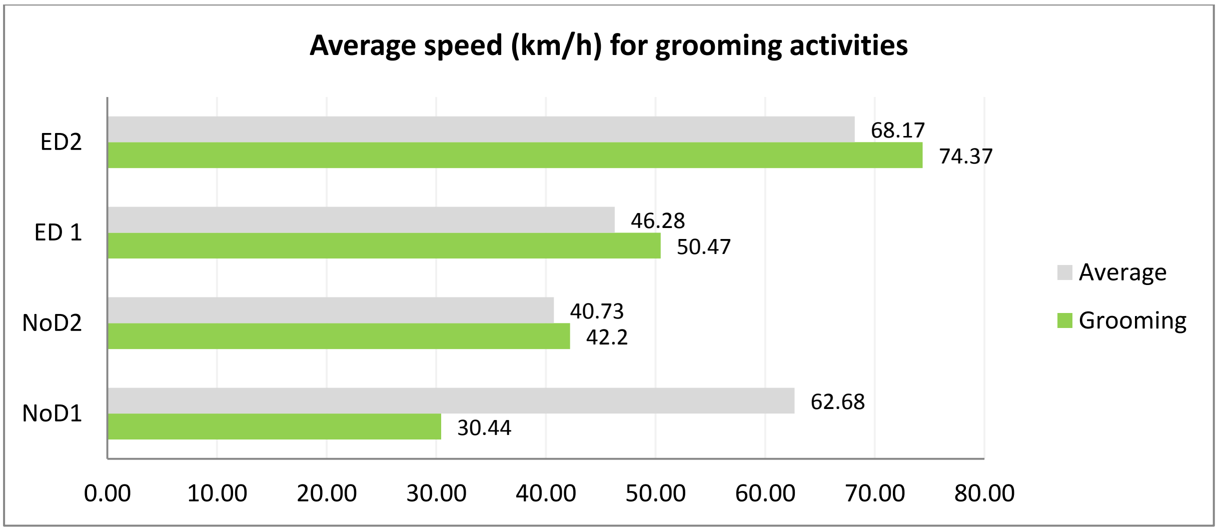

Figure 11: Average speed per driver (Grooming)

In comparison with NoD1 average speed over the driving period (62.68km/h) it seems that when the novice driver engaged in these grooming activities the average speed dropped to approximately half of the drivers' normal speed. This is in line with finding of Stutts et al (2003) that indicated that grooming activities could influence the driving task as engaging in this activity lead to greater deviations from lateral position and lower speeds. ED 1, ED 2 and NoD2 on the hand seem to drive slightly faster when grooming compared to the normal average speed maintained over the course of the driving time.

5.4.3. Person or object related activities

Figure 12 below provide an overview of the average speed maintained for activities which involved looking down, reaching for or putting something away as well as putting something other than food in the mouth. Figure 13 displays the average speed for these activities per driver.

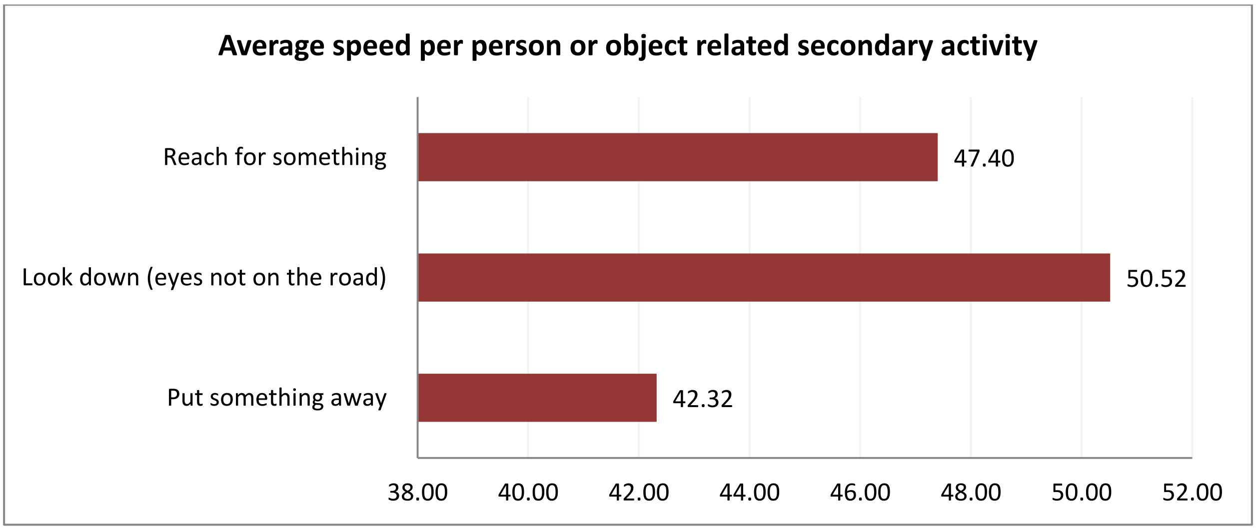

Figure 12: Average speed for person or object related activities

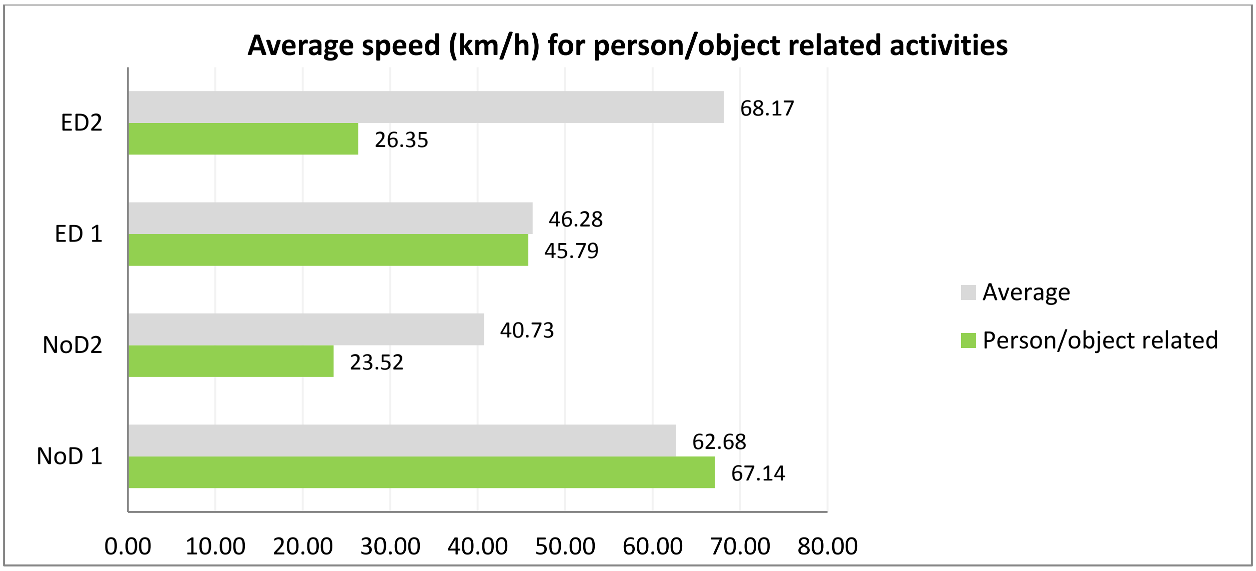

Figure 13: Average speed per driver for person or object related activities

Foss et al. (2014) states that reaching for an object in a vehicle increases risk of being involved in a crash by 1.4 times. Reaching for a *moving object* in the vehicle increases crash risk by 3 times according to VTTI (Klauer et al., 2006).

In general the average speeds maintained when reaching for something or putting something away was between 42 km/h and 47 km/h. Interestingly, the average speed maintained for looking down (with no eyes on the road) much higher (50.52 km/h).

NoD 1 had a much higher average speed for engaging in person or object related activities while driving than the other drivers. NoD 2 in contrast drives much slower when engaging in these activities, compared to his average driving speed. The same were true for the two experienced drivers, especially ED2 who in comparison with their average speed also seem to slow down significantly when engaging in these secondary activities.

This seems in line with findings from Stelling et al. (2012) that indicates that these distractions lead to slower vehicle speeds and larger following distances. Taking eyes of the road for any reason is a risk as drivers fail to see visual information and cues important for safe driving.

5.4.4. Dining

Figure 14 below provide an overview of the average speed maintained for dining activities.

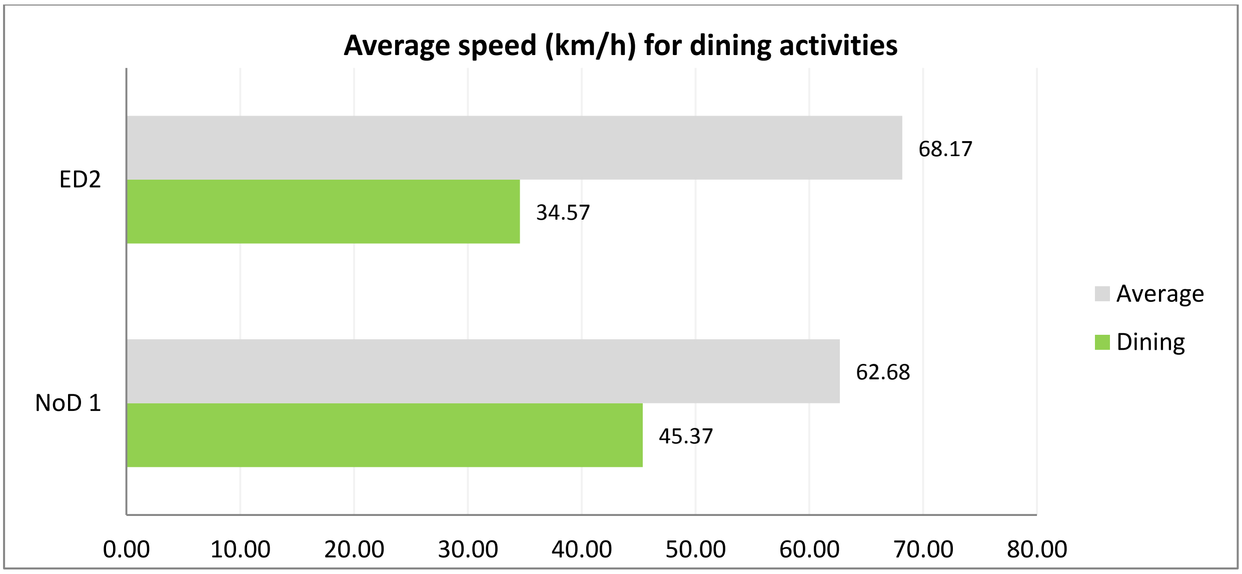

Figure 14: Average speed for dining activities

Most of the dining activities were coded for NoD1 and ED2. NoD1 maintained an average speed of 45.37 km/h and ED2 an average speed of 39.85 km/h for dining activities. For both these drivers it seems that the average speed when dining is significantly lower than the average speed measured for them over the driving period.

5.4.5. Electronic devices

Figure 15 below illustrates the average speed maintained when using electronic devices in the vehicle while driving.

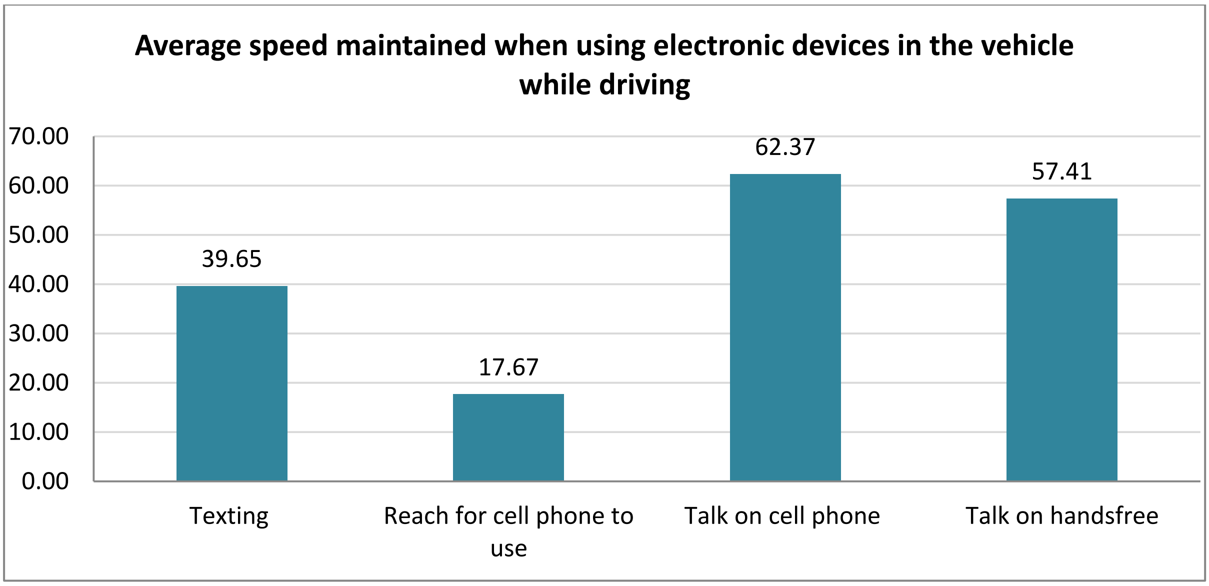

Figure 15: Average speed when making use of electronic devices while driving (All drivers)

Figure 15 illustrates that the average speed when talking on a held hand mobile phone was higher than for talking on a hands-free set. Brace (2007) emphasises that talking on a mobile phone impairs a drivers' ability to maintain an appropriate speed. According to the findings from Burn et al. (2002) drivers had significantly poorer speed control when using a mobile phone compared to other distractions. Even though hands-free devices are aimed at reducing physical distraction research, it causes the driver to divert his attention away from the driving task and instead focuses on the conversation (Breen, 2009; Caird et al., 2005).

Figure 16 illustrates the average speed for using electronic devices while driving per driver.

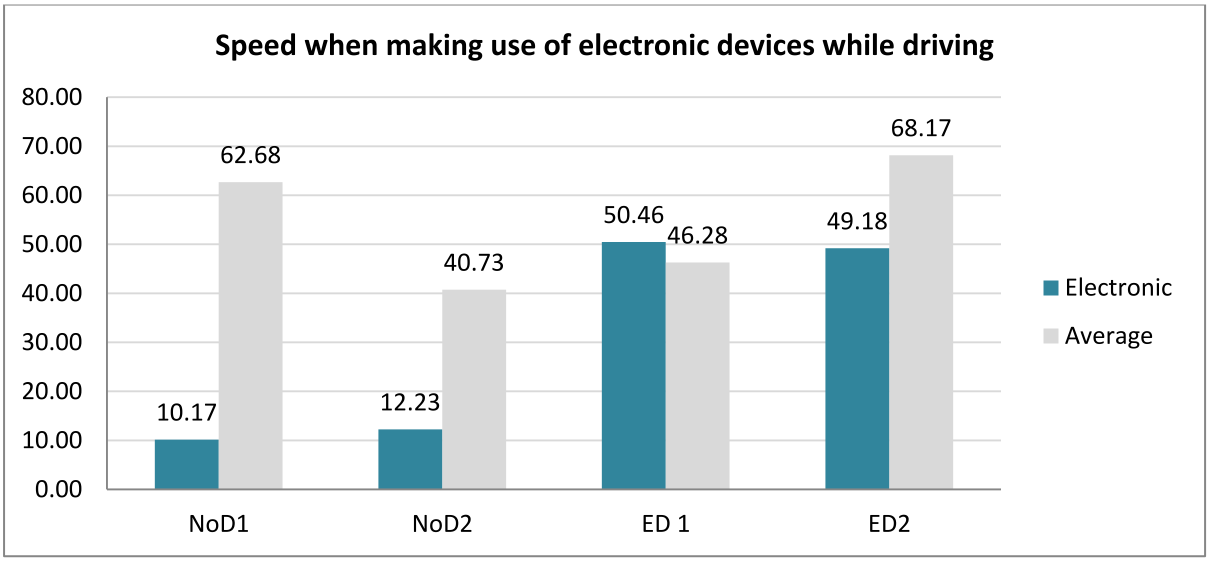

Figure 16: Average speed when making use of electronic devices while driving

It should be kept in mind that the novice drivers only used their mobile phones to text while the experienced drivers talked on their cell phones or hands-free sets as well as texted. Previous research has shown that when novice drivers do engage in cell phone conversations while driving, they tend to maintain their average cruising speed (Mayhew et al., 2013). But novice drivers wandered more in their lane when talking on the phone.

According to the research (Mayhew et al., 2013), experienced drivers tend to slow down when using the phone while driving. This only seemed to be true for ED2 as ED1 in fact drove faster than normally (46.28 km/h). The average speed for ED2 varied slightly when talking on a handheld phone or hands-free set. ED 1 on the other hand drove slower (and more consistent with the average driving speed measured over the driving period) when using a hands-free set (Figure 17). Drivers talking on a mobile phone miss critical information on potential hazard in their surroundings and are then not able to respond to unexpected situations (Peissner et al., 2011).

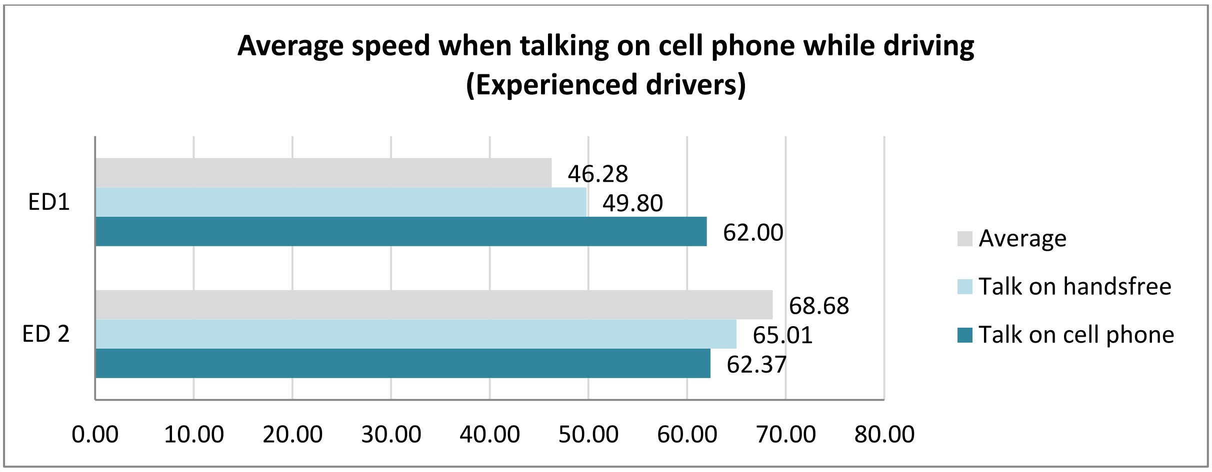

Figure 17: Average speed when talking on a phone while driving (Experienced drivers)

One novice driver (NoD1) only texted when stationary and the vehicle were not moving. NoD2 as well as the experienced drivers texted while driving (Figure 18).

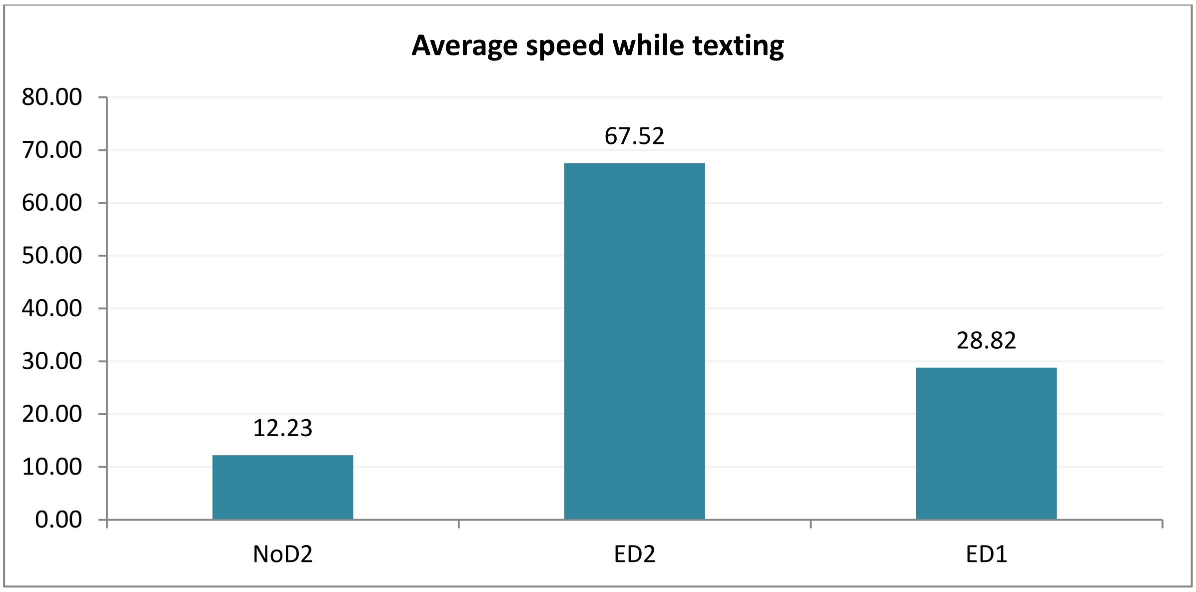

Figure 18: Average speed while texting and driving

Figure 18 illustrates that the average speed while texting for NoD2 was 12.23 km/h, significantly lower than the average driving speed of 40.73 km/h measured over the driving period. The same is true for ED1 maintaining a speed of 28.82 km/h while texting compared to the overall average speed maintained during the driving period of 46.28 km/h.

Research highlights that texting while driving slows drivers' braking reaction times, lane position varies more, and the time drivers spend not looking at the road is higher (Leung et al., 2012). By reducing vehicle speed, the driver may consciously or unconsciously attempt to create a safety buffer with the leading car to reduce crash likelihood (Petzold, 2011). This in turn could lead to the driver obstructing traffic flow (Stavrinos et al., 2011). Texting while driving has a negative effect on safety-critical driving tasks such as hazard detection as the driver need to physically divert his attention away from the road in order to attend to the texting task (Breen, 2009).

5.4.6. Vehicle related

As indicated earlier vehicle related distractions such as adjusting controls and steering with only one hand or instances where the driver had no hands on the steering wheel were coded separately. Although these behaviours might show potential distracted driving behaviour, it might also be associated with normal driver behaviour.

Figure 19 provide an overview of the average speed maintained by drivers when engaged with vehicle related distractions.

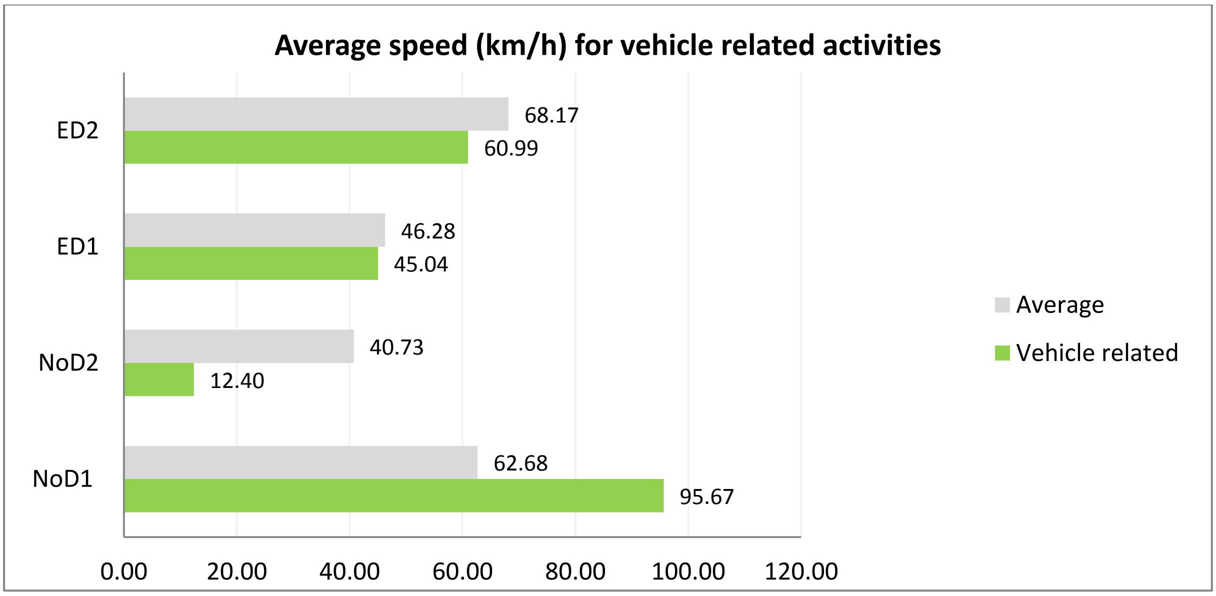

Figure 19: Average speed and vehicle related distractions

The average speed maintained by the experienced drivers during these activities varies slightly from the average speed measured over the driving period. However the average speeds maintained by novice drivers differ greatly from the average speeds measured for them over the driving period.

The average speed while engaging in vehicle related activities for NoD1 is much higher and for NoD 2 much lower. This difference might, however, be indicative of the level driving experience of the individual novice drivers and that NoD1 was in all possibility more comfortable to drive faster while engaging in these activities than NoD2.

5.4.7. Passengers

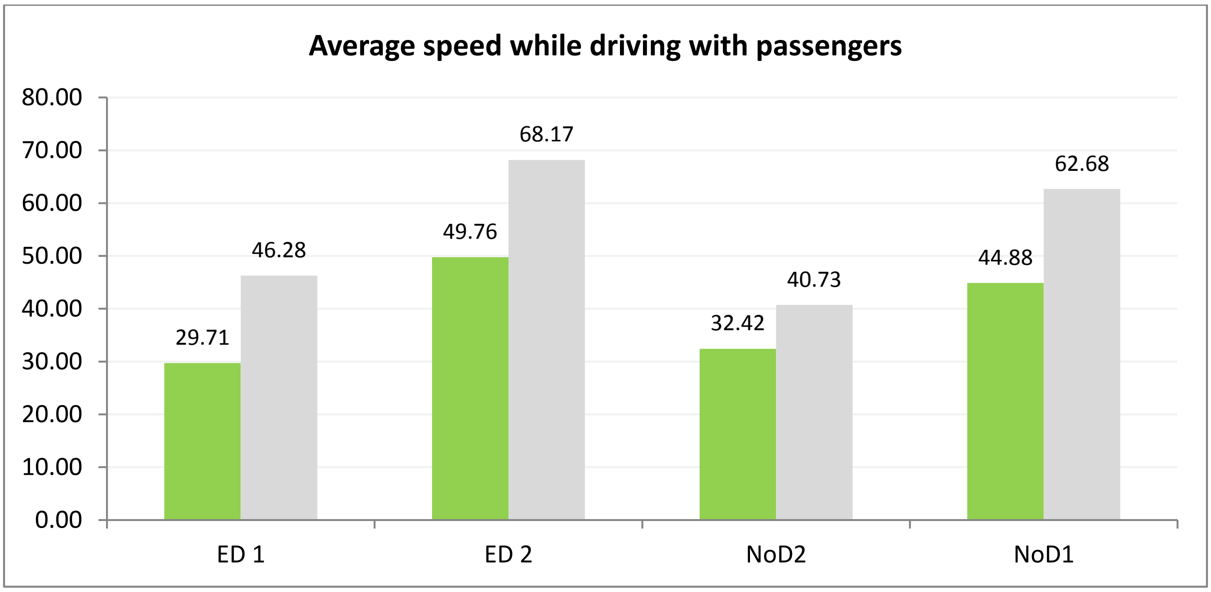

Figure 20: Average speed while driving with passengers

According to the research findings the largest proportion of time spent on distracting driving activities involved passengers. Figure 20 illustrates that all drivers drove slower than normal when driving with passengers in the vehicle. According to Foss et al (2014) passengers can be a significant source of distraction for novice drivers. Male drivers were also found to be more distracted while conversing with passengers (Irwin et al., 2011; Singh, 2010).

5.4.8. Other secondary activities

5.4.8.1. Seatbelts

Figure 21 indicate that the average speed at which experienced drivers felt they could drive without a seatbelt were higher than that of the novice drivers. This was, however, only slightly higher than that of NoD2.

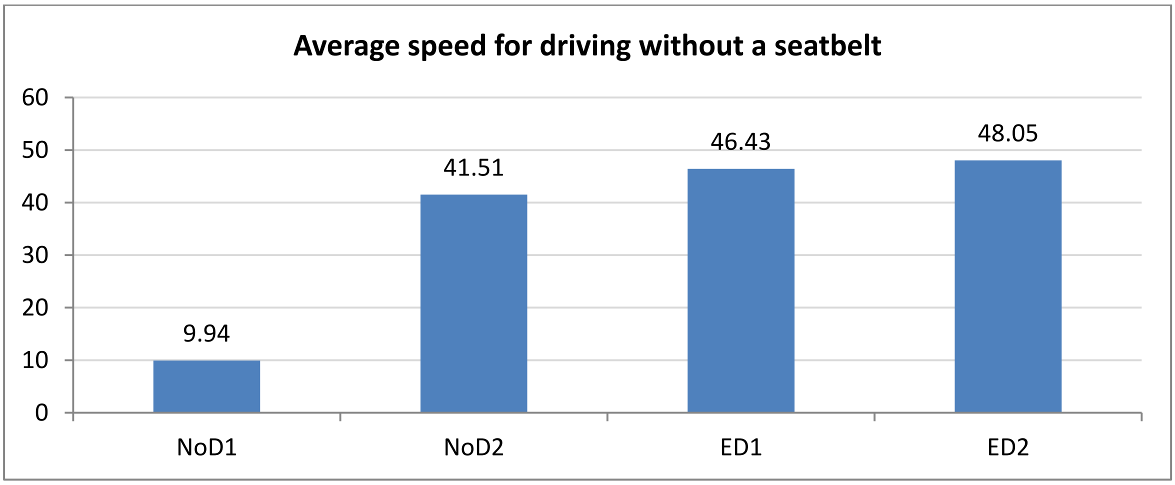

Figure 21: Average speed – not wearing a seatbelt

The speed at which ED1 and NoD2 felt comfortable not wearing a seatbelt correlated with the average normal driving speed of the drivers. For ED2 the speed was lower in comparison with the average normal driving speed observed over the driving period. NoD1 had the highest average speed over the driving period. The average speed at which this driver therefore did not wear a seatbelt was therefore much lower.

Not wearing a seatbelt is not a distraction but the realisation thereof and responding to it by reaching for and putting a seatbelt on is. The same is true for unfastening the seatbelt while driving. The average speed at which drivers unfastened there seatbelt were 28.25 km/h and 39.49 km/h for reaching and putting it on.

5.4.8.2. Smoking related activities

Smoking was only observed for ED1. Figure 22 illustrates the average speed maintained for smoking related activities.

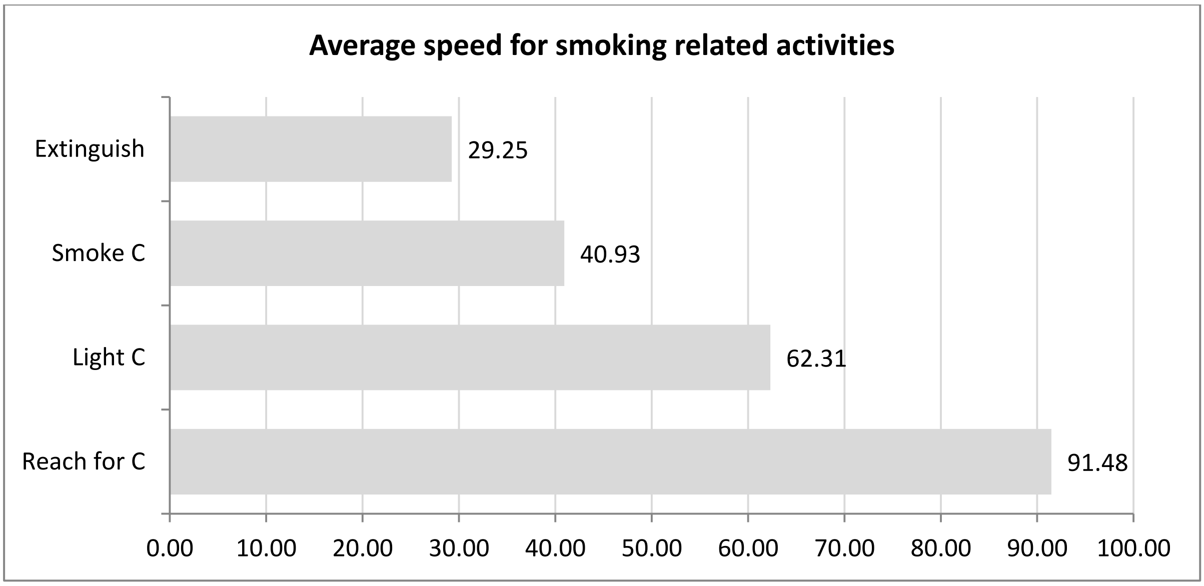

Figure 22: Average speed – smoking related activities

The driver generally maintained an average speed of 46.28 km/h over the driving period. When smoking a cigarette or extinguishes a cigarette the drivers slowed down. In contrast the average speed when lighting or reaching for cigarettes while driving was much higher than the norm.

According to Klauer et al (2006) and Singh (2010) smoking is a secondary activity that does not significantly increase crash risk. It is, however, an internal source of distraction and can possibly be associated with other activities such as driving with on/no hands on the steering wheel, aversion of eyes, reaching for something in the vehicle and so forth that has been associated with driver distraction.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1. Overview

The literature review highlighted that driver distraction is considered to be any activity that diverts the attention away from the primary driving task. This research aimed to identify and quantify the type and prevalence of inattentive and distracted driving in the available NDS dataset. In addition the research also tried to understand the significance of the inattentive behaviour.

A predefined coding scheme was used to identify and code any activities that could potentially be associated with inattention or distraction. Drivers did engage in secondary activities while driving although the frequency and manner in which they did so differed. Multi-tasking or engagement in more than one secondary activity at one time was present in approximately a third of the data analysed. Some secondary activities were observed for all the drivers while other types of activities only for some drivers. This again substantiate the need for a study where the research has a much larger dataset pool where these secondary activities can be investigated in terms of the influence it has on driving performance and elevated crash risk potential.

Identifying a lack of attention is difficult as it is not always a visible behaviour, but could be a form of mental absenteeism. By purely analysing the videos for physical attributes of inattention, it seems not possible to identify whether or not a person's mind is wandering. Internationally there also seems to be no consensus or accepted definition for what inattention is.

6.2. Normal driving: What does it entail?

As one would expect, normal driving made up the bulk of the driving behaviour for most of the time. However, the amount of time spent on "normal" driving differed among the drivers. Currently there doesn't seem to be any guideline internationally as to what constitutes "normal driving" and the possibility exists that normal driving in South Africa might be different than "normal driving" elsewhere in the world. It is implied that normal driving as is represented in the sample of data may contain attributes to be construed as abnormal is comparison to normal driving in countries that are more road safety conscious. However, a baseline definition was needed in order to code other behaviour and therefore for the purpose of this project normal driving was coded where the behaviour included driving behaviour where the driver had his eyes on the road, hands on the steering wheel and included the drivers waiting in traffic, being stationary or reversing the vehicle.

During the coding process it became evident that "normal driving" does co-occur with other types of secondary activities. An example would be instances where the driver is conversing with a passenger while looking at the road and controlling the vehicle with both hands on the steering wheel.

Initially it was thought that it would be possible to identify distraction based on the vehicle parameters cited in the literature (g-force events). However, after interrogating the vehicle data based on these parameters, no evidence of these g-force events were found for the specific driving period. This is despite that when the video material were analysed, there were evidences of secondary activities that are associated with internationally reported specific divergences in the vehicle parameters such as lateral deviations. This again raises a question as to whether or not South African drivers are so used to driving while engaging in secondary activities that the inattentive behaviour has become the norm rather than the exception. The NDS dataset of a small sample of drivers used for this research project, however, was not large enough, and the timeframe too short to test such a hypothesis and future research should consider exploring what constitutes normal driving and possibly establish a baseline and criteria for what is considered normal driving.

6.3. What type of driver inattention or distracted driving practices were prevalent?

In-vehicle distractions included dining, grooming, person or object related activities, possible distractions due to controls of the vehicle as well as passengers. Outside distractions were coded when there was clear evidence of a distraction, such as the driver turning his head to look outside the vehicle. The outside distractions were not identifiable within the scope of this study as only the driver videos were analysed. Outside distractions was also minimum.

Other distractions that were observed to a lesser extend included seatbelt behaviour as well as smoking behaviour, which was only observed for one driver. In South Africa wearing of a seatbelt is compulsory. Not wearing a seatbelt is not considered a distraction but the action of adjusting the seatbelt (fasten/unfasten) could potentially be.

Some of the behaviours coded and considered as distracting in the literature could, however, also be “normal” behaviours. This includes for example vehicle-related distractions such as looking down at the control panel, shifting gear and so forth that are essential components of the driving task. Future research needs to consider these types of activities in relation to co-occurring with distractions such as talking to a passenger or listening to music.

6.4. What is the significance of the research and what does this mean for future research?

The research has established that secondary activities with the potential to distract attention from the driving task were indeed present for all the drivers. However, the extent to which drivers engaged with secondary activities differed in frequency and duration. To determine the exact nature and impact of these behaviours on a South African driver population a much larger, more representative and culturally diverse sample will be needed.

Internationally, research has found that when drivers engage in grooming activities, they tend to slow down. This could only be observed for one of the novice drivers whereas the other drivers in fact drove slightly faster than normally. Grooming wasn’t something that the drivers engaged in frequently and although the average time allocated to putting on cream (31.2 s) and adjusting clothing (22.95 s) is significant, the risk associated with these activities is probably more orientated towards additional actions associated with the act of grooming, e.g. taking hands of the steering wheel, which have an effect on the physical ability of the driver to respond to changes in traffic situation.

Person- or object-related distractions were observed for all the drivers with looking down at something being the most frequent activity. International research has found a clear relationship between in-vehicle activities such as looking down or reaching for something in the vehicle and crashes. Crash risk increases significantly when eyes are diverted away from the roadway for more than 2 seconds, in this research it was found that the average time of looking down for one of the drivers was almost one minute. The average speed whilst looking down at something was much higher than for the activities such as reaching for something or putting something away. The findings indicate that two of the drivers slowed down significantly compared to their normal driving speeds, one driver drove at the same speed and one of the novice drivers drove faster than on average.

Dining was mostly prevalent for the second child and parent combination (ND1 and ED2). Eating was the most frequent activity coded for dining and lasted the longest. Both drivers significantly reduced their speed when dining and driving compared to normal speed.

Talking on a mobile phone impairs a driver’s ability to maintain an appropriate speed and hampers a driver’s ability to safely react to hazardous situations because a driver is distracted auditory, cognitively as well as physically. Only the experienced drivers conversed on their cell phones while driving. Three of the drivers texted while driving. With the exception of the one experienced driver, all the other drivers reduced their speed while interacting with cell phones in the vehicle.

Passengers as a distraction made up the largest proportion of driving time. Drivers talk to, respond and look at passengers. Driving with passengers though is an everyday occurrence and there might be a need to quantify the acceptable levels and dangerous levels of risk that passengers might hold in distracting the driver. However, when driving with passengers in the vehicle, all of the drivers drove significantly slower than normal.

In addition to the secondary activities described above, smoking and seatbelt behaviour were also observed. Smoking per se is not internationally regarded as an activity that increases risk. However, the associated activities such as reaching for cigarettes, searching for cigarettes as well as for example looking down to light a cigarette might potentially pose a risk to safe driving. In addition, not wearing a seatbelt is not distracting but the realisation during the journey to put it on or unfastening the seatbelt might be.

In terms of the activities that were observed, passenger related distractions were present in the largest proportion of driving time and drivers spent the most time on this activity. Interestingly, the second largest proportion of time was allocated to two types of secondary activities that are not internationally considered as significant, namely smoking and seatbelt behaviour.

Each of the activities observed can be compared to international findings and inferences can be made as to how dangerous these behaviours can potentially be. Each of these activities influences the primary driving task on some level and research has shown that even the slightest shift in cognitive, visual, auditory or physical resources needed to complete the driving task safely, increases the crash, or near crash risk potential.

6.4. Conclusion

Internationally it has been well established that distracted driving practices are a primary cause of crashes and near-crashes. This study contributes to a baseline understanding of what constitutes normal as well as distracted and inattentive driving in South Africa. Currently, only mobile phone use while driving is considered as problematic in South Africa. However, from the findings it is clear that drivers do engage in other types of secondary activities while driving. The frequency with which these activities occurred as well as the amount of time spent on them could potentially be more distracting and dangerous than mobile phone use when driving. A better understanding of distracted and inattentive driving will have many benefits, such as for example driver training that can be better informed by the additional information from NDS. With in-depth knowledge of how, why and under which circumstances distracted and inattentive driving occur in South Africa, it will be possible to plan, design and execute targeted education and communication campaigns as well as law enforcement activities.

In addition to understanding whether or not distracted and inattentive driving might be a concern, the study also set out to determine the value of the NDS methodology within a South African context. Even though this study is not representative of the general South African driving population, it has shown that it is possible to quantify driving behaviour in South Africa with the NDS methodology and that a larger investigation is warranted and necessary to understand the role that distraction play in crashes and near-crashes. This study therefore represents a stepping stone for future human factor research that can be used to curb the road safety problem in South Africa.

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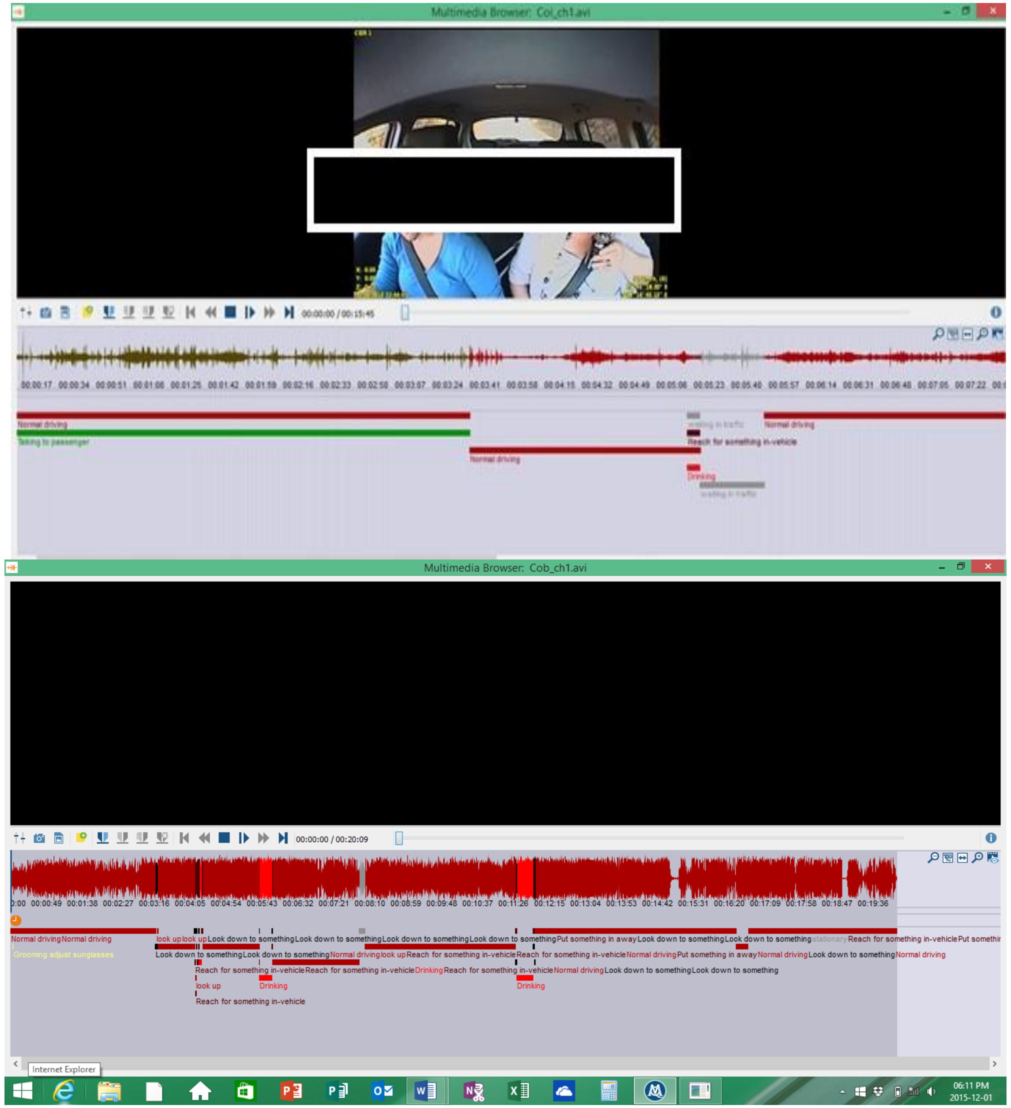
ANNEXURE A: CODING SCHEME DETAILING DISTRACTION ACTIVITIES (HANOWSKI, 2011)			
Type of distraction	**Coding theme**		
INTERNAL DISTRACTIONS			
Person or Object	• Talk/sing/dance with no indication of passenger • Interact with or look at other occupant(s) • Look at internal object • Reach for object in vehicle • Read book, newspaper, paperwork, etc.	• Look back • Put on/remove/adjust clothing Use calculator • Read book, newspaper, paperwork, etc • Look at map • Write on pad, notebook, etc.	• Put on/remove/adjust seat belt • Put on/remove/adjust sunglasses or reading glasses • Put on/remove/adjust hat
Electronic devices	• Dial cell phone • Talk or listen to hand-held phone • Talk or listen to hands-free phone • Adjust earpiece/headset	• Text message on cell phone • Talk or listen to microphone • Interact with dispatching device • Interact with GPS	• Interact with Satellite radio • Use camera • Use/reach for other device
Dining	• Eating • Drink from a container		
Smoking-Related	• Reaching, lighting, extinguishing • Cigarette in hand or mouth • Driver is using chewing/spitting tobacco		
Grooming	• Personal grooming • Bite nails/cuticles • Remove/adjust jewellery • Other personal hygiene • Adjust in seat		
Vehicle-Related	• Adjust instrument panel		

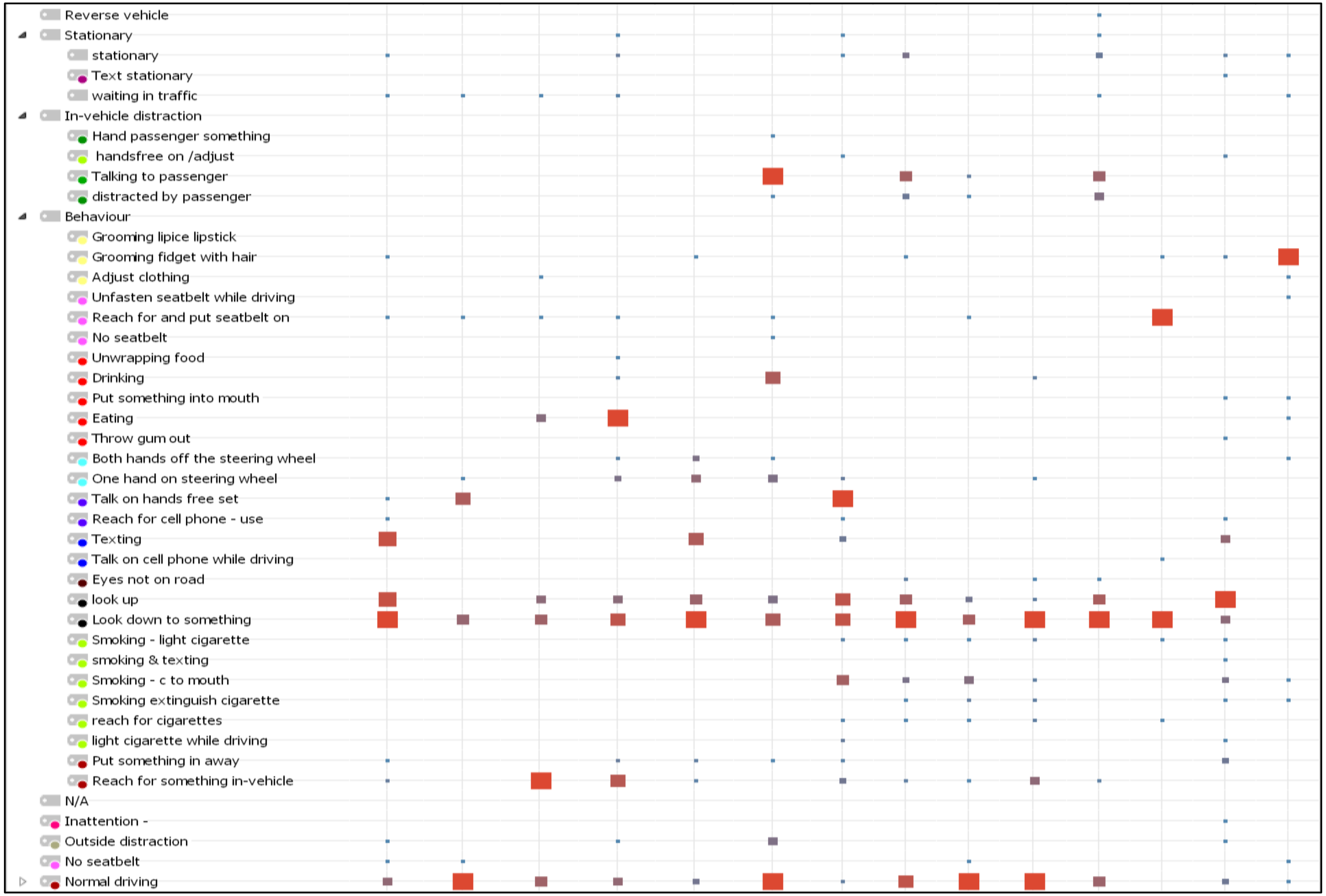
	• Turn on/off cab light • Clean cab interior • Put up/down window
EXTERNAL DISTRACTIONS	• Look at outside vehicle, person, animal, object • Look out rear window (visible rear window) • Wave to passing vehicle/driver
DRIVING-RELATED INATTENTION TO FORWARD ROADWAY	• Look at left-side mirror • Look at right-side mirror • Look at left-side monitor • Look at right-side monitor • Look at centre monitor • Check speedometer
IMPACT TO DRIVING TASK	• Latitudinal error (e.g., steering wheel control error leading to unintended lane deviation/violation) • Longitudinal error (e.g., acceleration/deceleration error leading to headway maintenance violation) • Other
URGENCY	• Urgent (e.g., lit cigarette in lap) • Not-urgent (e.g., texting) • Urgency Unknown (e.g., responding to dispatcher message)
TYPE	• Visual distraction (eyes off road and to distracting Agent) • Manual distraction (hands off wheel and on distracting Agent) • Cognitive distraction (mind off driving and on distracting Agent) • Auditory distraction (hearing off driving and on distracting Agent)

ANNEXURE B: EXAMPLE OF CODING



ANNEXURE C: CODING MATRIXES

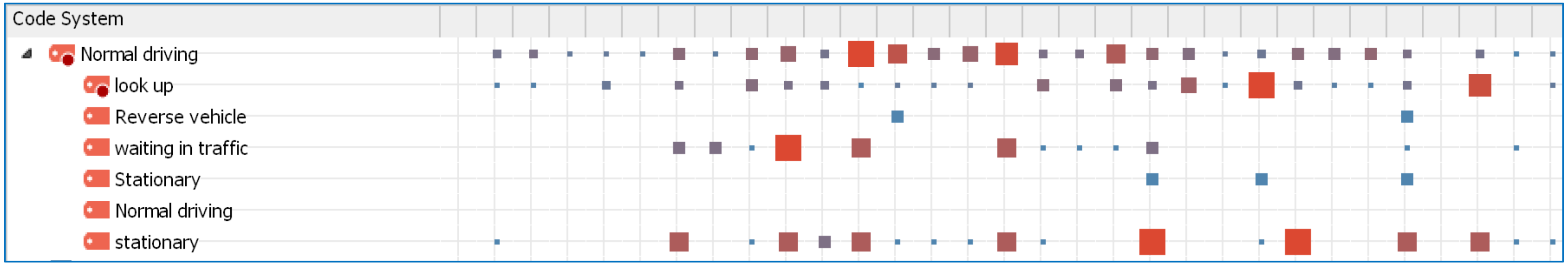
Experienced drivers



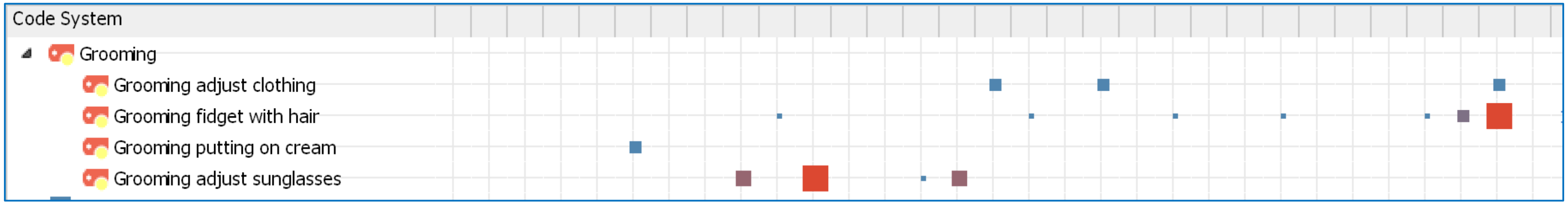
NOVICE DRIVERS

CODING GROUPS

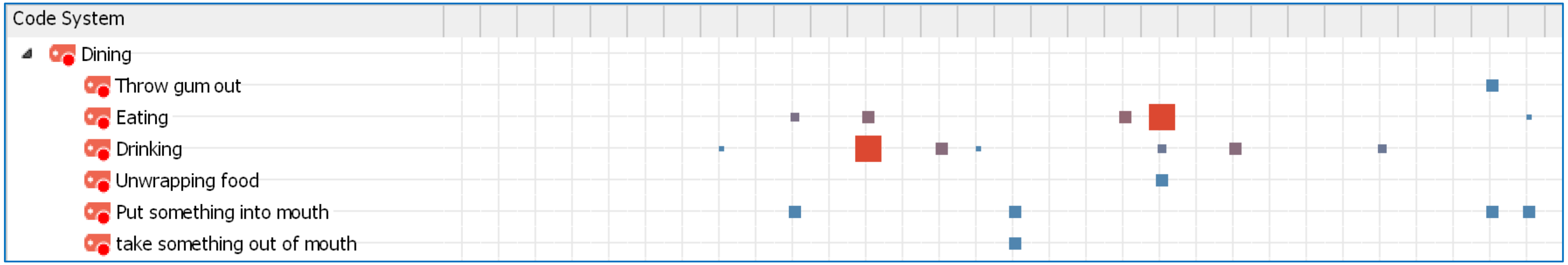
NORMAL DRIVING



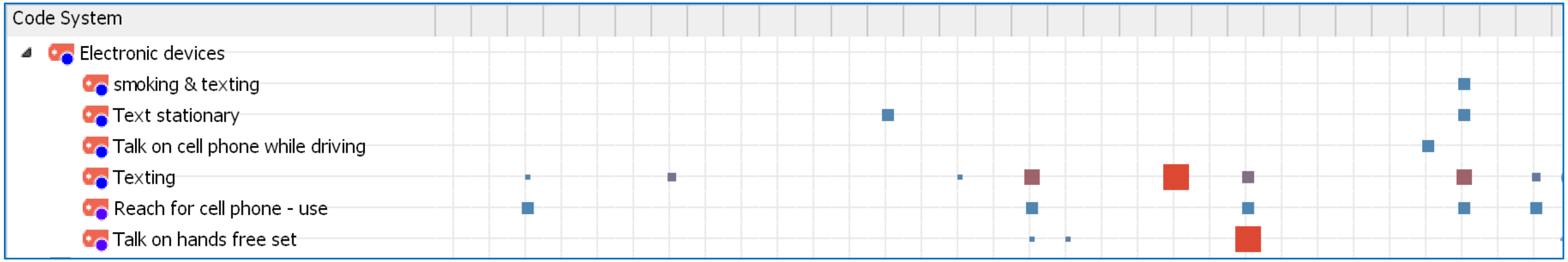
GROOMING



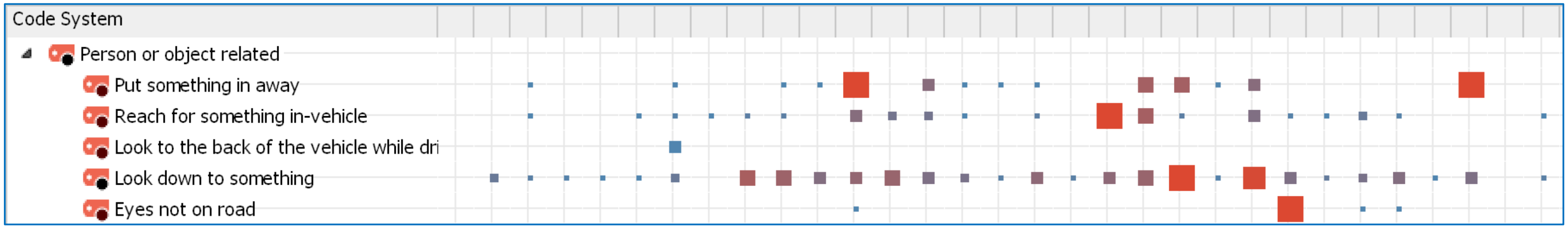
DINING



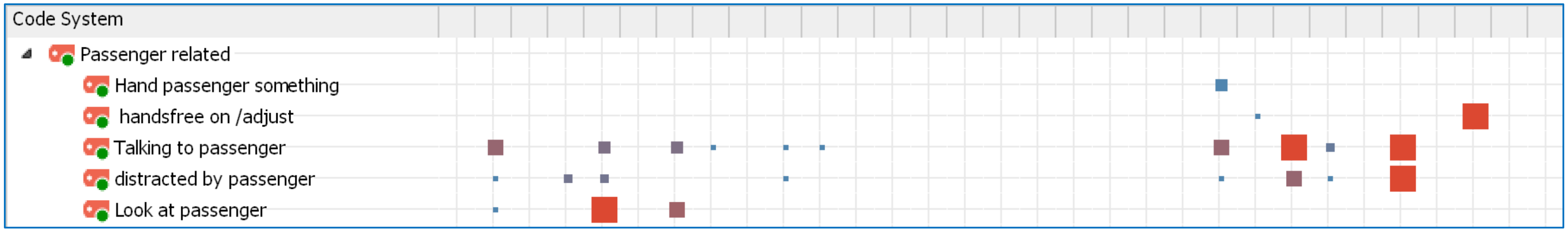
ELECTRONIC DEVICES



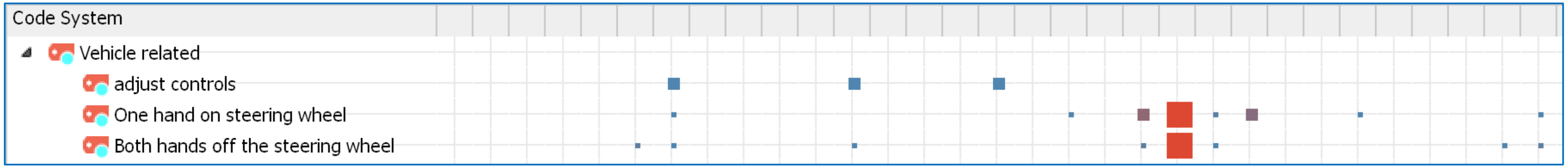
PERSON OR OBJECT RELATED



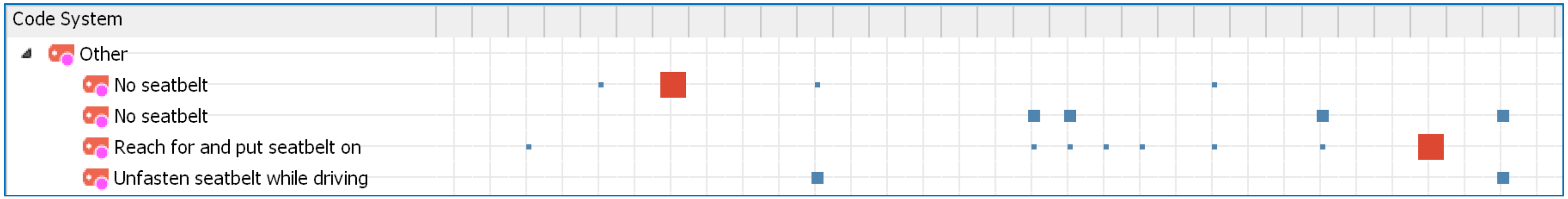
PASSENGER RELATED



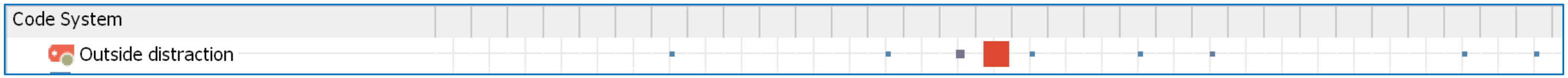
VEHICLE RELATED



OTHER



OUTSIDE DISTRACTION



SMOKING