An Exploratory Study into South African Novice Driver Behaviour

By

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Declaration

By submitting this thesis electronically, I declare that the entirety of the work contained therein is my own, original work, that I am the sole author thereof (save to the extent explicitly otherwise stated), that reproduction and publication thereof by Stellenbosch University will not infringe any third party rights and that I have not previously in its entirety or in part submitted it for obtaining any qualification.

April 2014

EXECUTIVE SUMMARY

Driving is a complex task that requires both the physical ability to drive a vehicle and the cognitive ability to do so safely. The ability to correctly integrate and apply information from the driving environment is essential for safe driving. In South Africa approximately 33 people per 100 000 population are killed annually in road accidents. Recent mortality data from South Africa has indicated that the age group 15 to 19 years old are the age group most likely to be involved in fatal vehicle crashes.

Novice driver behaviour has been confirmed as problematic across the globe and extensive research into novice driver behaviour has been conducted to understand and ultimately to curb novice driver deaths. Very little is known about South African novice drivers. This lack of knowledge makes it difficult to plan for training, education or preparing young South African novice drivers for the challenges they are likely to face on the road.

This study is a first stepping stone to understand this problem. This study utilises naturalistic driving studies as a method to explore differences between novice and experienced driver behaviour at a few preselected location types.

Since 2005 naturalistic driving studies (NDS) have been employed extensively in the rest of the world and this study is South Africa’s first small attempt to employ this methodology and apply it to specifically novice driver behaviour.

This thesis therefore not only explores novice driver behaviour in the context of South Africa, but also provides an overview of how the ND methodology can be developed for use in South Africa.

The document provides an overview of both novice driver behaviour and naturalistic driving study methodologies from abroad. Where available, reference to South African research and reports are made. The literature review considers demographic, developmental and personality factors that could potentially (and have internationally been proven to) influence novice driver behaviour in the context of society, family and physical environments. Popular theories that have been applied to novice driver behaviour are reviewed. These theories include the Theory of

Planned Behaviour, Social Learning Theory and the Theory of Intent. On the methodology side, the technology, its application as well as challenges and successes of the ND methodology are reviewed.

The research process is described in terms of the participants and their risk attitudes to road traffic safety prior and after the study. The research process also details the specifications of the technology used, the data collected and the associated processes to make the data manageable. The research process took a number of unexpected turns which included the development of a coding scheme for the image material. Initially it was thought that this coding scheme should be predefined. However once the coding process commenced it was clear that in-vivo coding was necessary for inclusion of all elements of the environment and the behaviour. These elements differed from video to video and participant to participant. Grounded theory was introduced in an attempt to explain the novice behaviour. Although the data analysed was not extensive enough to substantiate the use of grounded theory it is considered useful in operationalizing this coding scheme in future.

In addition to learning how to work with the data collection systems and how to integrate different types of quantitative and qualitative data in different formats, it also became clear that a strategy for managing large databases should be considered. This was an unexpected spin-off and is currently being investigated.

The findings of the study showed that certain behaviours (such as the left scanning of a driving environment) were neglected not only by novice drivers but also by experienced drivers. Further investigations could include research into understanding this phenomenon. The preselected site types included stop streets, traffic lights, traffic circles and intersections. Traffic lights and intersections in particular have in recent years been highlighted as hazardous locations in Pretoria, where the study took place. Differences in behaviours were highlighted for intersections but not for traffic lights, stop streets or traffic circles. However the difference in the proportion of time that novice and experienced drivers took to scan their environments around these preselected hazardous locations differed significantly. Experienced drivers were much more thorough than their novice counterparts.

This study was aimed at investigating the differences between novice and experienced drivers and aimed to develop recommendations that could potentially have implications for changing the driver training and education milieu in SA. However, the sample size (both participants and material selected for analysis) was too small to make meaningful recommendations towards change in this industry. It did however show clear differences between novice and experienced drivers, even in South Africa, and that this research needs to be expanded. The potential of this research for South Africa is enormous and could quite possibly, in future, change the way in which South Africans drive.

ACRONYMS

AA	Automobile Association of South Africa
DAS	Data acquisition system
DLTC	Driver License and Testing Centre
DoT	National Department of Transport
Enatis	National Traffic Information System
FOT	Field Operation Tests
GRSP	Global Road Safety Partnership
MRC	Medical Research Council
NDS	Naturalistic Driving Studies
NRTA	National Road Traffic Act
PrDP	Professional Driver Permit
RTMC	Road Traffic Management Corporation
SA	South Africa
WHO	World Health Organisation

ACKNOWLEDGEMENTS

"It is good to have an end to journey toward; but it is the journey that matters, in the end." —

Ernest Hemingway

This journey has been incredible in so many ways.

To the University of Stellenbosch, specifically the Dean of the Engineering Department, thank you for the opportunity to complete this postgraduate Engineering degree. To Professor Booysen from the Electrical Engineering Department, for making the grant available with which I was able to buy the equipment for this study.

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CHAPTER 1: INTRODUCTION

1.1. Overview

1.1.1. Background to novice driver behaviour

This study investigates novice driver behaviour in the South African context. According to Jacobs and Aearon-Thomas (2000), the African road safety situation is the worst in the world. Africa is generally considered a low motorised continent but 10% of all road traffic crashes globally, occur in Africa. Regionally, the south of Africa has the highest levels of motorisation and also the highest fatality rate. Between 1990 and 2000, sub-Saharan Africa recorded a 42% increase in road traffic fatalities (Jacobs et al., 2000).

African Ministers have committed themselves to reaching the Millennium Goals (National Department of Transport, 2006). Since this commitment was made a number of other high level initiatives and undertakings were undertaken. The most notable of these, namely the First Global Ministerial Conference on Road Safety (or as it is known, the Moscow Declaration) resulted in Africa recommitting itself to the reduction (halving) of road related deaths by 2014 (Moscow Declaration on Road Safety approved 2009). In 2011 the United Nations (GIS 2011) also launched the Decade of Road Safety Action 2011-2020. Despite all these declarations and actions taken, South Africa still has a poor road safety record. An estimated 14 000 people are killed annually on South African roads with many more motorists seriously injured or disabled (Department of Transport, 2011).

According to the Road Traffic Management Corporation (RTMC, 2011) some progress has been made in terms of reducing fatal road traffic crashes and fatalities. According to this latest annual report, fatal crashes decreased by 0.94% and fatalities by 0.86% during the period March 2010 – March 2011. These reductions, however, are still a long way from halving fatal crashes by 2014.

Human error has been highlighted as the most significant contributor to road traffic crashes in South Africa (Botha and Van der Walt, 2006; Gainewe and Masangu, 2010). Despite human factors being cited as the main contributor to road traffic crashes, it is still the factor that is least investigated and least understood.

One of the neglected areas of traffic management and road safety in South Africa is that of driver training (Ribbens, Venter, Van Niekerk and Venter, 2010). The driver training industry is not regulated, which effectively means that almost anyone can become a driving instructor which affects the quality of drivers and in the long-run the road safety situation on South African roads. Numerous debates around the relevance and efficiency of K53-driving test, standardisation of driver instructor training as well as investigations into the possibility of incorporation of learner driver licensing and driver training into school curriculums have surfaced over the past few years (Ribbens et al, 2010).

The RTMC Road Traffic Report (2009) indicated that, year-on-year; the number of drivers licences issued is on the increase. This includes learner licences, driver licences and professional driving permits (PrDPs).

Table 1: Percentage change in the issuing of drivers licences 2008-2011

	GA	KZ	WC	EC	FS	MP	NW	Li	NC
Change between 2008-2009	3.73%	4.09%	4.08%	3.83%	3.75%	6.28%	3.70%	7.74%	3.90%
Change between 2010-2011	5.82%	4.40%	4.42%	4.21%	3.42%	7.57%	2.56%	8.18%	3.79%

Table 1 represents the percentage change for driver licenses issued per province.

Table 1 illustrates the increase in the issuing of drivers' licenses across provinces in South Africa. The only province that recorded a decline in 2011 – 2012 was the North West Province. The joint significant increases in car ownership and the issuing of driver licenses beg the question of whether or not South African novice drivers are sufficiently equipped to deal with challenges on the road.

1.1.2. Road safety in the SADC region

The Global Status Report on Road Safety (World Health Organization, 2009) indicates that South Africa has reported experiencing approximately 16 000 road deaths annually. This constitutes 33.2 road deaths per 100 000 population. According to this report 56.8% of the road deaths are attributed to crashes involving four-wheel-drive motorised transport, 1.8% involve two-wheel motorised transport, and 2.3% are cyclists and 39.1% pedestrians. It is important to note that non-motorised transport deaths always involve motorised traffic.

In the SADC region South Africa's estimated percentage contribution (Figure 1) to road deaths is 55% (N=28981). This is compared to Mozambique 26%, Zimbabwe 13% and Namibia, Botswana and Lesotho each 2%.

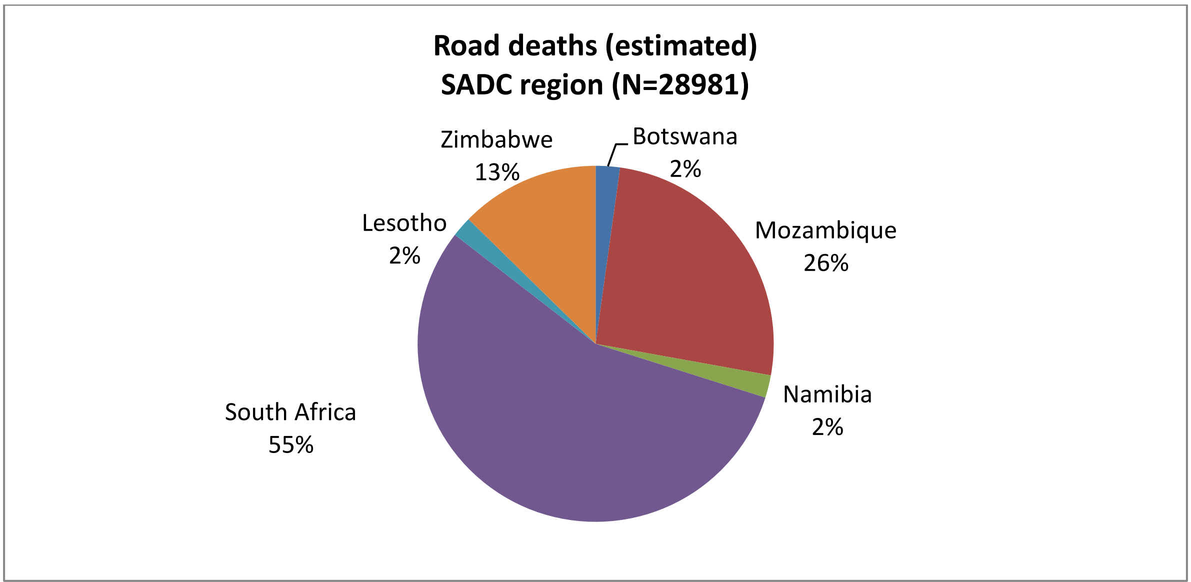

Figure 1: Percentage contribution to SADC crashes (World Health Organization, 2009)

If the actual reported risk of fatality is considered, South Africa seems to have the highest number of fatalities (33.2/100 000 population). This could however, be attributed to the fact that SA has a slightly better reporting system than neighbouring countries.

From the information presented in Figure 2 and 3 below, it is clear that most of the crashes involve four wheel-motorised transport and pedestrians. Botswana and

Zimbabwe had the biggest percentage of four wheel motorised fatalities, followed by South Africa (56.8% of all fatalities).

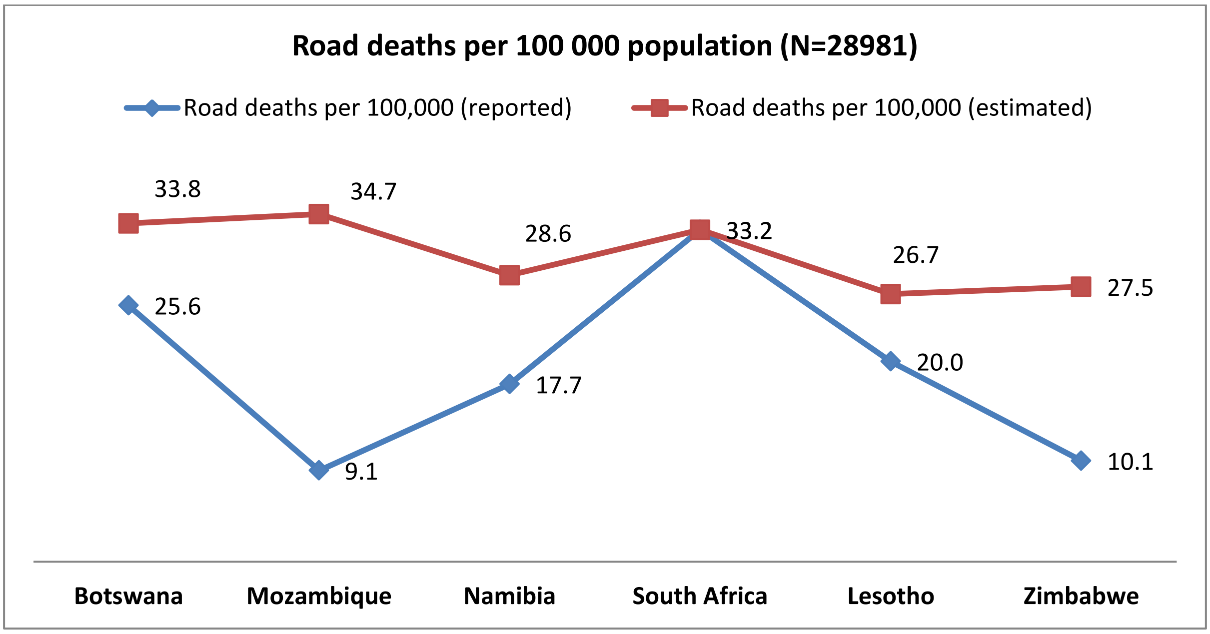

Figure 2: Road deaths per 100 000 populations (World Health Organization 2009)

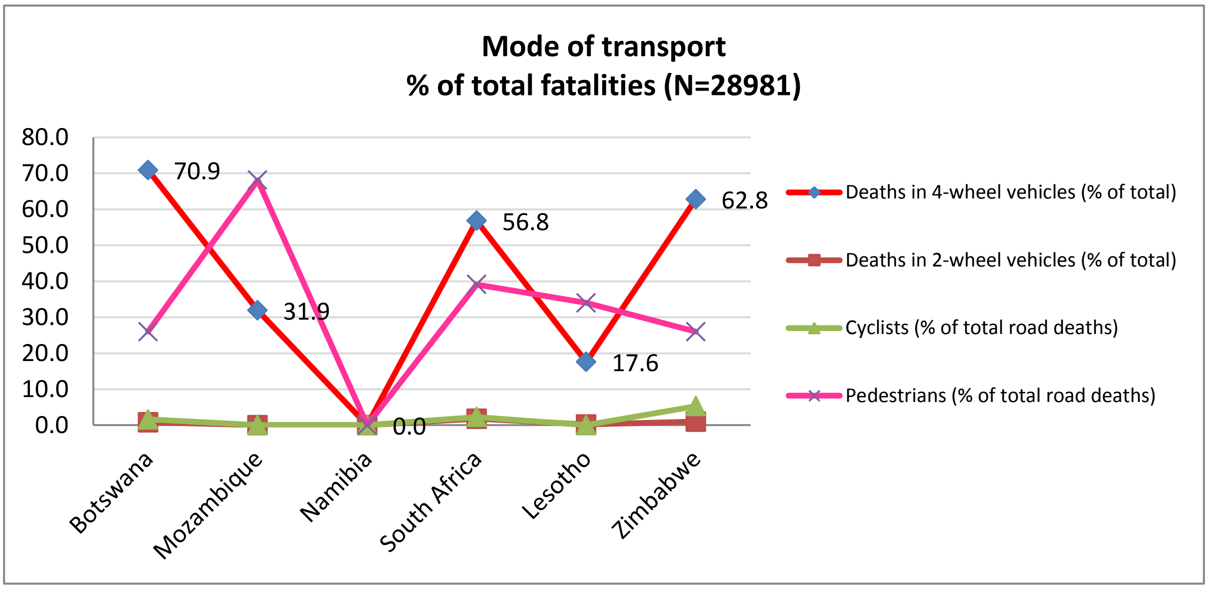

Figure 3: Percentage contribution to fatalities per mode (World Health Organization 2009)

1.1.3. Road safety in South Africa

The South African Road Traffic Act, Act 93 of 1996 makes no specific reference to definitions related to ages for young or novice drivers'. However Chapter 4 (items 15 and 17) of the Act states that in order to be fit to drive the person must:

Learner license:

- be in possession of a learner licence (not younger than 16 years);
- have obtained the learner license through a driver licensing and testing centre;

Driver license:

- have obtained a license for the corresponding type of vehicle that he or she drives;
- be found competent to drive the vehicle that the applicant is applying for;
- be 18 years or older;

All disabilities including sight and vision related problems need to be taken into consideration when testing a candidate.

In South Africa insurance companies are cautious when it comes to insurance for young drivers in their late teens or early twenties. Insurance premiums are calculated according to a sliding scale (Ncaca, 2007). Eighteen year old drivers will pay the highest premium with additional excess charges. Parents of these young drivers often misrepresent information by claiming that they are mostly the driver of the vehicle in order to get lower premiums. Ncaca (2007) quotes international statistics stating that young drivers account for about 45% of fatalities on the road between 11 pm and 6 am. This data also confirms that young drivers are ten times more likely to have an accident at night, rising to 14 times on weekend nights. Arrive Alive in South Africa has found that drivers between the ages of 16 and 19 years are four times more likely to crash vehicles than older drivers (Ncaca, 2007).

Haddow (1988) defined young drivers as drivers between the age of 18 and 24 years. It is expected that South African novice drivers will mostly fall in the 16-24 years age group. There might however, be older South Africans who learn to drive for the first time and who are therefore classified as novice drivers. This is due to the fact that people in previously disadvantaged areas have not always had the means to pay for driver licence tests or might not have had access to a vehicle. Socio-economic changes in South Africa also resulted in changes in car ownership, opportunities to obtain a licence and improved mobility in South Africa as a whole (Mokonyama and Venter, 2007).

Road Traffic Management Corporation data shows that 30-34 year olds (Figure 4) are most likely to be involved in fatal road traffic crashes in South Africa. It is important to note that this crash data includes all road users and not only drivers. A 14.63% increase in fatal crashes is observed from the age 15 upwards to 34 years. The age group 30-34 year old males is the age group mostly affected by fatal crashes. The age group 25-29 years is the second group at risk of being in a fatal crash. If risky behaviour is addressed early on, it is possible that this proportion of crashes can be addressed and lowered substantially.

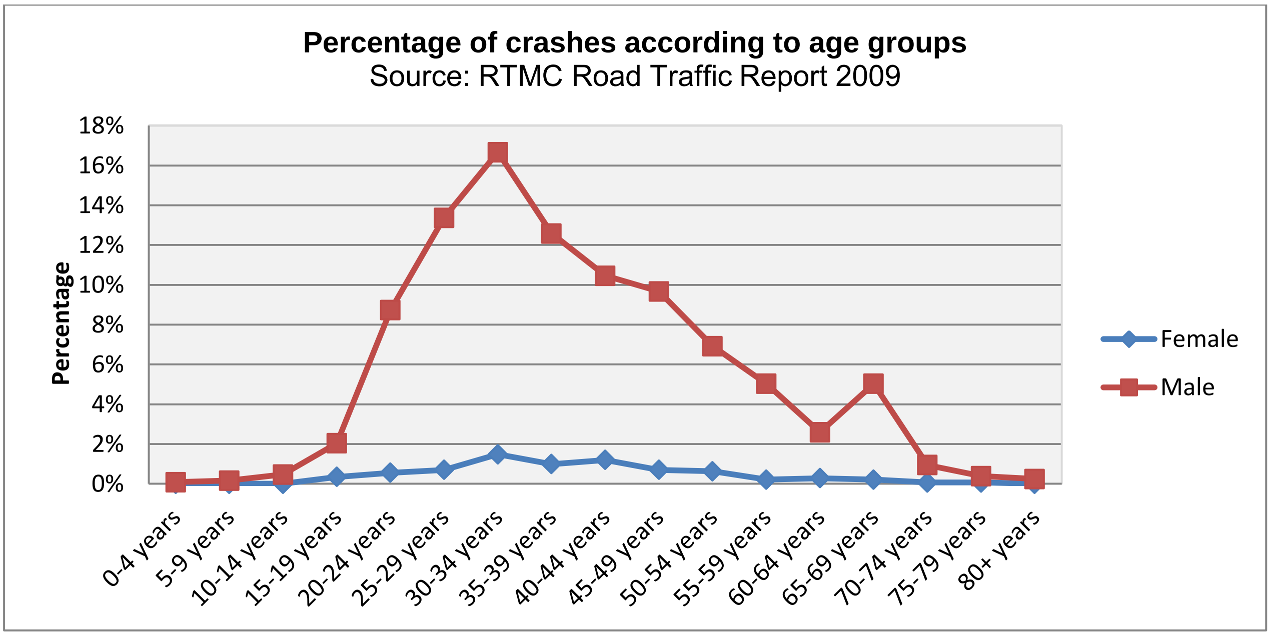

Figure 4: Percentage of fatal crashes per age group, RTMC 2009

Table 4 is quoted from the RTMC Road Traffic Report for March 2008. Two years' worth (year 2006-2007 and year 2007-2008) of actual data is displayed. During the year 2006-2007 only 63.7% of the fatal crashes could be correlated with age groups, the other 36.29 % were reported as unknown. For the year 2007-2008, only 43.4% of the crashes could be correlated with age groups with 56.6% reported to be unknown.

Figure 5 presents the actual number of fatal crashes according to age groups excluding the “unknown” category. For 2006-2007 this amounts to 9884 and for 2007-2008 to 8278 crashes assigned to age groups.

A similar trend is observed for the years 2007/2008 and 2008/2009.

Table 2: Fatal crashes according to age group and year

(Quoted from the RTMC Road Traffic Report 2008)

Age group	Year 2006/07	Year 2007/08
0-4 years	389	313
5-9 years	529	453
10-14 years	410	294
15-19 years	541	466
20-24 years	**1044**	**873**
25-29 years	**1311**	**1140**
30-34 years	**1448**	**1171**
35-39 years	1105	997
40-44 years	1004	798
45-49 years	683	594
50-54 years	531	420
55-59 years	320	263
60-64 years	219	195
65-69 years	128	106
70-74 years	103	71
75-79 years	56	60
80+ years	63	64
Unknown	**5631**	**6349**
Total fatal crashes	15515	14627

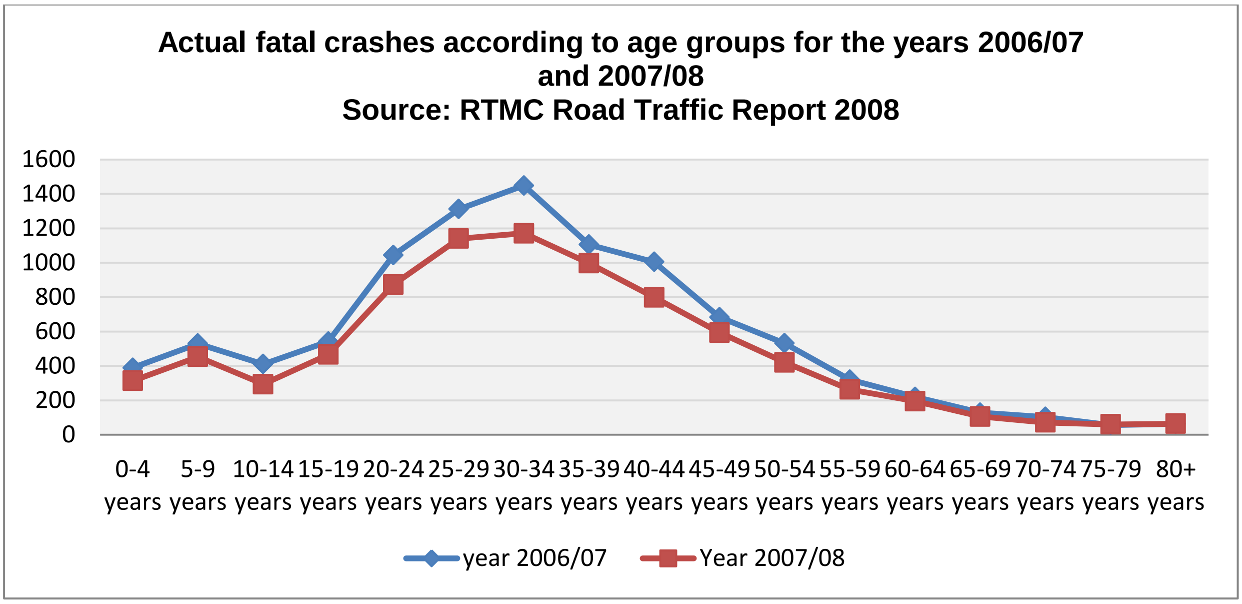

Figure 5: Actual crashes according to age groups 2006/07 and 2007/08

Chokotho, Matzopoulos and Myers (2012) recently calculated age specific driver mortality rates by using Western Cape mortality data. The authors indicated that driver fatality data is often misrepresented in that the analysis normally does not take the age profile of the population into account. This seems to imply that driver deaths are the lowest in the younger age groups when in fact the authors found that age specific mortality driver deaths were the highest in the youngest age group (15-19 years). The authors indicated that a lack of trustworthy data complicates matters even further. The figures below appear in a journal article and provide an overview of age related fatalities as well as driver fatalities per 10 000 licensed drivers. Figures 6 and 7 clearly provide a different picture than that of figure 5.

1.1.4. Recent developments pertaining to novice drivers in SA

In May 2012 the RTMC indicated that in order to address the high fatality rate on the country's roads, it had decided to partner with the private sector to offer driver education classes at no cost (RTMC to roll out project woza re-test, 2012).

In previous years, the Automobile Association of South Africa (SAPA, 2011) and the Medical Research Council of South Africa (Sukhai, Seedat, Jordaan, and Noah, 2004) have called for a three phase graduated licensing system for new drivers. More recently Chokoto et al (2012) also indicated that graduated driver licensing should be considered for South Africa.

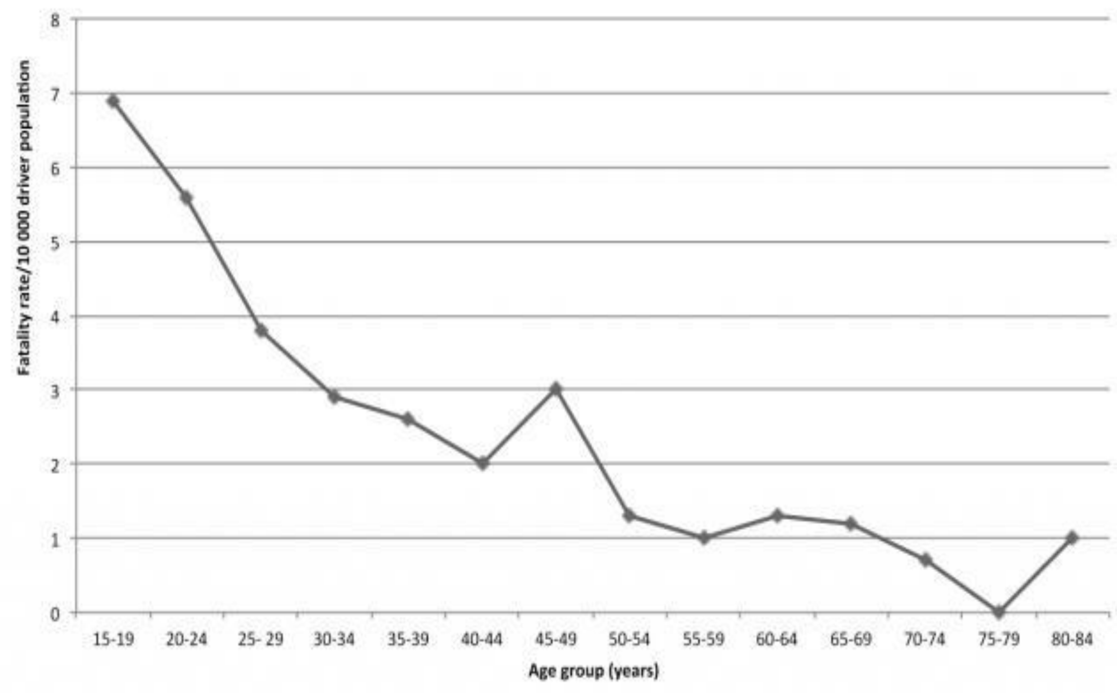

Figure 6: Driver fatalities per 10 000 registered drivers (Source: Chokotho et al, 2012)

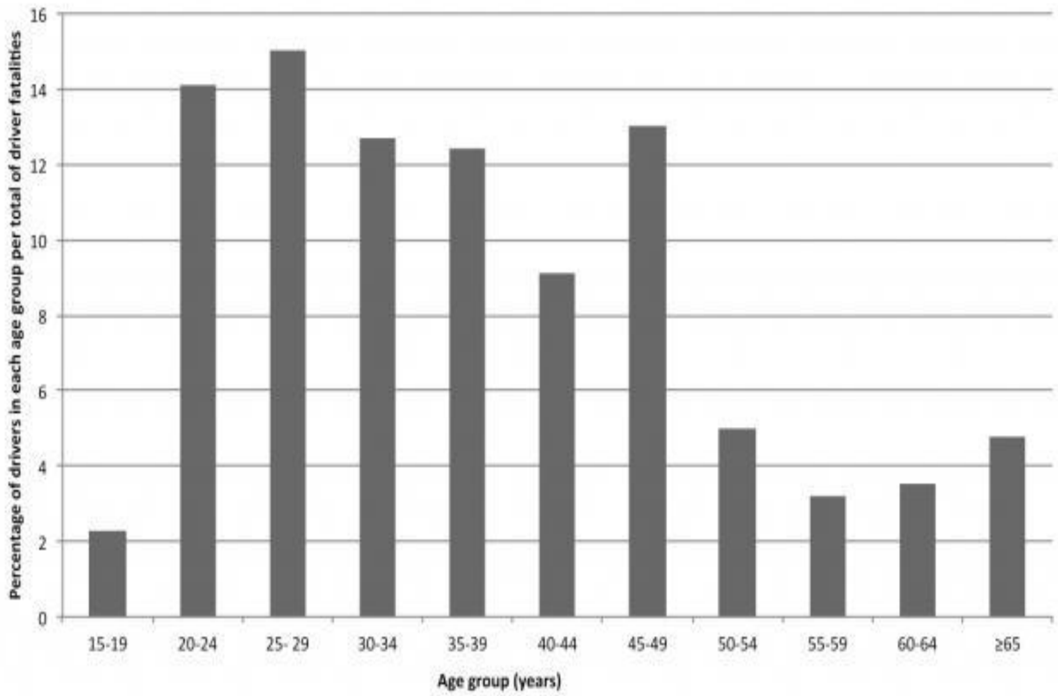

Figure 7: Driver fatalities per age group (Source: Chokotho et al, 2012)

1.1.5. Orientation on the topics under investigation in this study

This project monitors and records the behaviour of novice drivers and compares their behaviour to experienced drivers using a combination of sensors and cameras fitted to the participants' own vehicles. Naturalistic Driving Studies (NDS) have not yet been used in a South African setting. This research study therefore explores the feasibility of using NDS in a South Africa context with special reference to novice driving skills. The Data Acquisition System (DAS) allows for investigating the detailed actions involved in driving to be examined at microsecond level.

This study therefore explores two different topics.

The first topic under investigation is novice (newly licensed) driver skills. International literature on the subject gives a clear indication that newly licensed drivers are at their most vulnerable during the first 18 months after they successfully obtain their licenses. The second reason for investigating novice driver behaviour in South Africa revolves around the exorbitantly high number of fatal and serious crashes that occur on South African roads. By identifying at-risk behaviour early on it is possible to make recommendations applicable to driver training methods, content and legislation for young and inexperienced drivers in South Africa.

This study considers the problems associated with inexperienced and novice driving by making use of the NDS methodology and applying this methodology in a South African context. The research takes into account the possible factors that contribute to the problem of young and inexperienced drivers in South Africa.

The second topic under investigation is the application of the Naturalistic Driving Studies (NDS) methodology in a South African context. The term "naturalistic driving studies" refers to an unobtrusive approach to studying driver behaviour. This methodology enables researchers to study driver behaviour in the context of the driving task and road environment and informs researchers about 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.

A Data Acquisition System (DAS) consisting of cameras, various sensors, a computer and global positioning system collects data about the driver, road environment, vehicle performance and interactions with other vehicles. This information can give valuable insight into driver behaviour in different driving situations and under different circumstances. Internationally this methodology has been embraced by the United States, Europe, Canada, Japan and Australia. Through participation in the International NDS project South Africa has the unique opportunity to contribute to this important research study by delivering data that reflects the nature of intrinsic road safety aspects from a developing country's perspective.

Results from this NDS study could potentially provide support for the use of large large-scale NDS in a South African setting. If implemented on a larger scale the research could in the long run, provide valuable information on the driver behaviour of novice South African drivers. This could result in recommended changes to the current driver training practices as well as provide a better understanding of novice driver behaviour, skill and experience after licensing.

Although novice driver behaviour is scrutinised and compared with experienced driver behaviour, the DAS also collects important information on the vehicle and the driving environment. This information collected from the DAS is incorporated in the analysis in order to better understand the driving conditions, road safety situations as well as the driver's handling of the vehicle. Novice driver behaviour is therefore correlated with specific environments and driving conditions as well as speed of the vehicle, vehicle position etc.

1.2. Problem Statement

Novice drivers are at their most vulnerable when they start driving, especially during the first 18 months after licensure. Hazard perception is a skill that is learned over time and with driving experience. Internationally it seems that there are significant differences between novice drivers who have had previous training and novice drivers who had a minimum of driver training before they are issued with their licenses.

1.3. Research questions

a) How are hazards perceived by novice drivers?

b) How do novice drivers react and adapt to those hazards?

c) What differences exist between hazard perception in novice drivers and experienced drivers?

d) What are the differences in skills between novice drivers who have had previous training or driving experience, compared with novice drivers who have had little or no driver training before licensure?

1.4. Research objectives

In order to address these questions the study aims to measure the following indicators related to driving skill:

- Skills relating to the handling of the vehicle;
- Hazard identification skills;
- Perception of risk on the road;
- Adjustment to and handling of risk on the road.

Specific objectives will include:

- Determining the level of skill that novice drivers possess when they start driving;
- Exploring and understanding the sequence of decisions that novice drivers make when initially exposed to hazardous and dangerous driving situations;
- Comparing the sequence of decision making of the novice drivers with those of more experienced drivers in similar circumstances;
- Informing the development of approaches that could improve driver training methods and systems in South Africa;
- Exploring the feasibility of developing driver simulation technology for improved driver training in a South African context.

1.5. Hypothesis

Normally a research study would have one or more hypotheses which need to be proved or disproved. In this instance the most likely hypothesis would be to investigate whether:

> H_{0b}: experienced drivers detect and respond better to hazards than novice drivers or that.
>
> H_{1b}: there is no difference in hazard perception between experienced and novice drivers.

In this exploratory research study, the nature and type of data collected for this research study was of such a nature that a) the amount of quantitative and qualitative data was unknown at the start of the project and b)it had to be determined whether or not the actual image material would indeed result in something significant which was unknown. However if the analysis of the image material does result in some significant findings the results would have been assembled from relatively little or no evidence by building on the gathered evidence in order to explain a phenomena rather than searching for associations between evidence that would prove or disprove the theory. For this reason, grounded theory is deemed helpful with other driver behaviour theories (if applicable) applied to explain specific aspects of the behaviour that has been identified.

Grounded theory makes use of the best method available (Griffiths, 2013). Video data was the main tool utilised to collect the data.This collection of video behaviours culminated in the basic building blocks for understanding the process (and ultimately building a theory that could potentially explain the progression of hazard perception skills in novice drivers).

1.6. Delineation and limitations of the study

1.6.1. Lack of South African literature

Research related to young drivers in South Africa is limited. A review of the Road Traffic Management Corporation's (responsible for collecting and collating crash data in SA) annual reports revealed information on the number of learner driver licenses, driver licenses and public transport permits issued per year. These reports contain no information on age groups of road users or victims of road crashes in South Africa. In the section “Recent developments pertaining to novice drivers in South Africa” the main source of information was media reports obtained from various South African websites. Although websites are not normally considered to be a credible source of information, this source was used due to a lack of other scientific and research sources.

1.6.2. Recruitment of the “most suitable” participants

The recruitment of appropriate participants for this study was especially difficult. Secondary schools were considered to be an ideal context from which to recruit potential novice drivers. The schools however, declined to participate due to consent issues and the Department of Education’s stipulations. More information about this is provided in the methodology section.

Although a number of older and experienced drivers were willing to participate, this willingness diminished once the novice driver was brought into the equation. Two potential participant groups withdrew after realising that the cameras would be installed in the novice driver’s vehicle. These novice drivers were considered ideal for the study as the cameras would have been installed in the vehicle approximately one week after licensure. The reasons for withdrawing included the parents’ concern that the cameras might influence the newly licensed driver’s safety (own driver behaviour compromised by the presence of the cameras) and cited insurance issues possible run-in with law enforcement and so forth as problematic issues in granting permission for the novice drivers to participate in the study. This resulted in the recruitment of novice drivers who still complied with the 18 month risk period but who have had more experience than was initially anticipated.

1.6.3. Data collection challenges

The study proposal indicated that data would be downloaded weekly. Although utmost care was taken by the researcher to comply with this, it did happen that bi-weekly downloads were sometimes necessary. This was due to some of the participants going on vacation (April and June school holidays), being admitted to hospital and starting their tertiary education. The researcher was required to adapt to the participants daily and weekly programmes in order to keep the data collection process and intrusion into their lives at a minimum.

1.6.4. Quality of the data collected

Ninety-five per cent of the data collected is considered to be of good quality. However, the experienced drivers drove much longer distances with their vehicles. This compromised some of the data collected. The data logger (quantitative information) records all vehicle movements and a full record of all driving periods was available. The video data were problematic as the recorder restarts itself once the disc is full. This means that although there is information for all vehicle movements there might not be matching videos for those movements. This resulted in the researcher being required to match the log files and corresponding video files manually. This process (in which the images and log files were matched) is described along with the data reduction process in chapters 3 and 4.

GPS data was also not available in all the downloaded files. It seems that in some instances satellites were not observed/available which resulted in some of the vehicle movements and associated videos being omitted. The GPS data is dependent on the system locating satellites. When the vehicle was turned on and stood in doors (e.g. in a garage) the satellites could not be located until the vehicle was on the outside and moving.

1.6.5. The amount of data collected and skills to analyse the data

Large amounts of quantitative and qualitative data has been collected in this research study. The task to capture, transcribe and successfully analyse this data was enormous. This necessitated that the researcher develop a research protocol to reduce the amount of data to be analysed in order to get meaningful results. The different data sets require different analysis skills. It is fully possible for a multi-disciplinary team to mine and analyse this data, but such multi-disciplinary teams do not yet exist in South Africa. There should be a concerted effort to develop and cultivate teams who are capable of analysing this data optimally.

1.7. Underlying assumptions and motivation for the research

NDS incorporates a large number of different data collection techniques, storing of large bodies of data, analysis and finally application of the research findings in a meaningful way.

NDS has not yet been used in a South African setting. This research study therefore explores the feasibility of using NDS in a South Africa context with special reference to novice driving skills.

Results from this NDS study could in the long run, provide valuable information around the driver behaviour of novice South African drivers. This could potentially result in recommended changes to the current driver training practices as well as provide a better understanding of novice driver behaviour, skill and experience after licensing.

This project monitored and recorded the behaviour of novice drivers and compared this behaviour (in similar situations) with that of experienced drivers using a combination of sensors and cameras fitted to the participants' own vehicles. A range of predetermined events was defined and recorded among selected drivers over a specified period. The Data Acquisition System (DAS) collected data to allow for the investigation of the detailed actions involved in driving to be examined at microsecond level.

Although novice driver behaviour has been scrutinised in this study it is important to remember that the DAS can also collect important information on vehicle and driving environment.

This information collected from DAS is incorporated in the analysis in order to better understand the driving conditions, road safety situations as well as the driver's handling of the vehicle. Novice driver behaviour is therefore correlated with specific environments and driving conditions as well as speed of the vehicle, vehicle position, etc.

1.8. Significance of the study

1.8.1 Novice driving in South Africa

It is envisaged that these results could be used to gain insight into:

- The level and sequence of learning that takes place during the period directly after licensing;
- Knowledge, attitude and perceptions of the driver regarding the newly acquired skill, risk and challenges experienced;
- Improvement in the level of skill acquired after licensing;
- How learning processes and the quality of instruction influence acquisition of driver skills;
- Travel patterns and habits of newly licensed drivers.
- Identification of education and remedial strategies for improving experienced driver skills.
-

Results could in future inform:

- New policies related to driver training and testing.
- Recommendations on the revision of the K53 driving test.
- Improved driver instructor practices.
- The development of new methodologies to facilitate learning associated with acquiring this skill.
- Legislation applicable to newly licensed drivers (e.g. following times, traffic violations).

1.8.2. NDS as a new methodology

Through participation in the International NDS project South Africa has the unique opportunity to contribute to this important research study by delivering data that reflects the nature of intrinsic road safety aspects from a developing country's perspective.

1.8.3. Management of large databases

An unforeseen consequence of the study was learning to work with and manage large databases containing different types of data. Different methodologies to code and analyse the data were tried and tested. The amount of data that was generated was staggering and more detail regarding the storage and management of the data will be provided in chapter 3.

1.9. Overview of chapters

1.9.1. Chapter 1: Background to the study

Chapter 1 provides background information related to the research study. An overview of road safety in SADC countries and South Africa provides the context in which this study takes place. Chapter 1 provides information on novice drivers in South Africa and recent developments and initiatives that have been implemented to improve novice driving and licensure in South Africa. Chapter 1 also substantiates the reason for making use of NDS as a research methodology to investigate novice driver behaviour. The research questions and objectives are addressed and the limitations of study highlighted.

1.9.2. Chapter 2: Literature review

The literature review has two distinct purposes. Firstly, the literature review considers characteristics of novice drivers. Internationally, novice drivers are considered to be most at risk or most vulnerable during the first few months after licensure. The literature review takes into account social, personality and other contextual factors that might influence novice driver behaviour.

Secondly, the literature review provides an overview of NDS as a research methodology. It compares NDS to field operational tests (FOT's) and provides an overview of literature and projects that have been utilising the NDS methodology in the past few years.

1.9.3. Chapter 3: Research methodology

This chapter provides an overview of the research design (the design of the experiments) as well as the methods used to collect data. Mixed methods were used to collect and analyse both quantitative and qualitative data. The research methodology is explained in terms of the research instruments used to collect the quantitative and qualitative data and the processes followed in making the different types of data ready for analysis. The methodology chapter provides an overview of the data acquisition system as well as the qualitative software purchased for the qualitative analysis. The methodology chapter summarises how the different novice and experienced driver videos were selected for the analysis.

1.9.4. Chapter 4: Overview of the application of the coding scheme

This chapter also describes the development of a coding scheme for hazard perception in novice drivers and reasons for using grounded theory in an attempt to explain the process of how hazard perception changes over time for/in novice drivers. Grounded theory was used to provide a platform for the in-vivo coding which was only introduced in the project when the coding commenced. This chapter provides an overview of the codes generated; it touches on the main themes and provides the context for analysing the driver behaviour videos.

1.9.5. Chapter 5: Findings

Chapter 5 provides an overview of novice driver behaviour with special reference to four hazardous situations. These hazardous situations were identified for both novice drivers and similar situations were selected for experienced drivers although much fewer videos were coded for the experienced drivers. Applicable literature is referenced with respect to the findings. The results indicate that traces of hazard perception or the lack thereof can be identified.

The first part of the chapter summarises the information and findings from the data logger and video equipment as separate “entities”. The second part of the chapter provides an overview of the combined findings from selected videos. In the second part of the chapter the codes (as developed in the coding scheme) were applied to the selected video material and integrated with the data from the data logger.

In terms of the differences between novice and experienced drivers, differences were found in the manner in which novice and experienced drivers approach intersections and their right-turn behaviour at intersections. No significant differences between experienced and novice drivers were found for driver behaviour at stop streets, traffic lights or traffic circles. These four location types have been highlighted in literature as areas where potential traffic conflicts can arise and in especially Pretoria where this study was conducted, intersections, traffic lights and stop streets have been highlighted as hazardous locations. Differences in the amount of time that novice and experienced drivers allocate to scanning their environments were found. An interesting finding was that novice drivers (and in some instances experienced drivers) fail to scan the left of their environment. Experienced drivers did however allocate more time to scanning their environments and mirrors than novice drivers. Additional behaviours considered included speeding behaviour, behaviour at road works, distracted behaviour and behaviour in parking lots.

1.9.6. Chapter 6: Conclusions and recommendations

Recommendations and suggestions for future research are put forward. This chapter focuses on not only novice drivers but also provides recommendations for the methodology that was used, the coding scheme that was developed and their application.

In future, larger, more diverse samples might yield more representative findings which could inform the development of new training methods. Currently the sample size was too small and not representative of the South African population to come to representative conclusions.

CHAPTER 2: LITERATURE REVIEW

2.1. Introduction

2.1.1. Overview

Novice driver behaviour has been a topic for scholarly discussion for many years. The reason is because novice or young drivers, who have recently obtained their licenses, are overrepresented in road traffic crash statistics (Mayhew and Simpson, 1995; Deery, 1999; Scott-Parker, Hyde, Watson and King, 2013). Through the years several studies have documented the sharp increase in crash statistics of newly licensed drivers (irrespective of the age that drivers start to drive) in the first six to eighteen months of driving. There seems to be agreement among most researchers that novice drivers are in danger due to a) their age (developmental and personal factors that influence safety behaviour) and b) the level of driving experience that they have/do not have with driving on the road.

Figure 8 below illustrates the magnitude of the problem with the red arrow clearly indicating that traffic crashes are the main cause of death in the age group 15-24 years.

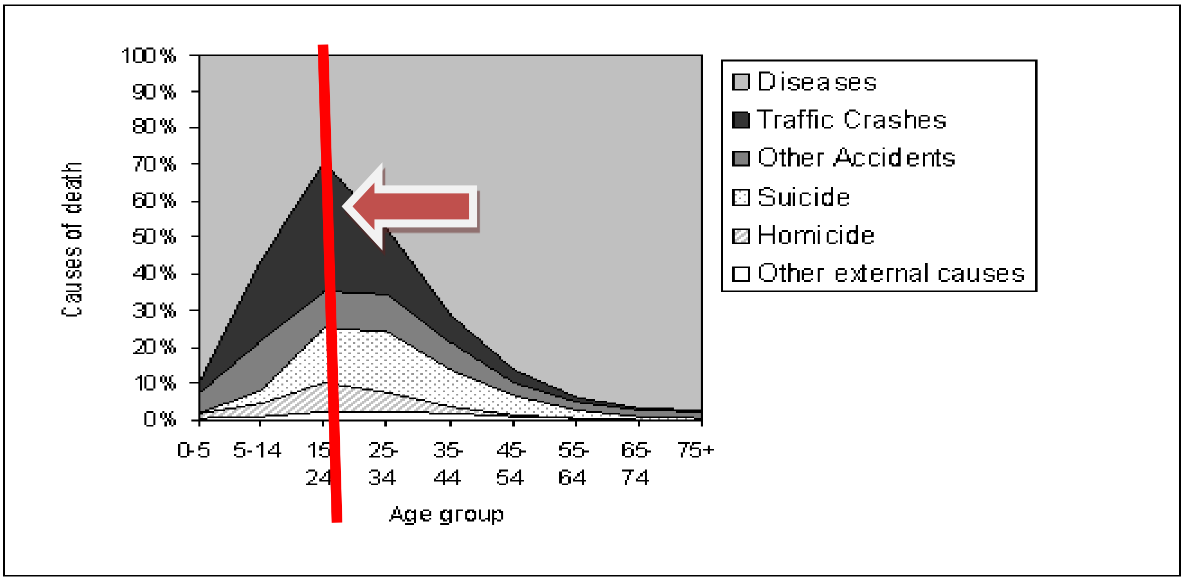

Figure 8: Representation of young drivers' age 15 to 24 years (EU) (World Health Organisation, 2009)

The European Union examples show that young drivers under the age of 25 years account for the biggest proportion of traffic fatalities in developed countries (World Health Organisation, 2009). According to the EU (European Commission for Economic Development, 2006) young drivers in OECD countries represent approximately 27% - 35% (or 25 000 people) fatally injured per annum (figure 8). SafetyNet (2009) reports that in the EU drivers between the ages of 18-24 are 2-3 times more at risk of being involved in a fatal crash than older drivers. This trend seems to be common to most developed countries including the UK, Sweden, Ireland, USA, Australia, France, New Zealand, Germany etc. (Kinnear, 2009).

McKay, Cobin and Larkin (2003) highlight the fact that in the USA in 1999, young (licensed, 16 years and older) drivers made up approximately 7% of the US driving population but were involved in 15% of all the crashes recorded. Furthermore the researchers highlight the fact that these young drivers were to blame for the crashes in 80% of the events.

Taris (1997) indicated that at least 25% of crashes in the Netherlands can be directly or indirectly attributed to the involvement of novice drivers. Similarly in Italy motor vehicle crashes is the main cause of death among 15–34 year olds with the largest number of road traffic crash fatalities falling in the 18-29 year old group (Bina, Grazziano and Bonino, 2006).

Mann (2010) stated that in 2008, 2853 people were killed on British roads. Overall 861 drivers (±30% of the crashes) were involved in traffic crashes. Young or novice drivers aged 17-24 years were involved in 635 of these crashes. Novice drivers therefore represented 74% of the total number of British drivers involved in fatal crashes during 2008.

More recently Scott-Parker, Hyde, Watson and King (2012) indicate that crash rates for young drivers (aged 25 years or less) and fatality rates in Australia have declined in recent years (decreases from 28.0% to 26.2% of driver deaths between 2001 and 2010) but that young people in Australia are still overrepresented in road crashes (crash data).

Although South Africa has no formal definition of a novice driver, insurance companies are conservative when it comes to insuring young drivers in their late teens or early twenties. Insurance premiums are calculated according to a sliding scale (Ncaca, 2007). Eighteen year old drivers will pay the highest premium with additional excess charges. Parents of these young drivers often misrepresent information by claiming that they are the primary driver of the vehicle in order to qualify for lower premiums. Ncaca (2007) quotes international statistics stating that young drivers account for about 45% of fatalities on the road between 11 pm and 6 am. This data also confirms that novice/younger drivers are ten times more likely to have an accident at night, rising to 14 times on weekend nights. Arrive Alive in South Africa has found that drivers between the ages of 16 and 19 years are four times more likely to crash vehicles than older drivers (Ncaca, 2007).

2.1.2. Defining novice or young drivers

Different authors have different criteria according to which a novice or young driver is defined. Again the definitions tend to vary from country to country and researcher to researcher depending on the research topic.

Kinnear (2009) states that in the United Kingdom, novice drivers refer to any driver younger than twenty years or to any older driver who has not yet been driving for three years.

A British report of the House of Commons (House of Commons, 2007) states that the definition of novice drivers leans towards drivers with less than three years driving experience. The report states that all drivers in Britain under the age of twenty are considered novice drivers. The report acknowledges that there has been a surge in the number of people 25 years and older who are issued with their licenses for the first time. Novice drivers are therefore in all age groups. Casualty and crash data in the UK includes age but not the date when the person obtained his or her license. Data that reports on "novice driving" in Britain therefore uses youth as proxy for the young drivers as an accident prone group. The House of Commons (2007) recommended that the term "young drivers" be used rather than "novice drivers". Young drivers are defined as drivers between the ages of 16-24 years (House of Commons, 2007; Ivers et al, 2009).

The West Australian Government (Western Australia Department of Transport 2011, p.102) distinguishes between two types of novice drivers. The following definitions are applied to novice drivers in Australia:

Novice driver type 1: *"A person is a Novice Driver Type 1 until they have held a driver's license for a period of at least one year or periods adding up to one year, and includes a first time learner's permit holder. Up until the end of the first year of holding a license a person will only be able to have three (3) demerit points recorded against them. If four (4) or more demerit points are recorded against a person, they will be disqualified for at least three months and any driver's license held will be cancelled".*

Novice driver type 2: "*A Novice Driver Type 2 is a person who has held a driver's license for more than one (1) year but less than two (2) years. Up until the end of the second year of holding a driver's license, a person will only be able to have seven (7) demerit points recorded against them in total. If eight (8) or more demerit points are recorded against the person, they will be disqualified for at least three months and any driver's license held will be cancelled".*

Therefore the difference between the two licenses is that for Type 1 the novice driver has held the license for less than a year and is not allowed to accumulate more than three demerit points while the Type 2 driver license is issued to drivers who have successfully held their type 1 license for 12 months. The Type 2 licenses are applicable for a further 12 months and the driver is not allowed to accumulate more than 8 demerit points.

The South African Road Traffic Act, Act 93 of 1996 makes no specific reference to definitions related to ages for young or novice drivers. However chapter 4 (items 15 &17) of the Act states that in order to be fit to drive the person must have a:

Learner license:

- be in possession of a learner licence (not younger than 16 years);
- obtained the learner license through a driver licensing and testing centre;

Driver license:

- obtained a license for the corresponding type of vehicle that he or she drives;

- be found competent to drive the vehicle that the applicant is applying for;
- be 18 years or older;

All disabilities, sight and vision related problems also need to be taken into consideration when testing a candidate.

Haddow (1988) defined young drivers as drivers between the age of 18 and 24 years. It is expected that South African novice drivers will mostly fall in the 16-24 years age group. However, there may be older South Africans who learn to drive for the first time and who can therefore be classified as novice drivers. This is due to the fact that people in previously disadvantaged areas did not have the means to pay for driver licence tests or might not have had the means to own or have access to a vehicle. Socio-economic changes in South Africa also brought about changes in car ownership, the opportunity to obtain a licence and to improved mobility in South Africa as a whole (Lombard et al, 2007).

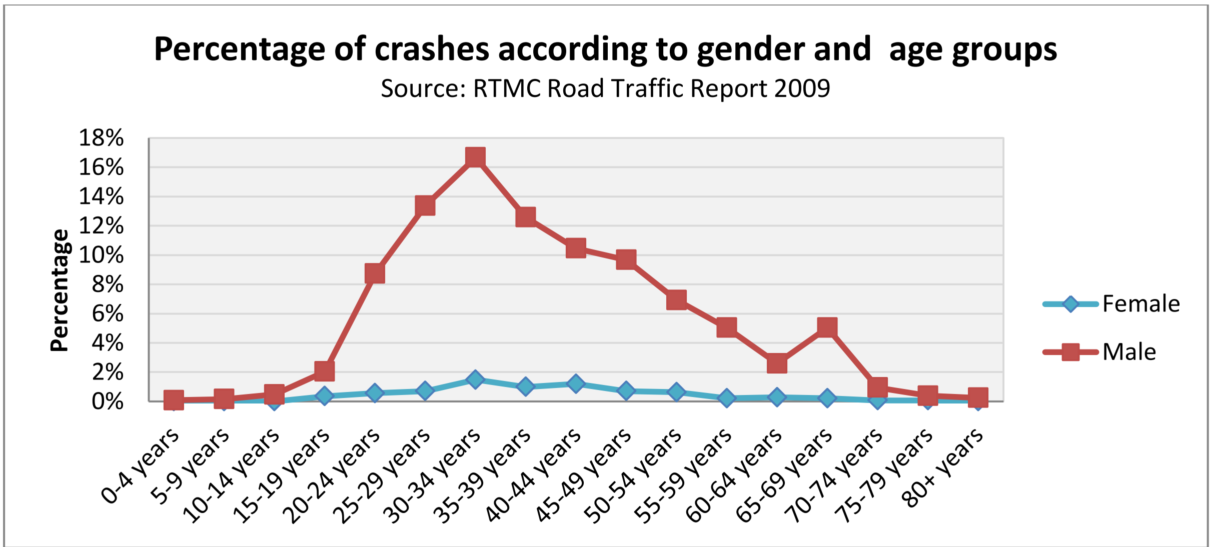

Figure 9: Percentage of fatal crashes per age group, RTMC 2009

The Road Traffic Management Corporation data however, paints a different picture, with 30-34 year olds (Figure 9) seemingly being most affected by fatal road traffic crashes in South Africa. A 14.63% increase in fatal crashes are observed from the age 15 upwards to 34 years. The age group 30-34 year old males is mostly affected by fatal crashes. The age group 25-29 years is the second group most at risk of being in a fatal crash. However, it should be remembered that the crash statistics include fatality of pedestrians. If only drivers were considered the picture might change substantially. Should risky behaviour be addressed early on in individuals' lives, it is possible that this proportion of crashes can be addressed and lowered successfully.

In order to get a working definition for a young or novice driver as well as in an attempt to not exclude any new South African driver, all of the above criteria have been considered. Part of the South Australian Type 1 definition of a novice driver seems to be the best fit: "A person is a Novice Driver until they have held a driver's license for a period of at least one year". This encompasses factors such as age, experience and development of appropriate skills.

2.1.3. Scope of this literature review

This literature review comprises two parts. Firstly, international research related to young and novice drivers' perception of risk, actual risk associated with young drivers as well as behaviour, personality and developmental traits that have internationally been correlated with young drivers is considered. The literature review provides an overview of education practices, licensing procedures and the use of in-vehicle technologies to train, research and assist novice drivers with their task.

The second part of the literature review describes NDS as it has been applied in an international context, highlighting the differences between experimental and laboratory research *vs.* NDS. It describes the most important findings from different NDS projects and presents an overview of the technology to be used in this study.

2.1.4. Limitations

Research related to young drivers in South Africa is limited. A review of the Road Traffic Management Corporation (responsible for collecting and collating crash data in SA) annual reports revealed information on the number of learner driver licenses, driver licenses and public transport permits issued per year. These reports contain no information relation to age groups of road users or victims of road crashes in South Africa. In the section "Recent developments" pertaining to novice drivers in South Africa the main source of information was media reports obtained from various South African websites. Although websites are not normally considered to be a credible source of information, this was resorted to because of a lack of other scientific and research sources.

2.1.5. Conclusion

There does not seem to be a clear consensus of what is meant by a novice or young driver. Rather it seems as if there is a collective agreement among researchers that novice driving is associated with demographic factors such as age and gender and as a result of the demographics e.g. age, developmental limitations such as reduced ability to perceive hazards and skills pertaining to the handling of the vehicle. For the purpose of this study “novice drivers” will be defined as having obtained their license in the previous six months. This is based on the research that the novice driver seems to be at his or her most vulnerable during the first 6-18 months of licensure. For the purpose of this study and in an attempt to understand the impact that age has on driving ability, the participants recruited were between the ages of 18 and 24 years.

2.2. Overview of driver behaviour research: theories and methodologies

2.2.1. Overview

A large amount of research is available dealing with novice driving. Different theories have been developed in an attempt to explain young and novice driver behaviour. Theories include deviance or criminological theories as well as sociological and psychological theories. Different methodologies are used to investigate driver behaviour. An overview of traditional as well as new technology orientated approaches including the NDS methodology will be reviewed.

2.2.2. Applicable theories for novice driver behaviour research

According to Williams and MacShane (1994) theories are generalisations that explain how events are related to each other as well as the circumstances under which these relationships occur. For the purpose of this literature review a number of social theories will be examined in order to explain the different aspects of novice driver behaviour. Four theories might be applicable to this research study. The first three theories (Theory of Planned Behaviour, Theory of Problematic Behaviour and

Theory of Intent, Expectation and Implementation) deal with characteristics of individuals that might explain their inclination or disposition to engage in certain types of behaviour. The last theory (Theory of Social Learning) describes processes and mechanisms through which individuals interact and are influenced by different spheres of social groups.

2.2.2.1. Theory of planned behaviour

The Theory of Planned Behaviour (TPB) can be used to understand driver behaviour and to explain differences in behaviour as the result of individual personality traits, such as sensation seeking (Yagil, 2001). It is commonly used to provide a deeper understanding of driver behaviour in an attempt to explain differences in behaviour based on individual personality traits, such as sensation seeking (Yagil, 2001). According to Taris (1997) the choice of a particular action is based on the attitude towards that action as well as subjective norms (what society at large thinks about the action). A commonly held belief is that speeding is motivated by the thrill or excitement associated with breaking the law by driving faster than the legal speed limits (Fleiter, Lennon and Watson, 2010). High sensation seekers, described by Zuckerman (1979) (Arnett 1994, p. 289) as people who need — *"varied, novel and complex sensations… [and thus] … take risks in order to gain such experience"*, are frequently studied in relation to risky behaviours such as speeding. A positive correlation has been found between sensation seeking and speeding (Arnett, Offer & Fine, 1997; Jonah, 1997; Yagil 2011). Sensation seeking has also been associated with attitudes towards the commission of traffic violations on the road (Yagil, 2001). Yagil showed that this correlation had an indirect effect on the intention to commit driving violations. High sensation seekers have more positive (high-risk) attitudes towards committing violations on the road than low sensation seekers (Yagil, 2001). Male drivers tend to seek sensation and according to Whisell et al (2003), the sensation seeking personality promotes risk-taking and high levels of sensation-seeking is often found in young male drivers. Yagil (2001) concluded that attitude rather than subjective social norms, were a better determinant in predicting the intention to commit a traffic violation.

2.2.2.2. Problem Behaviour Theory

Mann (2010, p. 6) states that Jessor and Jessor's 1977 Problem Behaviour Theory (PBT) illustrates the reasons why young people that engage in one type of risky behaviour (for example smoking) are also likely to partake in other risky behaviour such as driving under the influence of alcohol or marijuana. According to the Problem Behaviour Theory, problematic behaviour is classified as problematic, dangerous or inappropriate in relation to the existing social norms and standards of the society in which an individual lives. In response to this behaviour society exercises certain social controls (e.g. suspension of license when caught driving under the influence of a substance). Mann (2010, p6) defines it as follows: "*behaviour that is socially defined as a problem, as a source of concern, or as undesirable by the social and/or legal norms of conventional society and its institutions of authority; it is behaviour that usually elicits some form of social control response*".

Modern society organises itself in terms of rules and regulations and citizens are required to fit a specific profile and to live according to specific guidelines. When people do not conform to these guidelines, their behaviour is classified as problematic. This is important in the road and traffic environment as everything that happens on the road has clear and formal legal guidelines according to which drivers should behave. Novice drivers with less experience and no clear sense of the regulations might find themselves intentionally or unintentionally on the wrong side of the law or in hazardous situations that they might not yet know how to solve. This theory has possible implications for addressing risky behaviour before it starts. If the predisposition factors that lead to this risky driving is understood, it may be possible to address these factors with appropriate and timely interventions.

2.2.2.3 Theory of Intent, Expectation and Implementation

Mahardika, Ewing and Thomas (2009) distinguishes three concepts related to implementing a specific behaviour or in other words taking a certain action. Although these concepts were applied to consumer behaviour it is possible to extend these concepts to the driving context. According to Mahardika et al. (2009) intention is a major factor in making decisions related to either perform or not to perform an action (targeted behaviour). Behavioural intent is seen as a key factor in the prediction of behaviour. Behavioural intent is therefore defined as the *"degree to which a person* *has formulated conscious plans to perform or not perform some specific future behaviour" (Mahardika et al, 2009, p.6).* Behavioural expectation refers to *"the individual's estimation of the likelihood that he will perform some specified future behaviour" (Mahardika et al, 2009, p.6).* Implementation intent refers to *"specific plans that identify both a goal directed response and suitable situation in which to initiate that response" (Mahardika et al, 2009, p.6).*

Within the driving context the intent could for example, refer to a driver who beforehand decides to speed or to drink and drive under the influence of alcohol. However, intent could change over time as the time beween the intended and actual behaviour elapses. Within the driving context this gap (temporal instability) might provide a window opportunity to address or change for example the intend to "drive risky". This theory might also provide a basis for the design of educational and marketing material to address novice driver behaviour (target behaviour). Application of this theory will be developed as the research progresses.

2.2.2.4 Social Learning Theory

The Social Learning Theory from Akers (Akers, 1979) seems to be the most popular theory to explain novice driver behaviour. Scott-Parker, Watson, King and Hyde (2012) highlight the fact that the risky driving behaviour of young drivers should be informed by psycho-social theories that can explain the underlying behaviour and be used to formulate countermeasures and road safety policies.

Scott-Parker et al (2012) refer to the fact that when young drivers learn to drive a vehicle, they are exposed to positive and negative influences of peers and significant others. The Social Learning Theory revolves around the fact that primary learning is either operant or instrumental conditioning through which behaviour is shaped by the stimuli and consequences of the behaviour (Akers et al 1979). Social behaviour is shaped through direct conditioning or imitation of significant others e.g. parents, friends and authority figures (Akers et al, 1979; Scott-Parker et al, 2012). This behaviour is strengthened through reward or avoided because of punishment. Whether deviant behaviour persists is based on past experiences of how this behaviour has been rewarded or punished. Alternative behaviour is adopted through differential enforcement. People learn through social interaction with significant others in their lives. Acceptable social norms and values are defined by these significant groups. The more the individual defines the behaviour as ‘good’ or acceptable the more the individual will adopt the behaviour. These definitions are reinforced verbally and cognitively. The behavioural effects are rooted in the interaction between the individual and these significant other groups. Of these groups the most important are family and peer groups. If deviant behaviour such as risky driving is not addressed (punished), this behaviour is reinforced and justified. According to the theory social learning orders and specifies the relationships between different variables of interaction while “differential association” refers to the individual’s identification with different groups in society (Akers et al, 1979). This association emphasises the relationship between the individual and the different reference groups that influence the individual directly or indirectly (Krohn et al, 1985). A number of road safety studies on young drivers support the differential association and social learning theories. This include studies investigating the influence of peers and significant others on seatbelt use among Spanish drivers (Gras et al, 2007), willingness to drive without a license (Watson, 2004), anger and driving (Deffenbacher et al, 2001) as well as peer influences on speeding behaviour (Fleiter et al, 2006;).

Scott-Parker, Watson and King (2009) investigated the relationship between the Social Learning Theory, Social Identity Theory and psychosocial factors including age, gender and exposure. Scott-Parker et al (2009, p.472) state that *“Social Identity Theory (SIT) asserts that in order to maintain positive self-esteem and social identity as a member of a certain group, an individual makes inter- and intra-group comparisons across important salient dimensions of attitudes, behaviours, and other characteristics that favour the individual belonging to that group”* The researchers apply this theory to driving by pointing out that most novice drivers know what the “right” driving behaviour is, but that they modify their behaviour in order to fit in with the group and so develop their social identity.

Scott-Parker et al (2009) compare the Social Learning Theory (SLT) and Social Identity Theory and suggest that the SLT explains the associations with friends as models of attitudes and values as well as the significant other group that reinforces these behaviours through rewards or punishment. On the other hand the Social

Identity Theory speaks to the individual's sense of belonging and fitting in with a group of friends. Both these theories are used to explain novice driver behaviour.

2.2.3 Conclusion

Driving behaviour cannot be explained at the hand of just a single theory. Driver behaviour is influenced by personal dispositions, individual characteristics as well as the environment in which the individual functions. It is therefore important to consider all possible influences which might sculpt behaviour.

2.3. Novice driver behaviour

2.3.1. Background

Novice driving has been thoroughly researched through the years. Aspects of novice driving that have been investigated include personality characteristics, psychosocial elements; including cognitive issues explaining reduced ability to recognise hazards or potential hazardous or anticipation of unexpected situations and how to appropriately react to these situations. Intra-personal aspects investigated include personality traits such as impulsivity, aggression, hostility, deviance and self-control. Developmental research focused on the young drivers' need to experience sensation, cognitive egocentrism as well as overrated feelings of grandiosity such as feeling invulnerable and not being at risk. Driving experience and correlations with age have informed a number of interventions, policies and approaches for training young and novice drivers. Another large body of research investigates the training and practical aspects of how to improve young driver skills and to assist novice drivers in developing the necessary know-how to drive safely.

Tilleczek (2004) describes novice driving as "in the process of learning to drive, youth are engaged in attaining a critical journey towards adulthood". Access to a vehicle and being able to drive opens up a whole new world to any new driver. With this new world though comes a new level of responsibility to ensure both the drivers' own safety as well as that of other drivers on road.

Figure 10 below illustrates factors which need to be considered when trying to understand novice and young driver behaviour and crash involvement. The different categories or factors highlighted in the illustration will guide the discussion that follows. It should be noted that these factors do not function in isolation but are integrated and relationships between different factors are cross-cutting.

Novice driver behaviour will be discussed in detail with special reference to experienced drivers and possible differences or similarities.

2.3.2. Demographic factors

2.3.2.1. Gender

Young male and female drivers have different characteristics. Risk-taking behaviour is commonly associated with young males rather than females (Bina et al, 2006). Similarly, risky driving is reported to be associated with younger male drivers rather than older male drivers (Ivers, et al, 2009). Australian research found that young male drivers often had their licenses suspended or cancelled and are more likely to be apprehended for a driving offence than females (Vassellos et al, 2009). Whissell and Bigelow (2003) administered a self-reported risky driving questionnaire to a cohort of students and found that crashes were associated with gender, age and accident history. The incidence of crashes per kilometre driven was much higher for young male drivers in comparison to young female drivers. Vassellos et al (2009) found that young males are also more inclined to engage in other risky driving behaviours such as drinking and driving whereas females would rather abstain from drinking alcohol at all if they know they are going to drive. On the other hand they found that females tend to drive fatigued more often than males.

2.3.2.2. Age

In some countries licensure is as young as at 16 years (Deery, 1989). Lohero and Mayhew (2010) emphasised that 16 year old drivers have three times the crash risk than 18 year olds. McKnight et al (2003) state that even if licensure is delayed until 18 years, the pattern of high crash involvement is still high for the first year of driving after receiving a license for the first time. One of the reasons that age is important revolves around the fact that a 16 year old’s brain has not yet been developed fully.

De Craen (2009) stipulates that most importantly the frontal lobe that deals with 'executive' functions and which is essential for safe driving has not yet been fully developed. This includes the ability to plan ahead, control impulses, reason, etc. Isler and Starkey (2008) indicate that a young adult's prefrontal lobe is only fully developed by the age of 25 years.

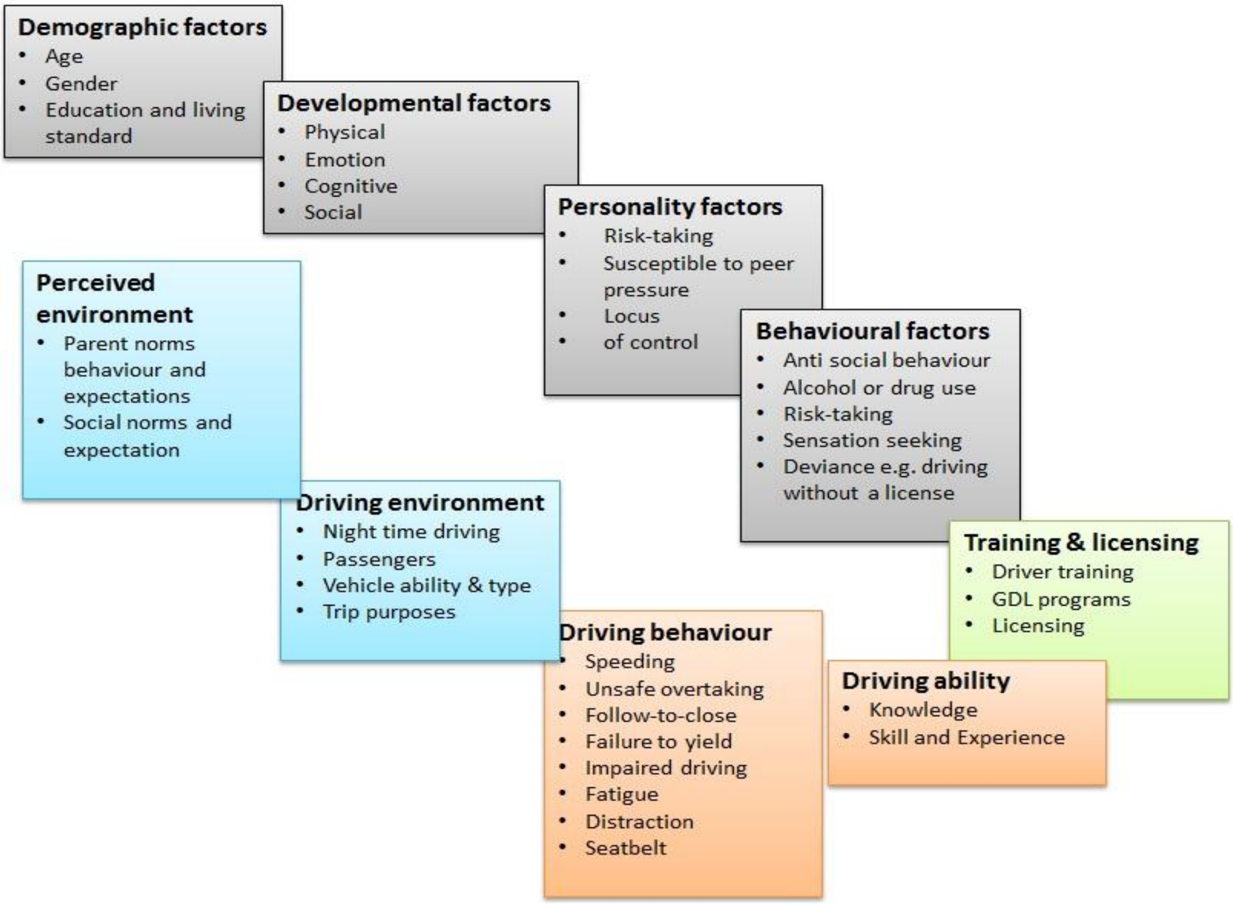

Figure 10: Factors affecting novice drivers (adapted from Shope and Bingham in Road Safety Authority Ireland, 2007).

Amarsingha and Dissanyake (2013) compared police crash data for novice (15 year to 24 year old) and experienced drivers between the years 2006-2009. In comparison with experienced drivers, the novice drivers were more likely to be involved in crashes during the darkness, in clear weather and on rural roads and roads with speed limits less than 60 km/h. Drivers with more experience on the other hand, were more likely to crash in work zones. The authors conclude that safety perceptions and behaviour are developed long before the novice driver actually starts driving and education programme are essential in instilling good safety principles from an early age.

2.3.3. Developmental factors

The fact that the brain of a 16 year old novice driver has not fully developed yet, could explain why novice drivers tend to take risks, are influenced by peers and significant others and why it takes years to develop the executive functions that are needed for driving.

Mäntyläa et al (2009) investigated developmental differences in the pre-frontal cortex of young novice drivers and the effect that development had on mediated executive control functions needed for driving. Executive functions refer to functions that are regulated by the prefrontal cortex of the brain. The prefrontal cortex regulates working memory, decision-making, the ability to distinguish between actions (e.g. right/wrong) consequences of action and so forth. This part of the brain is therefore essential in regulating driving actions.

In simulator research (Mäntyläa et al, 2009), high-school students completed a simulated driving task as well as six experimental tasks. The experimental tasks explored executive functions while driving. The results indicated that the individual differences in executive functioning were definitely related to simulated driving performance. It was found that participants with lower executive functioning made more mistakes in the simulated driving experiment. The findings revolved around the fact that lower executive functioning puts a driver at risk of an accident just after licensure due to the fact that their working memory and automation processes have not yet been developed properly. Similarly, Arnett (2002) focused on the developmental differences in 16 and 17 year old novice drivers. One of the critiques from the researcher was that in most novice driver literature these two age groups are clustered together without taking into account their developmental differences. The researcher states that these age groups should be seen as two entirely different life stages, where 16 year olds are still dependent on others, staying at home and most likely living with their parents. Seventeen year olds on the other hand are leaving school and entering a new life stage possibly away from home and independent. Understanding these developmental changes could greatly influence the way that researchers and practitioners think about and design driver education programmes (Arnett, 2002).

Whissell et al (2003) found that although young drivers are more likely to crash, the researchers indicated that most young drivers intentionally speed excessively or deliberately engage in behaviour that could cause crashes. The researchers therefore recommended that individual patterns of high risk driving be identified. The fact that young drivers are cognitively less mature could influence decision-making abilities which affect driving skills and choices made on the road. One of the solutions offered was to develop processes that could identify high risk drivers early on an attempt to rectify attitudes, beliefs and ultimately behaviour. The research also suggested that young drivers might only exhibit sensation seeking behaviour in the driving context. The research did not find a strong correlation between personality and driving but rather highlighted the role of situational factors suggesting that the choice of riding companions (peers), chosen route/distance and physiological factors played a bigger role in becoming sources of error for drivers.

De Craen et al (2008) monitored speed adaptation for novice drivers. This research highlighted the perceptions of speed in simple and complex driving situations by comparing novice (inexperienced) drivers' choice of speed with that of experienced drivers. The findings suggested that young, overconfident drivers were less inclined to adapt to slower speeds in complex situations than experienced and insecure drivers.

An interesting suggestion (Boyce et al, 2002) is that younger drivers were found to adapt more quickly to new driving circumstances than their middle-aged counterparts. Research (Boyce et al, 2002) also found that younger drivers exhibited riskier behaviour on all tasks except in relation to turning signals. Even though the researchers highlighted this as positive they reiterated the fact that younger drivers spent much more time on secondary tasks while driving.

Young et al (2007) stipulate that younger and older drivers have been found to be more prone to engage in secondary tasks while driving than experienced or middle-aged drivers.

In an attempt to identify contributing crash factors Braitman et al (2008) studied crash reports of novice drivers involved in a traffic crash within the first eight months of licensure. The researchers identified three factors that according to them, equally contributed to young drivers being involved in crashes. These included failing to see another vehicle or traffic control device along with speeding behaviour and loss of control of the vehicle. These contributing factors were caused by the novice driver as a result of not looking carefully, distraction, or inattention.

Driving skills improve over time and limited skills are associated primarily with the performance aspects of driving. These performance aspects are related to tasks at hand including the handling of the vehicle, use of the steering wheel to track the road as well as time to respond to traffic hazards (Deery, 1999).

Critical skills that need to be developed include hazard perception, attention control, timesharing and calibration. Hazard perception relates to the detection, identification and dealing with traffic hazards.

According to Keating et al (2008) the most recent research on maturation and development of adolescents has been in the areas of physical, psychosocial and brain development. According to these researchers, adolescence is the time when most cognitive development can be observed. Thinking becomes less abstract, which allows the young person to make considered multiple actions. This development also enables the young person to make decisions by anticipating consequences that stem from behavioural actions. Emotional liability is an additional developmental factor that needs to be taken into consideration with novice drivers (Ginsburg et al, 2008). All of these developmental issues are linked to self-perception, prone to be influenced by peer pressure and an increased need for autonomy. Keating et al (2008) indicate that for the young driver this novel way of thinking has implications for safe driving. Psycho-cognitive development assists the novice driver in developing expertise in order to competently and safely negotiates perceived risk. The novice driver now has the ability to reason better, process information faster and focus on acquiring a new skill such as driving. Experience is gained through continued practice and training of the skill.

As young people become older the number of fatalities and crashes decreases as the person becomes physically and psychologically more mature (Scott-Parker et al, 2009). According to Kinnear et al (2008) young drivers still need to develop the ability to recognise possible consequences resulting from current actions. Young novice drivers lack the ability to apply selective attention, anticipate things happening in traffic and do not have the skills to regulate their emotions. Young drivers lack the necessary skills to reason and make decisions in traffic, struggle to process event sequences and are slow to adapt to new situations.

2.3.4. Personality factors

Evidence from different studies associates personality characteristics such as sensation, lack of impulse control and aggression with being predictive of risky driving. On the other hand, altruism and consideration for others are associated with safer driving (Durkin et al, 2003). Engstrom, Gregersen, Hernetkoski, Keskinen and Nyberg (2003) point out that in terms of personality factors, aggression and sensations seeking were the most important predictors of accident involvement in novice drivers.

Trimpop, Herr and Kilkardy (1999) investigated the influence of personality traits of novice Canadian drivers. In this research it was found that risky behaviour and recklessness are not necessary interrelated. They also highlight the fact that their research indicated that some people plan ahead and plan carefully for their risk-taking behaviour.

Ulleberg and Rundmo (2003) investigated risky driving behaviour in novice drivers using a “personality-trait approach” and a social cognition approach. Personality measures addressed included: aggressiveness, unselfishness, nervousness and normlessness. The research found that these personality factors influenced risky driving indirectly as these personality traits determine attitudes to the behaviour. Higher scores on the sensation-seeking, normlessness and aggression scales were positively correlated with higher occurrences of risk-taking when driving (Ulleberg et al, 2003; Gulliver et al, 2007). Normlessness was associated with low barriers (resistance) towards influences from misbehaviour such as violating traffic rules and regulations. High scores on altruism and anxiety scales showed the opposite, namely that these individuals tend to follow the norm and traffic rules and regulations.

In 1998 Deery et al identified five clusters of sub-groups of young novice drivers based on personality traits and driving-related behaviours. After identification of the sub-types, the young novice drivers were exposed to a driver simulator where their results were matched with those of the earlier clusters into which they were categorised. Definite differences in driving style and especially how they behave in different situations e.g. emergency situations were highlighted. The research illustrated the fact that young novice drivers are not a homogenous group and that driver training and interventions should be adapted for different personality types.

Ulleberg (2001) identified six clusters of novice drivers. High risk groups included participants that scored high on sensation-seeking, irresponsibility and aggression but low on altruism and anxiety. This first group mostly consisted of young men. This group had confidence in their driving skills despite the fact that they also had the highest record of accident involvement. The second highest risk group comprised participants who scored high on sensation seeking, aggression, and anxiety scales. According to Ulleberg (2001) this profile indicates low levels of emotional adjustment. The other groups scored low on sensation seeking, aggression, anxiety and driving anger and higher on the altruism and anxiety scales. Gender differences were also found in these groups with females in particular scoring high on these scales. These groups were also found the most likely to be influenced by a traffic safety campaign.

Ulleberg and Rundmo (2003) state that research into the psychology of driving has through the years, tried to explain individual differences through two approaches, namely personality traits and social cognition. By integrating these two approaches, the researchers found a strong relationship between personality traits and risky driving behaviour. Attitudes toward safe driving seem to influence these traits. In this research social variables are correlated with personality variables and it was concluded that these variables are integrated supporting risk-taking mechanisms in traffic. Attitudes, perceived risk, social norms and behavioural control are central determinants of behaviour. Attitude has been associated with aggressive driving, speeding and so forth. Based on these findings one of the most popular approaches to road safety is to change perceptions of risk of young drivers. Ulleberg et al (2003) state that road safety campaigns often fail to demonstrate impact or behaviour change. The researchers argue that if personality traits were taken into account when designing these campaigns, the message could be better communicated and have a more profound impact on behaviour change.

Renner and Anderle' (2000) investigated juvenile traffic offenders in terms of extraversion, neuroticism, psychoticism, impulsiveness and venturesomeness. The researchers found that young traffic offenders scored high on the venturesomeness and extraversion scales. Potential correlations between neuroticism, psychoticism and impulsiveness were not confirmed.

Yagil (2001) states that the intention to commit traffic violations depended on two factors: firstly the time of day and secondly the presence of passengers in the vehicle. Persons with an internal locus of control perceive the consequences of actions as a result of their own behaviour. Persons with an external locus of control perceive the results of their behaviour as an end result of something outside or other than themselves. Yagil (2001) found a correlation between the intention to commit traffic violations and external locus of control. External locus of control has been found to correlate positively with sensation seeking behaviour. Taris (1997) studied driving behaviour as a function of desirability, controllability and verifiability of behaviour in relation to locus of control. None of these factors was found to be directly linked to locus of control or perceived seriousness of violations. Boyce and Geller (2002) however, found significant correlations not only between age and risky driving practices but indicated that Type A personalities (easily excited, explosive) more frequently engaged in risky driving behaviour practices. Aggressiveness in driving has also been correlated with risky driving practices. Whissell et al (2003) also state that aggressive driving is correlated with higher incidences of more severe crashes. It has also been linked to social deviance and antisocial behaviour. Aggressive driving is further linked to irritability and impatience.

Taris (1997) investigated novice driving as a function of situational and dispositional factors as moderated through locus of control. The way one drives has its roots in a series of conscious decisions to drive in a certain way. Taris defined the locus of control as the degree to which one feels that one can influence one's life or the extent to which one has control over things that happen. Persons who are externally orientated tend to make a choice about how to act, considering situational factors (outside of the person) while an internally orientated person tend to base their decisions on values, attitudes and so forth. Internally orientated people therefore are guided by external factors to a lesser degree.

Risky driving is reported to be associated with younger male drivers rather than older male drivers (Ivers, et al, 2009). Behaviour such as tooclose following distances, “speeding for the thrill of it”, traffic offences and not making use of seatbelts or using cell phones while driving are some of the reported risky driving behaviour that young drivers engage in (McKnight et al, 2003; Whissell et al, 2003).

Prato, Toledo, Lotana and Taubman-Ben-Ari (2010) state that risk taking behaviour of young drivers is guided by gender and a tendency to see sensation. The research also indicates that examples of parents, the amount of supervised driving and the level of parental supervision play a big role in novice drivers’ driving behaviour.

2.3.5. Behavioural factors

Behaviour such as too-close following distances, “speeding for the thrill of it”, violating traffic rules, not using seatbelts and using mobile phones while driving are some of reported risky driving behaviours that young drivers engage in (Braitman et al, 2008; Whisell et al,2003; Mckight et al, 2003). Bina et al (2006) found in Italy that young drivers, especially males, drive with friends during the evening and at night and that the association between leisure activities such as drinking alcohol, using drugs etc. is very strong. Road accidents among young male drivers who had spent time in public places such as discos were particularly high. The study also found that one of the most common transgressions among young novice drivers was driving without an official license. For both males and females drug use was a predictor of risky driving. For both groups a wide range of traffic offences was observed ranging from speeding to failure to adhere to traffic signals. The conclusion was that risky driving was part of a lifestyle that emphasised a disregard for social norms. This was strongly associated with “hanging out with friends” that has a similar lifestyle, hence the seeking of approval from the peer group.

Forward (2009) investigated the intention to commit a driving violation. The researcher found that age and annual mileage driven were significant predictors of speeding behaviour. Novice drivers who had ready access to a vehicle (able to drive frequently) were more inclined to engage in speeding behaviour.

2.3.6. Learning, training and licensing

The term driver education is applied to programmes for beginner drivers. Driver education aims to prepare the learner driver to become a licensed driver. This driver education incorporates both theory and practical experience (Lohero and Mayhew, 2010). In the United States typical driver education encompasses 30 hours theory and 6 hours practical training. In some instances the required practical training has been expanded to 8-10 hours behind the wheel.

As elsewhere in the world, licensure in South Africa depends on two components, first a theoretical test and secondly a practical on-the-road test. If the aspirant driver passes both these tests they are free to drive unaccompanied on public roads.

In the UK the licensing process (which is similar to SA) has been heavily criticised as the practical driving school training and the road test do not include driving on different types of roads, or driving in different and sometimes adverse weather conditions. Driver training does not expose trainee drivers to specific hazardous driving conditions and novice drivers develop skills for dealing with hazards only once they are licensed. Ferguson (2003) states that this elevated crash risk is the consequence of different factors that individually or in combination contribute to the problem. Risky driving, alcohol use, not using a seatbelt, distraction, fatigue and vehicle choice are some of the factors cited. Ferguson (2003) also points out that night time driving and passenger restrictions work because they keep drivers out of dangerous situations that could have been prevented. The researchers also state that legislation and restrictions cannot address all of these factors.

Pre-training serves the purpose of shaping driver attitudes and requires the new driver to take ownership of his behaviour before being granted the privilege of driving without restrictions (Kinnear, 2009).

In the United Kingdom recent research (Hutchins, 2008) revolved around investigations on how to smooth the transition from being an accompanied driver to being an independent driver. This study highlights the fact that once the novice driver is an independent driver, he/she suddenly has to negotiate challenges such as getting to destinations on their own, dealing with different hazards in traffic as well as with various weather conditions while driving. The report stipulates that “real-life” driving is vastly different when driving on your own for the first time than when driving with an instructor.

Literature (De Craen et al, 2007; McCart et al, 2003) further suggests that due to practice, the driving task skill in novice drivers quickly develops into routine and that sub-tasks become automated. It is therefore envisaged that novice drivers will show improvement after a small period of time provided they gained enough practical experience. McCart et al (2003) state that the cumulative number of kilometres driven is a more direct measure of experience and that in the United States, young people started driving well before they were legally allowed to do so and that after licensure the driving dramatically increased (in the USA learner drivers are tested from 16 years onwards). Response to the demands created by driving depends on the road environment, road design and other road users. In response to demands, the driver needs to make complex personal choices in order to safely negotiate the driving situation (SafetyNet, 2009). These choices lead to smaller or bigger safety margins based on perceived skill and ability to handle the present driving situation. In complex situations, inexperienced drivers need to make choices that increase the safety margins but it is often found that overconfidence in ability leads these drivers to make decisions that narrows the margin of safety considerably (SafetyNet, 2009).

Research emphasises that although training could influence development of cognitive and psychomotor skills it does not automatically lead to fewer crashes. It is stated that even though drivers might have successfully acquired the skill, it might not necessarily mean that they crash less than people who display positive attitudes toward safe driving (Lohero et al, 2010). Thus additional programmes and training should continue even after the new driver has mastered the basic driving skills.

A number of approaches to driver training and education programmes exists. These approaches include theoretical (classroom) training, simulation, computer-based training and practical driving experience. Internationally there has also been a move to introduce graduate driver licensing (GDL) in countries such as the UK and US.

Traditional driver education in America comprised approximately thirty hours of theoretical (class room instruction) and approximately six hours of practical (on-the-road) training before novice drivers were able to be tested for their driver licenses.

Although learning skills and improving cognitive abilities associated with driving are important, Lonero and Mayhew (2010) indicate that driving is much more than just learning a new skill. Novice drivers need to acquire the skill to safely operate and handle the vehicle in complex traffic situations. In a review of driver education and evaluation, Lonero et al (2010) admit that through the years, driver education and training have progressed or evolved from this classroom–based instruction to self-instruction. Self-instruction is becoming more and more popular through computer and internet-based training. However, computer and simulation exercises should not be substituted for on road and practical training.

Lenneman, Backs, Cassavaugh, Bos, and Van Bergen (2011) indicated that formal driver education is still a prerequisite in 33 of the 50 US states. In most states this instruction goes hand-in-hand with the GDL programme. In some states, a combination of theoretical and practical training is used to limit the number of supervised driving hours in the GDL programme or in some states to lower the learner driver enrolment age. Lenneman et al (2011) found that for novice drivers there was a 11% to 21% reduction in crash rates for novice drivers who enrolled in traditional driver education programmes (coupled with the GDL) compared with novice drivers who did not enrol in traditional education programmes.

The USA, New Zealand and North America have invested heavily in novice and teenage driving research (Hedlund, 2007; Kennear, 2009; Boufous et al, 2011). The outcome of this research was the implementation of a Graduate Licensing System (GDL). Ivers et al (2009) state that the graduate driver licensing system has a significant impact on the reduction of traffic crashes involving novice drivers in the countries that implemented the system. Australia implemented a modified version of the GDL in July 2007, where learners were required to keep a 100 hour log book of certified practice of licensure.

A graduated driver licensing system entails a multistage education programme. Countries such as Ireland, United Kingdom, Australia, North America and New Zeeland currently employ the GDL for novice drivers. All states in the United States have adopted a graduate or supervised licensing system. Foss et al (2012) noted that the Graduate License (GDL) Programme includes all three licensing stages: initial, intermediate and full licensure. The most important stage highlighted is the extended learner stage (intermediate) for beginner drivers where novice drivers are still required to drive under the supervision of parents. A specific number of hours need to be logged. This number of hours varies from state to state and can be between 0-100 hours, depending on the state. The authors indicate that in most USA states parents felt that 30-50 hours of supervision was the most appropriate. According to Ivers et al (2009) the GDL programmes are effective interventions characterized by multistage of learning which leads to different stages. Scott-Parker et al (2012) on the other hand stated that even though the GDL system has been successful in reducing crashes, younger drivers are still over represented in Australian crash statistics. Similarly, Foss, Martell, Goodwin, and O'Brien (2011) stipulated that these graduate licensing and training programmes have had limited success and recommended that this type of learning needed has to be addressed before GDL programme can be successful.

Foss, Mastin, Goodwin and O'Brien (2012) investigated the effectiveness of supervised driving practice. The researchers focused on fatal crash data for age groups 16 and 17 compared with older age groups and interviewed parents and novice drivers in all the states. Recommendations included an extension of the parental supervision period to at least 6 months. Many parents, however, felt six months was too short as novice drivers need to obtain experience in driving in all types of seasons, weather and road conditions before applying for a probationary license. Some of the restrictions associated with supervised driving were considered unrealistic based on the state (area) that the novice driver resided in. Restrictions such as night-time driving curfews in southern states (where the sun only sets at 9 pm) as opposed to northern states (where the sun sets earlier) were not deemed practical for training as in effect this implied that learners in the southern states had more time to practice than their northern counterparts.

Foss (2007) states that the “GDL is not a law in itself- but that it redesigns the policy environment in order for new drivers to learn to drive safely within the first year after obtaining their licenses”. This learning, through the GDL, provides a safer environment in which the novice driver can acquire complex driving skills.

The system gradually introduces the novice driver to “new privileges” based on the level and safety skill the novice driver displays over a period of time. At first restrictions are placed on freeway, night time driving and passengers allowed in the vehicle.

The GDL has three stages. During the first stage a learner license is obtained that only allows driving under supervision. Secondly, an intermediate driver’s license is issued that allows novices to drive unsupervised but with certain restrictions. Finally a full license is issued after the probation period. Foss (2007) emphasises that the first stage of the GDL system should be long enough for beginner drivers to obtain enough experience in a variety of traffic situations. He states that the intermediate phase should effectively limit the novice to situations that the novice drivers would be able to successfully negotiate. The GDL system provides opportunities for novice drivers to obtain the necessary skills, knowledge attitude and experience to participate safely in traffic (Hedlund; 2007). Foss et al (2012) highlight the “extended learner stage for beginners” that requires novice drivers to drive under supervision for a prolonged period of time. This ensures that the learner driver obtains as much experience as possible.

In Australia the “l*earner stage*” is considered to be the safest period of driving while the “*provisional or intermediate stage”* was found to be the least safe (Scott-Parker et al, 2012).

In New Zealand after passing an on-road test, the graduate driver gets a provisional license for 12 months. After these 12 months the novice driver is required to undergo a hazard perception test which graduates him to the next provisional license for a period of 24 months. After these 24 months have been completed the novice driver is again required to do an on-road test and if he successfully passes this test he obtains his permanent driver license. The on-road test provides the novice driver with valuable practical training while the hazard perception test gives an indication of the novice driver's perceptual abilities.

In the USA parts of or the whole GDL programme has been introduced in all states. Hedlund (2007) indicated that since implementation in 1996, more than 25 reviews of the GDL in different states have been published and that overall the involvement of young novice drivers in fatal crashes has dropped dramatically in the United States. Components introduced include combined components of the GDL programme including night-time driving restrictions, passenger restrictions and supervised driving requirements. In addition, novice drivers are expected to obey traffic rules and regulations, use their seatbelt, not talk on cell phones and ensure that they have a spotless driving record in order to advance to the next stage of the programme.

2.3.7. Driving ability

There are definite differences between social and cognitive abilities related to driving. Social processes influence the intention to drive in a certain way and this depends on the perception of what is right and wrong which is strongly influenced by social norms and acceptable behaviour by peers and significant others.

Cognitive skills on the other hand are concerned with the actual competency and skill influencing decision-making and actions when driving. Inflated self-belief in own abilities and poor hazard perception skills are often present in young novice drivers. Cognitive and social processes interact with each other. For younger people though, the social processes might be stronger and as they become older, cognitive processes and information processing as well as skills become stronger (Durkin et al, 2003).

2.3.8. Experience

International research shows that novice driver crash rates are highest in the first few months after licensing (when experience is limited). During the "learning to drive" process, crash risk is highest at the moment of licensure (Kinnear, 2009).

Cooper et al (1995) investigated driving characteristics and exposure to crashes for novice drivers' age 16 to 55 years. They found that novice drivers were involved in more crashes than experienced counterparts. The research indicate that lack of experience as defined by a short licensure time combined with low exposure and experience with travel contributed to novice drivers being involved in crashes.

Inexperience is affected by skills and related to a reduced ability to accurately interpret information from the driving environment, poor estimation of speeds and stopping distances. This lack of skills also causes slow or inappropriate responses to traffic situations (McKay et al, 2003; Deery 1999). Studies (Ulleberg et al, 2003; Cooper et al, 1995; De Craen et al, 2007; McCart, et al, 2003) found that the decrease in risk is correlated more with increases in experience than with age. Other studies (Jonah, 1997; Simons-Morton et al, 2005; SafetyNet, 2009) show that young people more readily engage in risky driving practices due to their age.

McGhee et al (2007) indicated that novice driver crashes occur mostly in the first seven months of licensure and then decline as the driver obtained more experience. Crash risk seems to depend on where the novice driver is in his learning process e.g. learner driver (low crash risk), recently licensed (high crash risk), driving for a year or more (McGehee et al, 2007). Most novice drivers involved in crashes have had their licenses for twelve months or less (De Craen, 2007; McKnight et al, 2003; Boufous et al, 2011). Learning to drive safely is complex and demands a lot of practice. Deery (1999) recognises that although they do not yet have the required perceptual and cognitive skills, young novice drivers acquire skills to control a vehicle quickly. Vehicle handling skills are learned in as little as a few hours. Hhowever, the higher order skills such as recognising and anticipating hazards in traffic situation may take as long as 10 years to master (SafetyNet , 2009; Mayhew et al, 2010). Therefore inexperience greatly contributes to young drivers' crash involvement. It seems that age is not always the common contributor but rather experience of driving. Gregorson et al (1996) describe inexperience as an additional cognitive workload on the driver and come to the conclusion that this mental workload is only significantly reduced through proper training and driving experience.

Cognitive aspects of driving are closely linked to the development of the individual.

Although driving skills are considered to be acquired quickly, it takes time to translate these skills into safe driving practices (Keating and Helpern-Felsher, 2008; Deery, 2000). Keating et al (2008, p.274) state that: *"driving requires a set of complex, interrelated, and simultaneous competencies, including psychomotor, cognitive, and perceptual proficiency".* In an effort to distinguish between novices, unsafe and overconfident drivers, an adaptation test was conducted (De Craen et al, 2008). This required experienced and inexperienced drivers to assess the speed they would be driving in according to traffic conditions in photographs. For each photograph both a simple scenario as well as a more complex scenario (add cyclist, pedestrian more vehicles etc.) was given. It was found that novices, unsafe and over-confident drivers were less inclined to adapt their speed in more complex road environments than experienced or safe drivers. The study concluded that incorrect self-assessment and overestimation of driving skills could have a negative impact on speed adaptation (De Craen et al, 2008).

Both skill and style influence safe driving practices. Research has shown that novice or young drivers are more prone to adopt riskier driving styles but may not have the skill to execute tasks safely. Kass et al (2007) conducted a simulated distraction experiment, comparing experienced and novice drivers, measuring driving performance and situational awareness. The study found that novice drivers committed more driving violations and were less aware of the traffic situation than experienced drivers.

Systemic approaches to the driving task should emphasise the contribution of cognitive skills in relation to overall performance. These cognitive skills are classified into attentional skills and decision making skills (Drummond, 1999). Deery (1999; 2000) highlights the fact that it takes much longer for novice drivers to develop perceptual and cognitive skills that will enable them to participate safely in traffic. The researcher compares novice driver skills to those of experienced drivers and finds that the ability to detect hazards is seriously underdeveloped. This underdeveloped ability has implications for risk perception, detection and responding to the risk in an appropriate manner. Young novice drivers often underestimate risk and are also more willing engage in risky behaviour while driving (Deery, 1999).

The figure below is a schematic representation of novice driver perception, skill and proneness to risk while driving. Research indicates that although it is possible to learn vehicle handling skills in a matter of hours, the skill to perceive hazards and to identify potentially dangerous traffic situations take many years of practice (SafetyNet, 2009). Deery (1999) presented novice/young driver perception of risk in the driving environment as in Figure 11.

Mayhew and Simpson (2002) argue that the only way to make sure that young novice drivers are safe drivers, is too impart the necessary knowledge and skills before novice drivers obtain the actual license.

Gregerson (1996) investigated the degree to which young drivers overestimate their driving skill. In an experiment comparing novice drivers who underwent “skills training” with those who did not, Gregerson found that there was no improvement in any of the groups actual skills but that the group who received the skills training believed that they were far more skilled than they actually were. In recent research Isler et al (2008), on the other hand found, that after a six month training intervention that focused on the frontal lobe executive function of young novice drivers’ brains, driving performance and executive functioning, general ability and sustained attention improved significantly in young novice drivers. According to these researchers, the participants showed an improvement in their overall driving performance and that more accurate self-evaluation of driving performance was related to higher levels of executive functions, in particular, working memory and cognitive switching. Thirdly, the study compared the effects of higher level and vehicle handling skills, confidence levels and attitudes to risk. After the training it was found that participants had improved skills related to direction control, choice of speed and visual search strategies. This also improved their ability to detect hazards in the road environment. Confidence levels were reportedly lower and attitudes toward misbehaviour such as speeding, overtaking and close following improved.

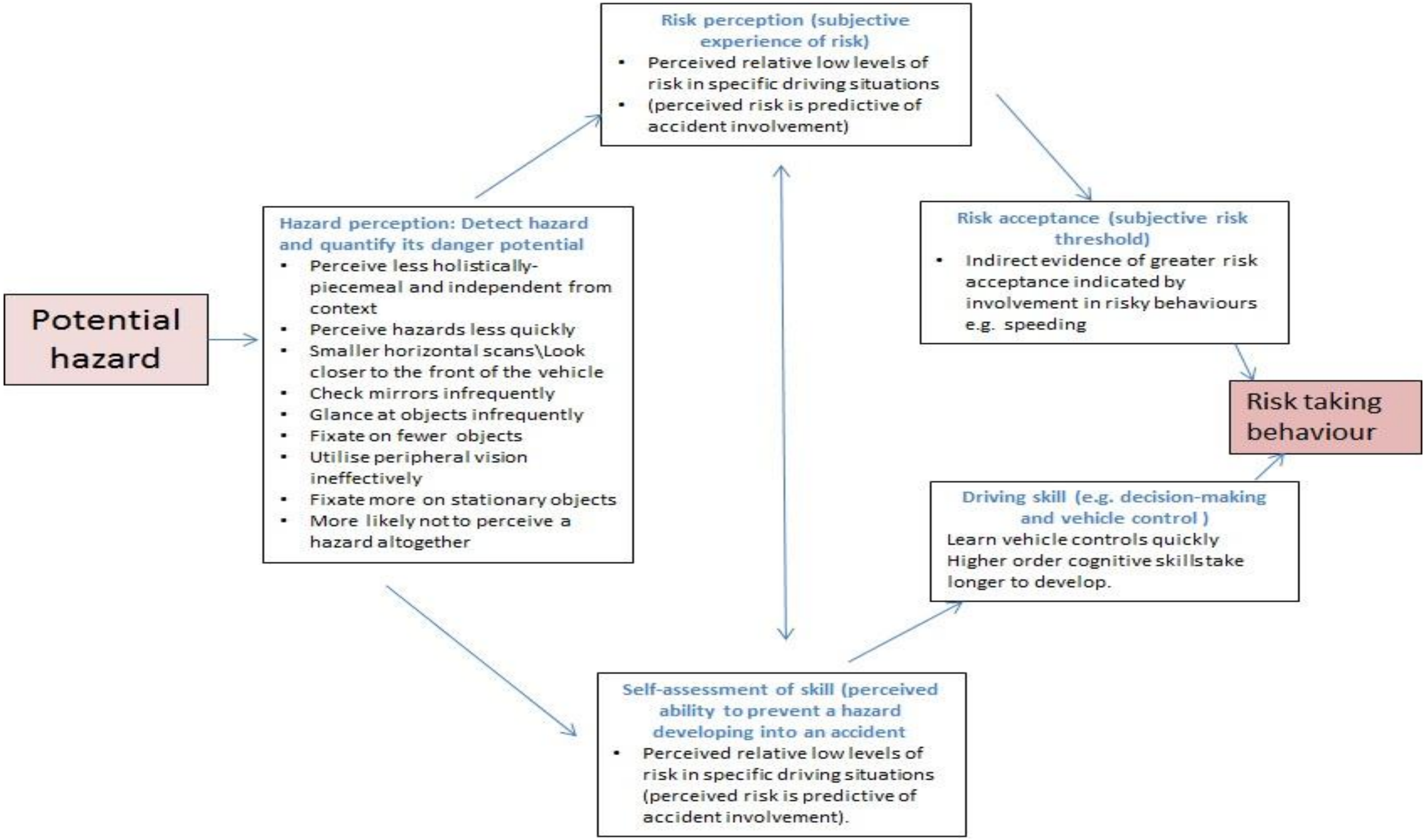

Figure 11: Factors associated with novice and young driver behaviour (Deery, 1999)

2.3.9 Attitudes towards road safety

Rundmo and Iverson (2004) evaluated the impact of a traffic safety campaign aimed at raising awareness about risk perception among novice drivers in Norway. A pre- and post-study was conducted before and after the traffic safety campaign. Afterwards the researcher found a heightened perception of risk after the campaign but that factors such as negative emotional reactions related to traffic hazards significantly predicted behaviour. In other words, Hu, Xie and Li (2013) explain that when an emotion arises, the person labels it as “feeling good” or “feeling bad”. A positive emotion would encourage a person to work toward that feeling while negative emotions are rather avoided. Therefore “negatives” associated with being in a traffic crash sustaining injuries, disabilities or damage in a crash should rather be avoided. Negative emotions are, according to Rundmo et al (2004), strong predictors of behaviour change. Rundmo and Iverson (2012) repeated this study and found that during the past nine years (from 2000 to 2009) traffic safety campaigns have had a positive influence on people in Norway’s risk perception. The researchers stated that although the changes in attitude towards risk were small it was definitely changing for the better. They concluded that sustained efforts in terms of traffic safety campaigns would yield results.

Attitudes toward behaviour are beliefs that revolve around the relationship between the actual behaviour and the outcomes of the behaviour (Yagil, 2001). Subjective norms form part of social pressure to perform or not perform certain behaviour. Subjective norms are closely related to cultural acceptance of behaviour. Attitudes towards using the road are entrenched in a young person long before they actually start driving. These attitudes tend to influence the way a driver drives on the road (Scott-Parker et al, 2009).

2.3.10. Hazard perception and attention

In general drivers are influenced by both risks and benefits. Novice drivers, however, seem to fail in the process of perceiving risk realistically (Durkin and Tolmie, 2010). Boufous et al (2011) state that although novice drivers can quickly acquire skills pertaining to the handling of the vehicle, their ability to perceive and react to hazards on the road are mostly under developed. Furthermore, in comparison with experienced drivers, novice drivers take longer to perceive and process potential threats on the road. Novice drivers experience hazard latency which refers to their inability to a) correctly recognise hazards in the traffic environment and b) to quickly and correctly react to the threat that hazards in the traffic environment pose (Scalfia, Borkenhagen, Lyon, Deschênesa, Horswill and Wetton, 2012). Pradhan, Simons-Morton, Lee and Klauer (2011) support the notion that novice drivers do not readily recognise hazards in the traffic environment and indicated that novice drivers are more susceptible to distractions. In research involving 42 young drivers, the conclusion was reached that in the twelve month period after the young driver had obtained his license, the novice driver increased his skills in terms of detecting hazards and became less distracted when driving. This was true for all secondary task engagements except cell phone usage. Novice drivers' elevated risk is a complex function of age, experience and misperception of risk on the road (Brown and Groeger, 2007). This research aimed to better understand the cognitive changes that take place from being a novice to being an experienced driver in order to inform training of novice drivers. Underwood et al (2002) found that novice drivers have restricted capabilities in scanning the road (visual search) in comparison with more experienced drivers. The research concluded that novice drivers did not have the scanning abilities due to limited mental resources to switch tasks (vehicle control *vs.* scanning of road). As novice drivers gain more experience they become more efficient in controlling the vehicle as well as scanning the road for hazards.

Underwood (2007) explained that hazard perception increases with experience. Experienced drivers learn to scan the road environment much more effectively and are more sensitive to complex road environments than novice drivers.

Attentional control is associated with attending to the appropriate things in traffic at the right amounts and at the right time (Mann, 2010; McKenna, 2010). Timesharing refers to dealing with changing workloads in the environment and calibration to matching driving performance with task demands. Mayhew and Simpson (2002) stipulate that there are eight critical skills that young drivers need to master in order to drive a vehicle: steering control; speed control; multi-tasking; visual search;

hazard detection; risk-assessment; decision-making and risk-taking. The researcher further states that novice drivers, regardless of their age, lack some of these skills.

Deery et al (1998) relate driving skill to "experience-related factors" in which risk perception and attentional control is included, while driving style is related by the researchers to "age-related factors".

Attentional skills should be viewed as the basis for safe and effective driving (Drummond, 1989). According to research, lapses in attention and inefficient distribution of attention are important considerations when investigating novice drivers' crash involvement. Drummond refers to work done by Zaidel, Paarlberg and Shinar in 1979 and lists four basic attributes of attention and performance:

- Intensity as measured by the total effort invested;
- Distribution as reflected in the allocation strategy;
- Regularity indicated by persistence and consistency of the attentional behaviour;
- Mode of control as indicated by the extent to which behaviour is controlled by the self.

Kinnear et al (2008) listed the limitations that young novice experience:

- Perceive hazards holistically and less quickly
- Smaller horizontal scans
- Look close to the front of the vehicle
- Check mirrors infrequently
- Glance at objects infrequently
- Utilise peripheral vision ineffectively
- Fixate on fewer objects
- Fixate on stationary objects
- More likely not to perceive a hazard at all.

Crundall, Underwood and Chapman (1999) investigated the differences in the peripheral vision of experienced and novice drivers. Peripheral vision is important to detect hazards in (or around) the driving environment as well as for successful lane maintenance. The field of vision is described as the area around the "point of fixation" (in other words the point of focusing) from which environmental information is obtained and then stored after this visual task. Crundall et al (1999) state that normally the detection of a hazard occurs when the driver’s covert attention is captured, after which the eyes are guided towards the stimuli. According to this research the field of vision becomes wider the more a driver gains experience. The driver is able to covertly collect more information from his field of vision while becoming better at extracting relevant information from the environment in order to appropriately respond to it. This reduces the mental task load as it becomes automated. The research found that novice drivers take significantly longer to detect objects from their peripheral vision and to react on the information than experienced drivers. This finding might have implications for the manner in which novice drivers are subsequently trained.

Labbett and Langham (2006) investigated driver behaviour at junctions (intersections) at a specific location in Sussex, England. The authors investigated the phenomena of “look but failed to see” which occurs when a driver fails to detect other road users, resulting in a crash. The results indicated that drivers conduct a rapid scan of the environment around the junction but that the drivers in all probability are not attending to all details. Furthermore, all of the drivers spent less than 0.05 seconds scanning the environment around the junction. In terms of experienced and novice drivers, the results indicated that experienced drivers tended to focus on small areas in front of them, or focused on areas where they “know from experience” hazards can be found. Surprisingly, the novice drivers scanned a bigger area and were able to detect vulnerable road users, not detected by the experienced drivers.

2.3.11. Exposure

McGehee et al (2007) state that the fact that young drivers are over represented in crash statistics is significant because the number of kilometres driven tends to be lower while their involvement in fatal crashes is higher per kilometre driven. As has already been mentioned, crash rates for novice drivers are found to drop substantially in the first six months of driving or during the first 5000 km of driving (De Craen, 2007). McCart et al (2003) indicated that crash and citation rates for young drivers were much higher during the first kilometres and first weeks after licensure when they are starting to drive independently.

Research emphasises the importance of independent driving (Hutchins, 2008). Independent driving though comes with increased responsibility which develops through awareness and awareness develops through experience (Hutchins, 2008). Newly licensed drivers have limited skills and abilities to participate in traffic safely. The lack of skills puts young drivers at risk (Lohero et al, 2010). It is stated that young drivers take unnecessary chances, have limited scanning abilities and are not able to locate and identify potential risks as well as they should. Furthermore newly licensed drivers are not able to make and execute decisions quickly based on their perceptual abilities in traffic.

McKnight et al (2003) found that for young drivers involved in the majority of non-fatal crashes the most important reason was their lack of safe operating routines. Young drivers do not intentionally decide to drive dangerously,(speed or drive under the influence of alcohol) but dangerous driving behaviour is therefore mostly due to a lack of safe operating routines.

In conclusion, numerous studies have aimed to highlight the most prominent factor making this road user group one of the most dangerous. Some research highlighted age as the contributing factor while other research highlights inexperience as a factor. Kinnear (2009), however, suggests that these two factors run parallel to each other, with inexperience weighing in as the heavier contributor to young drivers' involvement in fatal crashes.

2.3.12. Peer groups

Fleiter et al (2006) support the fact that peer groups or significant others could influence novice driver behaviour. Fleiter et al specifically focused on the influence of "significant others" on speeding behaviour of novice drivers. This research, based on Akers' Social Learning Theory, investigated the influence of both peer groups and family members on the novice driver's behaviour. Harre et al (2005) found that young drivers acknowledge that their peer group (age group) could fall within a high risk category but for the most part the individuals do not view themselves as being at risk. Harre et al (2005, p.216) refer to young drivers as having an "unrealistic optimism" and "a biased belief that one is less likely than his peers" to experience adverse and negative events such as being involved in traffic crashes.

Age and gender of passengers are good predictors of risky novice driving (Fleiter et al, 2006). Novice driver crash risk increases when carrying passengers of the same age. Female passengers tend to reduce male risky driving such as following too close or speeding when in the vehicle. On the other hand the presence of male passengers in the vehicle increased the likelihood of the driver engaging in risky driving behaviour (Simons-Morton, Ouimet, Zhang, Klauer, Lee, Wang, Chen, 2011). In stark contrast to the findings above, Albert and Dingus (2011) found that when peer groups were present in the vehicle as passengers, the driver tended to drive less riskily compared with driving alone. This suggests that peer groups as passengers in the vehicle could have a positive effect on young driver behaviour. Simons-Morton et al (2011) concluded that this is due to the injunctive norms which are formed through perceptions and what the young driver thinks their peers expect from them rather than direct peer pressure.

2.3.13. Parents and siblings

Parents and older siblings can potentially play a significant modelling role to positively influence novice drivers. However, Fleiter et al (2006) found that peer group influences were much stronger than family influences on behaviour. The researchers concluded the strong influence of friends should be incorporated in interventions aimed at preventing risky driving.

2.4. Driving environment

2.4.1. Vehicle factors

Ivers et al (2009) also state that younger drivers tend to drive older vehicles. This might be an unavoidable consequence of affordability but essentially older vehicles might not have all the modern day safety equipment that is found in modern vehicles and might need more maintenance. This could have implications for road-worthiness.

2.4.2. Crash characteristics

Engstrom et al (2003) indicate that young novice drivers are over represented in most types of crashes. In Sweden, the over representation of single vehicle and loss-of-control crashes are especially noticeable. This trend is also observed for the rest of the European Union (Safety Net, 2009). Furthermore, novice drivers seem to have an increased risk per kilometre when driving at night. Weekend and weekend nights were especially dangerous.

In Australia, a Centre of Accident Research and Road Safety fact sheet (CARRS-Q Fact Sheet, 2013) states that novice drivers are over represented in single and loss of control crashes as well as head-tail crashes and intersections crashes. Loss of control crashes are mostly associated with driving around curves in the road.

2.4.3. Perceived driving environment

Durkin et al (2003) stipulate that norms are perceived conventions or rules in society that dictate correct behaviour in social groups. Descriptive norms create pressures to conform to one's peers (friends) while injunctive norms refer to perception of what others (parents, rest of society) want the young adult to do. Both of these types of norms apply to young novice drivers. Durkin et al (2003) emphasise that norms are closely related with developing a sense of identity and a sense of belonging.

Shope (2006) states that for most of their life while growing up, the novice driver has been collecting information about his or her driving environment. The perceptions formed about "normal" driving greatly influence the manner in which the novice driver will drive. The novice driver forms these perceptions based on the examples he sees from parents, peers and other drivers on the road. Shope further emphasises that it is not only significant others that influence these perceptions but that these perceptions can be shaped by the broader community, media, culture and so forth. Perceptions could for example be influenced by movies, racing car culture (Formula 1), and community norms (e.g. tolerance of drag racing). The perceived driving environment therefore comprises of the physical as well as the psychosocial environment.

2.5. Driver behaviour research methodologies

2.5.1. Introduction

Traditionally, driver behaviour (also novice driver behaviour) has been primarily investigated through the use of self-reported behaviour studies, simulation studies and observation. More recently different types of technologies such as field operation tests and NDs approaches, have been employed in order to collect and analyse real word driver behaviour data that will provide more insight into normal driver behaviour as well as the causation and prevention of incidents and crashes.

This section provides a brief overview of the research methodologies that have been employed to investigate driver behaviour over the years. It also serves as a rationale and introduction to the Naturalistic Driving Study's (NDS) methodology used in this study.

2.5.2. Traditional methods

Traditionally, driver behaviour has been researched making use of self-reporting studies (questionnaires), epidemiological studies as well as controlled experiments and simulation studies.

2.5.2.1. Self-report studies

Self-report studies mostly make use of questionnaires in order to research a specific behaviour. These questionnaires normally comprise of validated question batteries (Van Nes, Backer-Grøndahl and Eenik 2010). Self-reported studies are employed to investigate personal factors such as age, emotions, gender, etc. characteristics in relation with aspects of safe driving and crash proneness.

In terms of novice drivers a number of self-report studies have been conducted, namely:

- Types of novice drivers and risky driver behaviour (Deery and Fildes, 1999; Ivers et al, 2009; Scott-Parker, et al 2013).

- Characteristics, personality and attitude (Deffenbacher et al, 2001.Laapotti, Keskinen, Hatakka and Katila, 2001; Uleberg and Rundmo, 2003; Machin and Sanskey, 2008).
- Behaviour where different self-report scales are used to report on factors influencing safe driving (Deffenbacher et al, 2001; Eensoo, Paaver, and Haro, 2010; Ivers, et al 2009).
- Studies that report on skill (De Craen et al, 2007; Machin et al, 2008).
- Vehicle handling (Palamara et al, 2012).

The main criticism against self-report studies revolves around human errors and bias in the studies. Backer-Grøndahl et al (2009) indicate that self-report studies are "the indirect observation of the measures a researcher is interested in".

According to Van Nes et al (2010) self-report studies rely on the participants' own interpretation of their own behaviour. Self-report studies are therefore open to recall (memory) bias, social influences, misunderstanding of questions and respondents answering "what they think is the correct answer".

2.5.2.2. Epidemiological studies

These studies draw primarily on crash databases which are obtained from the police or other entities collecting data e.g. World Health Organisation. The information from these databases provide information related to (for example) crashes at a population level. The problem with epidemiological and crash database studies is that they only reflect the information which was available to and captured by the police, traffic authorities and so forth. The information available might therefore not be sufficient to understand the crashes that occurred (Van Nes et al, 2010).

2.5.2.3. Controlled experiments and simulator studies

Through the years the standard for conducting human behaviour studies has been centred around highly controlled experiments. According to Van Nes et al (2010) the main advantage of controlled experiments is that observation of the behaviour is direct and immediate. The researcher controls the variables in the experiment which contributes to better interpretation and structuring of results.

Studies conducted in real vehicles (on for example a test track) are considered controlled experiments as the driving environment, in which the participant operates is still controlled (Backer-Grøndahl et al, 2009). This is necessary as the researcher still needs to come to conclusions about causal factors influencing the behaviour being measured. The environment, including other vehicles, road users, objects on the road etc., are artificial and often an observer would be present in the vehicle to instruct and evaluate the performance of the participant. Therefore, even though the vehicle might be instrumented, the situation is still controlled and observations take place under these controlled conditions.

Simulator studies (Deery, Kowadlo, Westpahl-Wedding and Fildes, 1998; Yang, Jaeger, and Mourant, 2006; Kass, Cole and Stanny, 2007) and experimental studies (Harre, Forester and O'Neil, 2005; Borowsky, Shinar and Oran-Gilad, 2010; De Craen, Twisk, Hagenzieker, Elffers and Brookhuis, 2008) are used to evaluate risk perception through the use of still pictures or videos. These are experimental studies in a controlled environment where the participant is often connected to, for example, an eye tracker, computer screen and so forth.

Observational studies are classified into before- and after studies as well as cross-sectional studies (Institute of Transportation Engineers 2009). In a before and after study, the attributes of what is being measured stays constant. However the before study entails that participants interact with what is being researched (e.g. stopping behaviour at an intersection without a traffic light) before any treatment has been applied to it. In the after study the behaviour is again measured after the treatment has been applied (e.g. stopping behaviour at a traffic light after it has been erected at the intersection).

Cross-sectional observational studies are used to investigate the differences between groups. An example is the study of two groups that have common features (e.g. novice drivers who use alcohol vs. novice driver who do not use alcohol). The comparison would therefore focus on the safety aspects of the behaviour that is not common (Institute of Transportation Engineers 2009).

Therefore compared to naturalistic driving, the environment as well as the participants are controlled and are then not a natural or real reflection of behaviour.

2.5.3. New methodologies

Driver behaviour in especially the United States and Europe has for the past decade, been focused on understanding driving in a much more detailed and holistic manner.

In Europe, Field Operation Tests have been conducted to test human/vehicle interaction with in-vehicle devices. Naturalistic Driving Studies have been employed by the United States (Dingus et al, 2006) and Europe (Van Schagen, Welsh, Backer-GrØndahl, Hoedemaker, Lotan, Morris, Sagberg, Winkelbauer, 2011) to better understand driver, vehicle and road environment factors and influences and the subsequent influence of these factors on road safety. The 100-Car study was conceptualised in 2002 (Neale et al, 2002) with the objective of collecting scarce pre-crash information from real world data. The large-scale European NDS study includes: Norway, Netherlands, Austria, Spain, United Kingdom and Greece (Eichhorn & Van Schagen, 2011). Other countries that have since 2006 also engaged the NDS methodology include Japan (Uchida and Mochida, 2010), Canada (Harbluk, 2011), Australia (Regan, Williamson, Grzebieta and Tao, 2012) and Israel (Prato, 2010).

2.5.3.1. Instrumented vehicles: Field Operation tests (FOTs)

Field Operation Tests (FOT) refers to the methodology used by vehicle manufacturers, researchers and practitioners in Europe to test ICT and Intelligent Transportation Systems (smart-vehicles) solutions for better traffic management. FOT focuses on the effect that vehicle technology has on driver behaviour and investigates the possible uses of technology in order to make vehicles as safe as possible.

Field operation tests (FOT) are extensively used by countries such as Europe, USA, Japan and Australia (Barnard and Carsten, 2010). FOTs intend to test in-vehicle systems (IVIS) and advanced driver assistance systems (AVAS). FOTs are conducted to better understand the effects these systems have on driver behaviour and how drivers interact with these systems. In Europe, large field studies 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 behaviour (Dingus et al, 2006; Bekarias, 2011).

A brief overview of FOT projects follows:

The FESTA project (Field Operational Test Support Action) was undertaken by the EU in support of field operational tests across Europe. The FESTA guidelines established a standardised methodology for FOTs and had the following goals with regards to field operational tests (FESTA):

- To ensure ICT based systems and functions are effective, safer, cleaner
- To provide better efficiency in a real traffic environment;
- To have an understanding of how drivers accept, behave and interact with these systems
- By using real time data it is possible to investigate the impact of ITS systems on the user
- To create and improve awareness on the use of ITS systems not only in Europe but across the world.
- Ensuring that the systems can be transferred across the globe.

Tele-FOT is a collaborative research programme in Europe comprising eight participating countries. The research is aimed at testing understanding on how the ITS functions influence drivers and the driving task. It investigates the functions that after market and nomadic devices have on the driver task and will influence the way that interactive traffic systems are designed. The research (Tele-FOT Wiki.) will provide insight in safe driving practices as well as to operational aspects of driving such as efficient fuel use.

2.5.3.2. Instrumented vehicles: Naturalistic driving studies

As mentioned previously, NDS is a fairly new methodology (Dingus et al, 2006; Sagberg et al, 2011; Eichorn and Van Schagen, 2011) that aims to investigate driver behaviour in a natural environment. The driver is expected to drive the way he or she normally does without any instructions or special interference from experimenters. From these observations, researchers are able to make conclusions regarding the driver, the vehicle and the driving environment. This research enables researchers to understand driving behaviour in a number of situations ranging from behaviour in different weather conditions, roadways and near collisions or actual collisions. Understanding these relationships will provide much better insight into making traffic systems safer.

Bärgman and Victor (2011) differentiate between the two methodologies by defining FOTs *as "a method to evaluate ITS"* and "*NDS a method to understand factors leading to accidents and incidents".*

Earlier reference was made to traditional methodologies that are highly dependent on controlled environments (Van Nes et al, 2010). With the NDS methodology no experimenter is present to instruct or observe the participant. Sagberg et al (2011) indicated that a naturalistic driving study is used to investigate everyday driving behaviour. NDS makes it possible to investigate this behaviour within the context of the driver, environment and the vehicle. What makes NDS different is the fact that there are no experimental control and the data collection takes place in an unobtrusive manner.

On the other hand, Bauman, Bengler and Gelau (2006) describe naturalistic driving studies as studies that follow an experimental approach, although they aim to provide descriptive information about driver behaviour. So although the study is not controlled in the traditional sense of the word, a great deal of planning still has to go into the design of the study.

Baumann et al (2006) state that the goal of NDS is two-fold:

- to describe the impact that specific measures or systems have on driving behaviour;
- to collect information related to driver needs from naturalistic observations.

Backer-Grøndahl et al (2009) also support the fact that NDS allows for validation of other traditional data collection methods such as self-reporting studies. This real world data is important for example, in vehicle manufacturing. Real world data is used by manufacturers to inform the development of new safety technologies in new vehicles and so forth. As discussed earlier, traditional methods of real world data collection methods include self-reported behaviour tools such as diaries, questionnaires and focus group discussions.

Tivesten (2012) illustrates (Figure 12) the type of data and the instruments used to collect real world data. Tivesten distinguishes between observations, self-reports and on scene measurements. Minor crashes and severe crashes can be investigated by employing research methods such as insurance data, police reports and in-depth reports and to a lesser degree through mail surveys. Naturalistic driving, focus groups as well as interviews and diary entries could be utilised to investigate normal driving as well as near crashes and incidents. Mail surveys were highlighted as a possible tool for investigating normal driving behaviour.

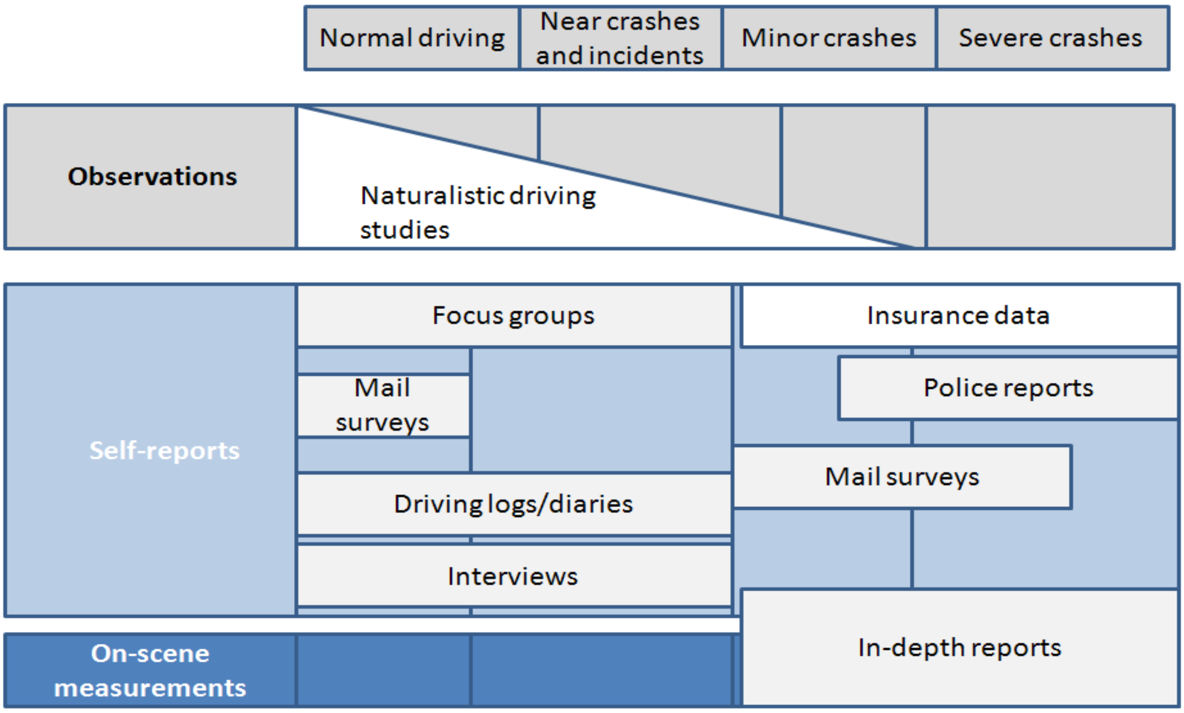

Figure 12: Data collection methods for real world data (Tivesten 2012)

Backer-Grøndahl et al (2009) classify naturalistic driving studies into three types:

- baseline/normative/exposure studies where the aim is to investigate driving behaviour and performance;
- critical incident/near crash studies where the main aim is to characterise and investigate such incidents;
- system-focused studies where the aim is to study the driver's interaction with in-vehicle systems (Field Operation Tests or FOTs).

Sagberg et al (2011) state that because such large volumes of data is collected in naturalistic driving studies, it is possible to answer pre-defined questions or to answer new research questions post-hoc. Also, with the large body of research it becomes possible to describe crashes and near incidents both quantitatively and qualitatively (Backer-Grøndahl 2009).

Detailed data can be collected on a number of aspects that influence the driver, environment and vehicle. The data gives access to better exposure data (Backer-Grøndahl et al, 2009; Reagan et al 2012) which makes it possible to calculate relative risk and the proportion of crashes related to a wide range of activities associated with driving behaviour. Drivers expose themselves to dangerous actions that could potentially lead to an adverse event. Through NDS, researchers can study exposure to this wide range of activities. Better exposure data along with the kilometres travelled, provide an opportunity for researchers to investigate more actual crashes or near crash events than exposure to risk of a crash increases with the number of kilometres travelled. Normative data is collected through the NDS approach which makes it possible to compare data between different countries employing the research method (Regan et al, 2012). The NDS data also has the potential to verify or validate results from other studies, such as self-reporting studies.

According to Sagberg et al (2011) the basic driving parameters collected through this study should include speed, acceleration and vehicle position. Video recordings are essential for the NDS and should include front and rear cameras as well as a view of the driver (Sagberg et al, 2011). Video data can be event triggered or continuous. Additional variables that can be included if the technology is available include: steering wheel information, acceleration and braking as well as following distance measurement through the use of radar (Sagberg et al, 2011).

A Naturalistic Driving Study is a useful tool which can assist researchers in understanding the events that lead up to a crash (Dingus, Hanowski and Klauer, 2011). In order to study crashes (rare events) a large sample of drivers and a lot of exposure the data are needed. The more kilometres travelled, the higher the chance of getting actual crash or near-crash (exposure) data (Backer-Grøndahl et al., 2009). The initial 100-car study (Dingus et al, 2006) resulted in the gathering of:

- 2 million vehicle miles of driving;

- 43 000 hours of data;
- 241 primary and secondary driver participants;
- 12 to 13 month data collection period for each vehicle; 18 month total data collection period;
- Five channels of video and many vehicles state and kinematic variables.

This information can be collected for actual crashes as well as near-crash events where the only exception is that the driver took evasive action in the very last seconds to “save” himself from being in a crash. The researchers emphasise that the methodology can be used to give information pertaining to the driver state, performance and behaviour seconds up to when the crash occurred and secondly to estimate the exposure of the driver in the related circumstances. Due to the fact that crashes are actually rare events, NDS was considered to be suitable for investigating near-crashes and incidents (Backer-Grøndahl et al, 2009). The advantage of analysing crashes and near-crash events is that the researcher can directly observe the driver behaviour and understand the contributing factors in terms of the environmental and vehicle factors that influenced the occurrence. Klauer, Dingus, Neale, Sudweeks, and Ramsey (2006) along with Jovanis, Shankar, Aguero-Valverde, Wu, and Greenstein (2012) define the following events as follows:

Crash refers to *“any contact with an object, either moving or fixed, at any speed, in which kinetic energy is measurably transferred or dissipated”* (Jovanis et al, 2012, p.1).

A near crash is defined as a *“circumstance that requires a rapid, evasive manoeuvre by the subject vehicle, or any other vehicle, to avoid a crash; the manoeuvre causes the vehicle to approach the limits of its capabilities”* (Jovanis et al, 2012, p.1).

A crash-relevant or critical incident refers to *“a circumstance that requires a crash avoidance response on the part of the subject”* (Jovanis et al, 2012, p.1).

Different aspects of driver behaviour have been researched using naturalistic driving observations in the past few years (Regan et al, 2012). Aspects include lane changing behaviour, drowsiness, interaction between different types of vehicles and driver characteristics. A summary of the different research projects employing NDS is presented below.

2.5.3.3. Overview of projects

100-Car Naturalistic Driving Study: In the USA, the first NDS study was called the 100-Car naturalistic driving study (NDS). The 100-Car naturalistic driving study was the first study in which vehicles were instrumented with the objective of collecting large-scale naturalistic driving behaviour data (Dingus et al, 2006). Drivers participating in this study received no specific instructions and no experimenter or researcher was present during the drives. The drivers drove around with instrumented vehicles for a period of 12 months which resulted in a large body of data collected for the driver, vehicle and environmental factors. According to Dingus et al, (2006) the most notable aspect of the 100-vehicle Car study was the creation of an event database that included video, driver and vehicle data. Furthermore this video data can be played and re-played to fully understand the context and the environment in which events take place. This data is available for analysis of multiple variables over many years. Klauer et al (2010) state that in addition, the 100-Car study database gives researchers the opportunity to develop different baseline measures for establishing relative and estimated risk as well as determining how large the data base should be in order to get meaningful data related to determining risk.

SHRP2 – Vehicle-Based Study: Since the inception of the research in 2005, a number of different NDS studies have been designed. The SHRP II programme in the United States has been expanding and building the research methodology to include other types of transport, such as larger vehicles in the US used in commercial operations, young drivers and so forth.

PROLOGUE: After the initial success with the 100-Car study, the European Union followed suit and investigated the feasibility of a European NDS study. A large scale European study called “Promoting real Life Observations for Gaining Understanding of road user behaviour in Europe” or PROLOGUE was commissioned. The PROLOGUE project is described as a feasibility study to investigate the use of NDS in Europe and to develop methodologies in order to establish a scientific and organisational platform for managing NDS in Europe (Backer-Grøndahl, Phillips, Sagberg, Touliou, Gatscha, 2009). PROLOGUE consists of a number of smaller projects that focus on novice drivers, in-vehicle technologies and vulnerable road users (among others) through site based observations. All trip details regarding the vehicle, route and driver are recorded. The PROLOGUE project aimed to assess the feasibility of the 100-car and the more recent 2000 car studies in the US in order to assess the use and viability of the research methodology in Europe (Winkelbauer, Eichhorn, Sagberg, and Backer-Grøndahl, 2010).

DACOTA: DaCoTA project (Driver Behaviour Monitoring through Naturalistic Driving Observations) developed an implementation plan for monitoring driver behaviour data in order to inform the development of road safety policies and procedures for the European Road Safety Observatory or ERSO (Talbot, Meesmann, Boets, and Welsh, 2010). Where PROLOGUE aimed at gathering data about unsafe behaviour, Pilgerstorfer et al (2011) indicate that ERSO aims to use naturalistic driving initiatives to gather continuous data representative of each European country and focusing on the development of Safety Performance Indicators (SPI) for the EU. PROLOGUE used the data for research based applications where DaCoTA aimed to use the data to develop decision-making tools.

In the European PROLOGUE study reference is made to the fact that if researchers want to understand driver behaviour in the real-world context, NDS might be the best methodology to do so (Backer-Grøndahl et al, 2009). Although heavily dependent on resources including technology and manpower, NDS eliminates many of the limitations associated with research in the laboratory. Drivers were expected to go about their everyday driving as they normally do. Researchers (Dingus, 2006; Baker-Grondahl et al, 2009; Van Schagen et al, 2011) found that drivers rapidly “forgot” about the presence of monitoring equipment and instruments in the vehicle and this resulted in a large body of research data for “normal” driving behaviour. Naturalistic driving studies therefore refer to the unobtrusive observation of driver behaviour within a natural setting (Dingus et a., 2006; Van Schagen et a., 2011). However, some researchers (Baker-Grondahl et al, 2009) stipulate that observer effects cannot be ruled out altogether and that more research into the effect of the cameras on driver behaviour is necessary. (Backer-Grøndahl 2009) indicates that NDS is different as the experiment is not controlled in a laboratory or through an experimenter/observer.

Australia also embarked on a NDS study and Regan et al (2012) argue that road safety strategies in Australia have been successful because the strategies are based on tangible evidence. Naturalistic driving studies are perceived to be a process by which this tangible evidence can be collected (Regan et al, 2012). Previously, "evidence" collected by Australian authorities included data from crashes obtained by police, hospitals, coroners' offices and data from licensing departments in Australia. However Regan et al (2012) state that that this type of information lacks depth and quality, particularly with respect to human factors. The motivation for the Australian NDS study argues for a large scale study that involves a number of universities and academic/research institutes with strong support from the private and industry sectors. The researchers make a compelling case as to why a ND study is necessary for the country. Arguments revolve around the fact that driver behaviour that has previously been difficult to research can now be targeted with more success. At a national level statements such as "speed kills" can be investigated. The researchers argue that in some cases speed does kill while in other not. The circumstances under which "speed kills" or "does not kill" can be scientifically investigated. A second argument was that the transferability of the data should be investigated. This means that unless Australia has its own data, the researchers cannot compare results of for example the SHRP II data.

To the question: "Is the SHRP 2 data applicable to Australian drivers", the answer is "we don't really know" because we have not run in Australia a NDS to benchmark driving behaviour and performance across the two countries" (Reagan et al, 2012, p9).

Olsen, Hanowsky, Hickman and Bocanegra (2009) investigated the impact of driver distraction in commercial vehicle operations, using naturalistic driving data. Data from 55 drivers operating at 16 different locations were involved in the research. A total of 4452 safety critical events were identified. These safety critical events included crashes, near-crashes, traffic conflicts and lane deviations. Along with the 19888 other events (uneventful and routine driving data) the key findings from the study indicated that drivers were engaged in non-driving related tasks in 71% of the crashes, 46% of near crashes and in 60% of all safety critical events. The research indicated that commercial drivers tend to get distracted easily, with their focus shifting away from the road. This has serious safety implications. The research made certain recommendations to rectify this behaviour.

In the PROLOGUE study, Sagberg et al (2011) categorised eight driver behaviours study investigated. Coupled with these behaviours a list of four conditions under which the behaviour could take place was developed. The behaviours and conditions are combined in a matrix. Sagberg et al (2011, p11) recommend this matrix to identify specific topics for research within the ND study.

The driving behaviour categories included (Dimension 1):

- Distraction and inattention
- Fatigue, sleepiness or other severe impairments
- Decision-making, driving errors, driving style and performance
- Lane changing and position
- Speed and acceleration
- Gap acceptance
- Aggressive driving
- Learning

The situational categories were described as (Dimension 2):

- Driver background and trip characteristics
- Road system, environment and ambient conditions
- Vehicle design, equipment and condition
- Traffic volume composition and interaction with other road users.

Klauer, Dingus, Neale, Sudweeks and Ramsey (2009) investigated the quantitative and qualitative differences between drivers who were involved in a high number of crashes or near-crashes compared to drivers who have been involved in fewer crashes and near crashes. High risk drivers were more inclined to travel at inappropriate speeds, to brake hard and to accelerate and decelerate faster than drivers with low crash rates. The behavioural data was correlated with roadway and vehicle information. The researchers found that the results of this study and understanding the variety of contributing factors influencing risky driving, could play an important role in driver monitoring and feedback systems.

Hanowski, Olson, Hickman and Dingus (2006) investigated the interaction between light and heavy vehicles. This data analysed was part of the 100-Car Study and included all light and heavy vehicle motor vehicle interactions recorded for the project. The project aimed to get a better understanding of the light and heavy vehicle interactions and to develop a classification scheme for these interactions. The findings of the study made recommendations on driver behaviour and driving techniques of light motor vehicles, which were mostly found to be at fault during these interactions. Contributory factors included distraction and aggressive driving. The findings of this study formed the basis for the development of countermeasures to address heavy and light motor vehicle interactions.

Also making use of the 100-Car study data, Lee, Llaneras, Klauer, and Sudweeks (2007) interrogated the data to obtain a better understanding of the key driver behaviours that contributed to rear-end events. The research also took into account vehicle kinematics (acceleration deceleration, g-forces) that influenced the event. The findings from the study have important implications for the improvement of rear-signalling devices, for example, light functioning and characteristics.

An investigation into the use of near-crashes as surrogate measures for actual crashes revealed a strong relationship between the frequencies of contributory factors in near- and actual crashes (Guo, KLauer, McGill and Dingus, 2010). The researchers found that contributory factors to the risk of a crash were underestimated if crash data alone was analysed. The near-crash data is therefore important in providing additional information related to contributory factors that could lead to crashes.

Lane changing behaviour and near crashes were investigated by also utilising the data from the 100Car study. Fitch, Lee, Klauer, Hankey, Sudweeks and Dingus (2009) found important information related to mirror-checking, indicator or signalling behaviour as well as information related manoeuvres (such as breaking or swerving) aimed at avoiding a forward collision. The researchers (Fitch et al, 2009) found that although drivers need to be aware of their surroundings at all times in order to avoid a crash, drivers are limited as they can only attend to one location at a time. This could have serious implications for drivers in dense traffic.

McLaughlin, Hankey, Klauer and Dingus (2009) investigated the contributing factors to run-off-the-road crashes and near-crashes. The findings illustrated that run-of the road crashes typically happened during low visibility and dark conditions. More run-off-the-road-crashes also happened on roads with low friction, rather than on roads that were clear and dry. Just over half of the crashes investigated occurred on straight roads, followed by curves and intersection turns. Distraction contributed to most to the run-off-the-road-crashes. Other factors included short following distances (by the subject vehicle therefore encroaching on the lead vehicle), discontinuances in the road way and incorrect or late route selection.

Backer-Grøndahl et al (2009) also refer to the role that NDS research could play in understanding the effect that the road, infrastructure, traffic conditions and the interaction between drivers could have on driver behaviour. A new area of investigation revolves around eco-driving and traffic flow studies. According to Sagberg et al (2011) ND studies make it possible to assess driving style and patterns which in turn provide researchers with new knowledge of factors influencing fuel consumption and “eco-driving” practices.

Sagberg et al (2011) however are of the opinion that NDS could potentially be used for much more research pertaining to traffic management. It also provides information related to traffic flow and factors influencing choice of route, travel distances and speed. Information on route choice, travel time and travel patterns can be analysed and for example fed back into planning phases for the development of road networks and traffic managements strategies.

Van Nes et al (2010) indicated that NDS could potentially be used to identify future hazardous locations. By observing and anaysing data related to specific locations where hard braking or sweve actions occur, the potential “black spot” can be addressed before they become a serious problem.

In the EU the research methodology has also been expanded to include projects on two-wheelers (motor bikes and cyclists).

2BeSafe is a European project that employs the naturalistic driving study approach for powered two-wheelers (motorcycles). As in the NDS vehicle study, the motorcycle is equipped with video monitoring equipment as well as various sensors.

This research was commissioned under the European 7th Research Framework and was commissioned because so little research on motorcycle behaviour has been conducted in the past. Very few research tools (e.g. simulators) are available to study motorcyclist behaviour. The study focused on behavioural and ergonomic contributions to crashes. The objective of the research was to better understand the root causes of motorcycle crashes and to develop countermeasures to reduce the number (2BeSafe, 2012) of crashes as well as the severity of motorcycle crashes. Cafiso, Di Graziano, Giudice andPappalardo (2013) reported on preliminary findings from the 2BeSafe project specifically with regards to identifying of critical motorcycle behaviour events using GPS data. The results showed that motorcycle riders often underestimate the type of event they could be involved in. In terms of the classification system for crashes, near crashes and incidents (Klauer et al, 2006; Jovanis et al, 2012) motorcycle riders often did not think that they had just experienced a near crash or a critical event.

Naturalistic cycling study made use of video equipment mounted to the cyclists' helmet to capture the traffic environment from the cyclists' perspective (Johnson, Charlton, Oxley and Newstead, 2010). For each cyclist, approximately 12 hours of footage was recorded over a twelve week period. The research looked at cyclist behaviour, the behaviour of the motorists sharing the road with the cyclists as well as the shape of the road and the road environment. The aim of the study was to investigate pre-event behaviours as well as factors in the environment that influenced cyclist crashes and near-crashes. The results indicated that on-road cyclists (in Australia) tended to ride safely and that they made use of cycling facilities if available. Cyclists in general had good head movements (scanning behaviour) and major events were caused by motorists rather than the cyclists. These results informed recommendations pertaining to raising awareness for motorists in terms of sharing the road for cyclists. The recommendations were mainly focused around law enforcement and educational activities.

Projects related to novice driver behaviour will be discussed under section 3: overview of novice driver behaviour.

Appendix D provides an overview of NDS projects from 2005 to date.

3.5.3.4. Instrumented vehicles

Participants in the ND studies typically use their own vehicles. These vehicles are instrumented with a data acquisition system (Backer-Grøndahl et al, 2009; Van Schagen et al, 2011). Backer-Grøndahl et al (2009) refer to the value that NDS research could potentially have for understanding the effects that in-vehicle technologies have on driver behaviour. The researchers acknowledge that FoT's are being conducted but add that NDS might provide additional insight into the behaviour and interaction of drivers with in-vehicle devices. NDS could provide valuable insight in the characteristics of population groups (young, disabled and older drivers etc.) in order to design ITS applications appropriate for those end-users. Van Nes et al (2010) emphasised that NDS could be used to improve Intelligent Transportation Systems (ITS) by better understanding driver behaviour coupled with issues such as traffic flow, infrastructure requirements and so forth. With this information the ITS applications can be developed to function much more effectively to reduce crash risk. Information on driver behaviour could potentially lead to the development of in-vehicle systems that raise awareness when the driver gets distracted, tired and so forth.

In the 100-Car study it is stated that a Pentium based computer was used which stored data from different networks of sensors (instrumented) vehicle.

Sensors included:

- A data box
- Accelerometer box to determine longitudinal and lateral acceleration
- Equipment that provided information related to leading vehicles (driving in front of the instrumented vehicle)
- System that detected conflict between vehicles and on the side of the instrumented vehicle
- Incident box that flagged critical incidents for the researchers
- Video-based lane-tracking systems to measure lane keeping behaviour and video (image material) to validate any of the findings obtained from the sensors.

Additional information was collected through:

- automatic collision notification (possible collisions);
- cellular communications to determine system status and vehicle position;
- system initialization equipment to automatically control system status;
- a GPS positioning subsystem to collect information on vehicle position.
- radar to measure closeness or proximity to other vehicles.

Additional equipment included an “incident” button the driver could push in the event of something happening on the road and a glare sensor.

The image recording devices were considered extremely important as this provided a continuous stream of information as to what is happening inside and outside the vehicle (Dingus et al, 2006). The cameras monitored the driver’s face, the drivers view to the outside of the vehicle as well as an “over the shoulder” view of the driver’s hands. There was also a camera that covered rear and forward views of the vehicle. Dingus et al (2006) stipulate that the system had to be digital to allow for “software-controllable video compression capability”.

In the DaCoTA project, Pilgerstorfer et al (2011) made use of two systems. The first (Scenario 1) entailed the data logger system, an accelerometer and GPS. Of interest to the researchers in this experiment was the person and vehicle kilometres travelled, number of trips, time in traffic and speeding behaviour. The second system (Scenario 2) also included cameras and additional sensors able to collect additional driver data including lane changing behaviour, signal and light use, seatbelt use, headway and so forth.

Talbot et al (2010) indicate that the Controller Area Network or CAN data provides detailed information on the electronic controls of the vehicle. In the large naturalistic driving study planned for the EU the fact that the CAN data varies from manufacturer to manufacturer was deemed problematic as a large number of different types of vehicles were to be used in the study. The researchers noted that if they wanted to get information from the CAN that related to the safety systems in the vehicle, an agreement with the manufacturers needed to be entered to.

The Global Positioning System (GPS) records the position of the vehicle at any time. Map matching (Geographical Information System or GIS) is the method used within the DaCota project to link the GPS data with the roadway. The variables that can be linked to the roadway data are limited to the detail that a map can display. Talbot et al (2010) indicate that the most popular variables from the roadway and maps available in Europe are road classifications and area type. Other information that might be available includes indication of the nature of the road, including speed limits. Although the researchers indicate that additional information could be added to the map, information such as road or slope profiles, curve characteristics, signs and priority rules are rarely available.

Video data is an integral part of the naturalistic driving studies. With video data it is possible for the researchers to pinpoint the events that lead to incidents. Talbot et al (2010) note that continuous video data takes up a lot of storage space and need additional human resources in order to deduce and code important data. Although some progress has been made with "machine learning" and computer recognition of events in video data, this is still not deemed cost effective and the researchers recommend that human observers should be used for this task. This requires a lot of effort and time to go through all the video data. Talbot et al (2010, p.60) state that:

"..video analysis is used to qualitatively confirm that the triggered events (near crashes) do conform to the qualitative definition. External video can be used to validate aspects of the scenario, while internal video can be used to validate driver state and gaze direction. In essence, video confirmation can help to establish if the incidents observed are in face real near crashes."

3.5.3.5. Data collection

In the DaCota study, the first scenario recruited 10 Austrian participants (5 male and 5 female). The data logger was the "*Pdrive lite ®"* system and the participants were required to drive with the system for a period of 4 months. This system recorded all data except for video data (Pilgerstorfer et al, 2011). 3466 trips were recorded and analysis of the data revolved around the type of road, day of week, gender, length and duration of the journey.

In the second scenario of the DaCota study, 7 participants (3 male and 4 female) were used to collect data with the more elaborate instrumented vehicles. This study took place in Israel and the driving period during which data was collected was six months. Data collected and analysed included road type, gender, weekday, time of day, length and duration of journey, speed and acceleration as well as headway and lane departure movements (Pilgerstorfer et al, 2011).

Wiegand, Hanowsky and McDonald (2008) indicate that once the data has been collected there is a need to: (i) identify potential events), (ii) check the validity of these triggered events and (iii) apply a data directory to verified conflict events.

3.5.3.6. Data analysis

Boyle, Hallmark, Lee, McGhee, Neyens and Ward (2012) identified and prioritised key research questions for the SHRPII NDS study and tried to establish the importance of different research elements that should be contained (e.g., methods, data, questions) in research plans as well as the analytical methods that should be in place to address these. Specific research questions need to be answered in any research study. The problem with naturalistic driving studies includes the possibility that insufficient event data might be generated to answer these research questions. The researchers suggested that surrogate crash measures be included in the study work plan from the onset of the programme.

Jovanis, Shankar, Aguero-Valverde, Wu, and Greenstein (2012) reported on the prospective data analysis methods to be used with NDS data from the University of Michigan as well as the Virginia Transport and Technical Institute (VTTI). Jovanis et al (2012) started off by modelling the event detail of each of the incidents recorded in the 100-Car study. This led to crash classification and research questions. This classification is important as this forms the basis for the analytical work conducted on various road-ways and environments.

Davis and Hourdous (2012) report on the methods that could potentially be used for the analysis of the SHRP II naturalistic driving data. The goal of the study was to determine ways to develop and test analytical models and methods which can be applied to the data. For this research both site-based (fixed cameras at intersections etc.) and vehicle data (instrumented vehicles) were used and subjected to various analysis methods. The researchers indicated that the sample size (thirty three events) was too small to be generalizable. The conclusions were as follows (Davis et al, 2012):

- It is possible to quantify the degree to which a near crash could have been an actual crash based on the driver's evasive actions
- It was possible to extend methods that provide counter information to include more complex structural relationships. In other words methods that were previously not used in combination can now be used together to analyse the different sets of data.
- The data analysed had the potential of providing insight related to crashes and near-crashes at specifically low volume intersections.

Both studies (Davis et al, 2012; Jovanis et al, 2012) emphasised that the data from NDS studies needs to be complete and without any errors that could limit the extent to which the data could be used in statistical modelling. The researchers highlighted the importance of transparency, consistency and analysis of future naturalistic driving data. Context should be considered extremely important when analysing the data. Issues of kinematics (movement data) are important and should be included in future models of analysis. Kinematics and their relationship to the driver and geometric properties of the roadway should be thoroughly investigated.

3.5.4. Strengths and weaknesses of the methodologies

The strengths and weaknesses of the large scale NDS study in Europe are summarised by Backer-Grøndahl et al (2009) in table 3 below.

NDS has the potential to overcome the limitations of traditional data collection (Reagan et al, 2012). A traditional method such as the analysis of crash reports often does not provide all the information needed to understand the factors and root causes that actually caused the crash. NDS is novel way in which research can collect road safety data. The methodology allows for the direct observation of driver behaviour and can provide insight into inattention, drowsy driving, specific behaviour etc. but also collects important data about the environment and the vehicle that could be utilised to improve traffic management, infrastructure as well as recommendations on efficient driving for better fuel consumption, lessening emissions and so forth. This allows for optimal observation of the driver, environment and vehicle (Van Nes, Backer-Grøndahl and Eenink, 2010). Van Nes et al (2010, p334) identified the following benefits of NDS research:

- NDS research allows for direct observation of driver behaviour;
- Observations are realistic as they are set in an everyday environment, allowing for unobtrusive observation of behaviour;
- Observation of incidents leading to crashes or near-crashes can be conducted – this allows for some interpretation regarding the causality and different factors leading to the incident that otherwise have not been known.

Table 3: Strengths and weaknesses of the NDS methodology (Backer-Grøndahl et al, 2009)

Strengths NDS	Weaknesses NDS
• Direct observation of behaviour • Direct observation of critical events, near crashes and actual crashes	• Low internal validity with respect to causal explanation • Low control over external variables
• High ecological validity - naturalistic and realistic context	• Potential for biased samples
• Unobtrusive, strengthening ecological validity, limiting reactivity/observer effect (that participants change behaviour merely because they are observed)	• Potential for observer effect
• Long duration, limiting reactivity and experimenter effects are minimised	• Resource demanding in terms of sample, duration, data gathering, data storage, data analysis
• Objective observations, not subject to recall biases,	
• Generalisation of results from large database and samples	
• In-depth information about factors contributing to accidents	
Strengths of experimental and simulation studies	**Weaknesses of experimental and simulation studies**
• Experimental control allowing for causal explanations	• Artificial study settings/limited generalisation
• Direct observations	• Low ecological validity,
	• Observer effects
Strengths of self-report/epidemiological studies	**Weaknesses of self-report/epidemiological studies**
• Large samples	• Self-report biases
• Actual crashes	• Insufficient information on preceding factors
	• Indirect observations

3.5.5. Ethical considerations of NDS highlighted in the literature

The fact that driver behaviour is observed without the driver consciously being aware of the recording equipment all the time means that it is possible to collect data from drivers that represent the actual driving behaviour under different circumstances. Over and above the normal benefits that have been listed as to why ND studies can be useful in traffic management and road safety, Sagberg, et al (2011) also indicate that ND study results can be used and translated into useful information to:

- Provide feedback to learner drivers
- Inform the development of eco-driving courses
- Develop courses for elderly drivers
- Develop commercial driving courses and training
- Develop in-vehicle recording systems to monitor risky driving
- Monitoring indicators for statistics purposes.

Some researchers, however, question the objectivity of the fact that drivers are observed and the assumption that the drivers at some stage forget about the equipment. Regan et al (2012) state that potentially there might be limitations that could be associated with the NDS methodology. Firstly the researchers ask the question whether or not the driver really truly ever "forgets" about the recording devices and whether or not this data collection is truly objective. Secondly, the methodology is resource hungry, meaning that a lot of resources (financial and human) need to be invested in the equipment, data gathering and storage and analysis phases of the research.

Guttman and Lotan (2011) raised and investigated the issue of ethics, specifically with regards to privacy issues. In the study (Guttman et al, 2011) they found that if cost was not a consideration, most of the parents were willing to install cameras in vehicles monitoring their children's behaviour. However when costs were considered half of the parents indicated that they would not install such devices in their children's vehicles. Half of the parents felt that installation of monitoring devices would improve communication between the parent and child while the other half of parents believed it would hamper the trust relationship they have with their children.

Privacy issues (Guttman et al, 2011) were contrasted with a parents' moral obligation to install the technology in the vehicles for the sake of road safety. Most of the parents felt they had a duty (moral obligation) to know how their child was driving despite the fact that the technology invades the young drivers' privacy. Table 4 below summarises parental reaction for and against the installation of cameras in their child's vehicle.

Other issues included: the cost of the installation, conflict that might arise due to confrontations between parents and children and security concerns that outside sources could get hold of the data. However, NDs were not originally designed as a monitoring tool but as a research tool to provide insight into driver behaviour with the aim of reducing crashes.

Table 4: Parental reasons for and against installation of cameras in young drivers vehicles (Guttman and Lotan, 2011)

Pro-installation	Against installation
Cannot ignore information from video- morally obliged to take action to improve behaviour	The technology infringes on the young drivers privacy
Receive factual data and information	Parents should not spy on their children or take up the role of a police officer
Observe a larger "picture" of how their child is driving-learn things about their driver behaviour they did not know before	It will reduce the young drivers' self-confidence
Attend to issues/problematic behaviour regularly over time.	Parents need to "let go" and give the young driver independence
	Parents would become obsessive
	It will influence the confidence of parents toward the child negatively- no need for the technology if you trust your child
	The technology is limited and does not address issues such as driver distraction.

2.6. Naturalistic driving studies investigating novice drivers

A number of naturalistic driving studies involving teenage and novice drivers have been conducted. These studies focused on risky driving practices, investigation of factors influencing young driver behaviour and crash risk after the first few months of licensure. Reagan et al (2012) also make reference to the value that NDS could have to evaluate road safety initiatives aimed at improving novice driver behaviour through training, new engineering measures and in-vehicle technologies.

Boyce and Geller (2002) recruited 61 licensed drivers (29 males and 32 females) from southwest Virginia between the ages of 18 to 82 years. The researchers grouped the drivers into three categories namely younger (23 drivers), middle-aged (22 drivers) and older (16 drivers). Driving performance was collected in an instrumented vehicle with video monitoring and recording equipment. The equipment consisted of four small concealed cameras and a data recorder. The following information was collected: safety-belt use, number of times a turn-signal was used and left, right, and emergency flashers, vehicle velocity including average speed, velocity changes and velocity variance (in mph) and following distance measured in meters. Self-reported behaviour and personality questionnaires probing risky-driving were administered to the participants. The findings supported the fact that risky driving such as not using a seatbelt, following too close and speeding too fast for the circumstances were strongly correlated with age. Younger drivers tended to engage in more risky behaviour. On the other hand the research found that older drivers were less likely to use turning signals which could possibly be explained by the fact that older drivers feel they have successfully and safely employed this behaviour over years and therefore it has become a habit.

Event triggered video monitoring equipment was installed in vehicles driven by 16-17 year old US students. The data collection equipment was designed to capture 20 second clips of the forward cabin (on the driver) whenever the vehicle exceeded lateral or forward thresholds accelerations. The information was used to give feedback to novice drivers through their parents. It was envisaged that this intervention was a means to identify risky driver behaviour from which novice or young drivers could learn from their mistakes. It was found that through use of this technology, coupled with a weekly review of safety related events, novice or young driver behaviour could be positively influenced and thereby decreases their risk of crashes (McGhee et al, 2007).

Hedlund (2007) compares two NDS studies conducted by Virginia Tech. The first being the 100-Car study and the second a study that observed 40 newly licensed drivers for a two week period after they received their licenses. Hedlund concludes that in both studies young novice drivers:

- Displayed willingness to engage in risky behaviour
- Used handheld electronic devices
- Drove while impaired by fatigue or alcohol
- Failed to recognize hazards
- Committed judgment errors in assessing driving risks
- Had poor decision-making under stress
- Displayed late reactions after indecision.

In the 100-Car study, young novice drivers were found to make judgement errors four times more frequently than older drivers.

Prato et al (2010) investigated novice driver behaviour for the first twelve months after novice drivers obtained their licenses. These drivers were part of a Graduated Licensing Programme where the new drivers were accompanied by older and more experienced drivers for a period of three months after licensure. The vehicles were equipped with a data acquisition system (DAS) and measurements included the collection of image material, deceleration, acceleration as well as trip start and end times. The researchers found that the novice drivers who were inclined to be more sensation seeking drove more riskily after their supervision period ended (no supervision in the vehicle) but that the supervision period influenced the level of risk-taking positively. The researchers indicated that the supervision period for new/novice drivers should be deemed as important in driver training.

Lee et al (2011) describe the naturalistic driving methodology (Naturalistic Teen Driving Study) used to research teenage driving for a period of 18 months of newly licensed drivers. The data acquisition system was installed in 42 vehicles driven by 16 year old drivers. The data acquisition system consisted of cameras, sensors (accelerometers, GPS, yaw, front radar, lane position, and various sensors obtained via the vehicle network) and a computer with removable hard drive. According to the researchers this NDS study confirmed that crash and near crash rates were highest among novice drivers in the first six months after they have obtained their license.

Simons-Morton et al (a) (2011) concluded that in-vehicle monitoring provides an objective measure of the kilometres driven as well as the g-forces exerted by the vehicle. The researchers state that elevated g-forces were the highest among the “youngest” (19-20 year old) drivers. Furthermore the rates of crashes and near crash events along with elevated g-forces were four times higher for teenage drivers than for their parents. The researchers though, found that risky driving was less common in instances where either peers or parents were present in the vehicle.

Simons-Morton et al (b), (2013) state that the research conducted by Lee (2011) highlighted the fact that within the teen driver group there are three groups that can be distinguished: a) a group with very high crash rates which was maintained during the study; b) a group which started out with a high crash rate which declined after the first 6 months of driving and c) a low risk group that had few crashes over the study period. Simons-Mortan et al (2013) expanded on this research and investigated the kinetic energy (kinetic risky driving) as a predictor of crashes or near-crash events. This means that the researchers measured the g-forces of the driving activities such as hard breaking, rapid acceleration and rapid deceleration. The research found that elevated g-forces in the previous month were a good predictor of the likelihood of a crash or near-crash event in the following month. The research found that young drivers with high kinetic risky driving (more hard stops and sharp turns) were more likely to crash than young drivers with low kinetic risky driving behaviour. An interesting finding from Simons- Mortan et al (2013) was that the riskier group with previously high crash rates got better at avoiding crashes over time but that the driving behaviour of the group did not necessarily became less risky. In other words although the group crashed less, they did not drive more safely and continued to brake hard, accelerate and decelerate fast. The explanation given was that driver behaviour improves over time and with experience.

2.7. Applicable literature for the development of a coding scheme making use of grounded theory

2.7.1. Introduction

Novice drivers are over represented in crash statistics and this project provides an opportunity to better understand skills deficiencies contributing to this. Musicant, Lotan and Toledo (2007) stated that even if crashes are thoroughly investigated, little or no information on driver behaviour patterns are available and that information related to individual risk levels are limited.

This project focuses on three such skills namely hazard identification, hazard perception and handling of the vehicle. If a better understanding of these skills can be facilitated it would be possible to make inputs into the training curriculum of young and novice drivers as well as to provide evidence and supporting information to government pertaining to issues such as restrictions on hazard perception testing, provisional licensing and graduated driver licensing programmes.

The purpose of this chapter is to detail the methodology followed in the development of a driver behaviour classification/coding tool/scheme that was used to code the image material (at a tactical level) collected in the NDS project.

Hazard perception in is a skill that develops over time (Grayson and Sexton; 2002). Grayson et al (2002) indicated that hazard perception is a skill that can be measured scientifically and objectively. Earlier psychometric tests were used to measure hazard perception within the licensing process. These tests discriminated between experienced and inexperienced drivers but did not correlate or show accident liability. Further research by TRL interrogated the items in the psychometric tests that best encapsulated hazard perception and found that test items (questions) in the hazard perception test which required good scanning abilities as well as the ability to predict dangerous situations were mostly associated with hazard perception. New drivers are not only learning a new skill but are formulating new rules and developing new responses to different situations and new patterns of interaction (Grayson et al, 2002). Hazard perception is associated with experience and learning the art of recognising potentially hazardous situations and ultimately with accident liability. It was therefore proposed that if hazard perception can be taught from an early age, this improved skill could potentially reduce young drivers’ accident liability.

Measuring a skill is not easy and Grayson et al (2002) state that with hazard perception the effectiveness of the skill is measured in reaction time. This is ironic as with increasing age, skill generally deteriorates, while with hazard perception it is expected that this skill would improve over time. Previous hazard perception tests (excluding psychometric tests mentioned earlier on) included static pictures or films where participants were requested to respond to the hazards in the images or films (TRL test, VicRoads test).

Hazard perception (Grayson et al, 2002) was measured in terms of:

- Response time to specific hazards
- The number of hazards detected
- Average assessment in terms of the hazards

In developing the hazard perception test, it became clear that although the operational definition of hazard perception was accepted as the “ability to identify potential hazardous situations” additional definitions of what is meant with these “hazardous situations” was needed. For the development of this coding scheme it is again an important consideration and although the development of this scheme draws heavily on research from other countries, it would be expected that these hazardous situations (which is potentially different in SA from other countries) would also need to be defined for South African conditions based on the scenarios captured in the image material.

2.7.2. Approach

A literature review provides the basis for the development of these coding schemes. Due to a lack of South African data, use was made of international research that focuses on:

- existing coding schemes and models
- reaction times in traffic
- errors, lapses and violations
- visual search strategies
- behaviour at certain roadway features such as for example stop streets and traffic lights.

Initially the idea was to develop a coding scheme in the form of a matrix detailing the various behaviours as well as the severity of each of the coded behaviours. For each of the behaviours identified, a code as well as a weighting in terms of seriousness was to be assigned. The coding scheme was planned to be pre-developed and then applied to video images. However, once the coding started it was realised that there were so many situations and behaviours that needed to be coded that a new approach was needed. Grounded theory was therefore used to develop the coding scheme.

2.7.3. Theory for the development of a classification scheme

2.7.3.1. Levels of control in driving

Michon (1985) indicates that a driver needs to have three levels of skills and control. At a strategic level the driver needs to be able to plan his trip, take into consideration what route he is about to take as well take into account issues such as costs associated with the trip. The tactical level describes control and manoeuvring (figure 13). At the tactical level the driver is required to react and manoeuvre a response to immediate traffic conditions. The driver therefore needs to respond accurately and quickly to demands in traffic and all of these demands are related or associated with the goals set in the strategic level. Little or no information is available from the data to understand the strategic level of behaviour as depicted in the figures below. This classification scheme focuses on the tactical and operational levels of driving.

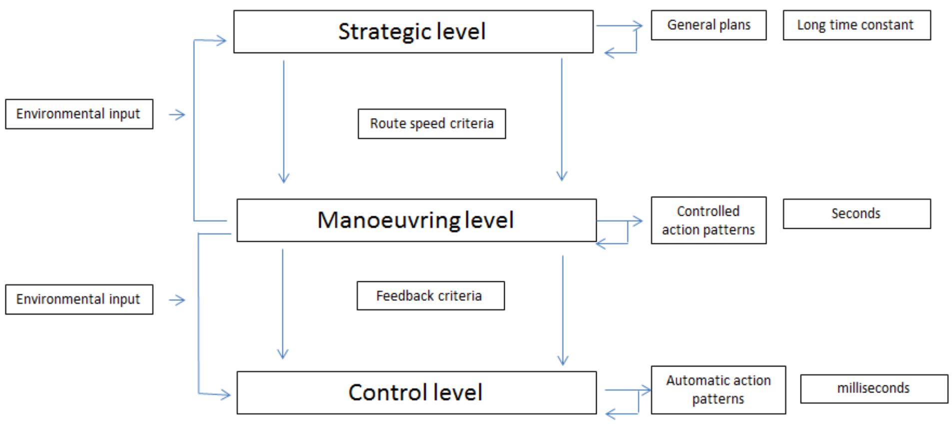

Figure 13: Driver skills and control at different levels (Michon, 1985)

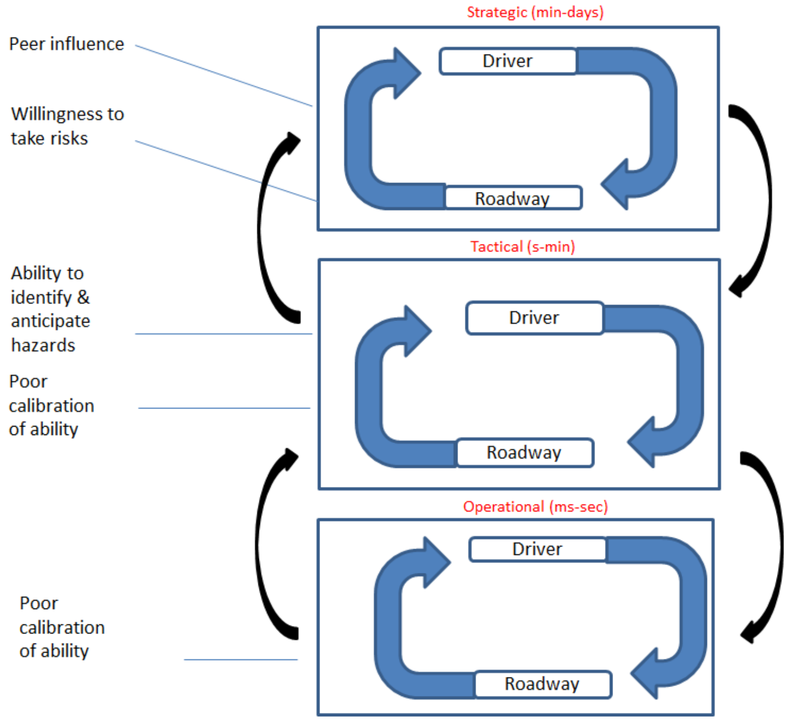

Figure 14: Application to operational, tactical and strategic levels of driving (Lee, 2007)

Lee (2007) applied the same levels of control to those of novice drivers. Operational control of the vehicle reflects the drivers' ability to maintain a desired speed or lane position. The tactical control of the vehicle reflects a driver's ability to select appropriate speed, identify and anticipate hazards and identify necessary manoeuvres. Strategic behaviour is reflected through choice of route, acceptance of norms and risks and whether to allow passengers in the car. Failures of control at each level and the subsequent propagation of these failures across levels describe many of the factors that contribute to the overrepresentation of young drivers in car crashes.

Each level of control in figure 14 includes a closed loop control system. Driving safety depends on effective feedback and feed-forward control at each of these levels. Feedback control depends on the timely assimilation of information regarding how effectively actions achieve the driver's goals. Feed-forward control depends on how well an internal model allows the driver to anticipate future events so that control actions can be planned to meet the driver's goals. Annotations in Figure 14 highlight some of the reasons for the high crash rate among young drivers, which include:

- Imperfectly learned vehicle control skills, which lead to poor control and less spare attention capacity to accommodate unexpected roadway demands.
- Poor ability to anticipate and identify hazards
- Willingness to take risks, such as shorter following distances and higher speeds
- Poor calibration of abilities relative to driving demands
- Sensitivity to peer influences in adopting inappropriate norms

Sagberg et al (2010) indicate that there are various “categories” for observation with naturalistic driving. These categories include inattention (driver distraction, engagement in secondary tasks and perception and processing of driver information, fatigue and decision-making, errors, lapses and so forth. Sagberg et al (2010) state that the phenomena of distraction and inattention are closely related to drivers’ perception and processing of information from the driving and traffic environment, including both inside and outside the vehicle. But the authors warn that it is not possible to observe processing directly, not even with the naturalistic driving approach. However, the authors allude to the fact that it is possible to make some inferences from observation of visual search behaviour in relation to information provided by signs and markings, combined with observations of the driver reactions to the information, e.g. in terms of complying with regulatory information, changing lanes to prepare for exits, etc.

The development of this classification scheme is cognisant of category one (inattention) with the sub-category “information processing” (which might be difficult to observe) as well as on category three which refers to general driving style, errors and lapses.

2.7.3.2. Hazard identification and perception

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. Driving experience therefore plays an important role in hazard perception. The perception of hazards cannot be emphasised enough (Whelan, Senserrick, Groeger, Triggs and Hosking: 2000). The researchers state that failing to search the road way was the single most common factor in crashes. The researchers state that hazard perception tests have found their way into licensing processes in Australia, New South Wales and Western Australia.

Previous methodologies used to assess hazard perception include (Whelan et al, 2000):

- Psychometric testing
- Encounters on test drives
- Ranking of photographed scenes (scale of hazardousness)
- Presentation of video scenes with varying degrees of danger and difficulty
- Measurement of visual search patterns while on a test drive

Crundall et al(2012) note that different researchers have come to different conclusions regarding hazard perception abilities in novice drivers over the years. Even though there is conflicting evidence, the UK Government in 2002 decided that there was enough strong evidence to introduce hazard perception testing for learner drivers. This means that certain hazard perception criteria have been included in the licensing procedures and learners have to pass the hazard perception test before they are awarded a driving license.

Chan, Pradhan, Pollastek, Knodler and Fischer (2010) indicate that according to crash statistics and police reports, novice driver crashes happened because novice drivers failed to scan the roadway, were unable to manage speed and to maintain attention. Chan et al stipulate that although experienced drivers might also fail to adhere to these three requirements of safe driving, it is expected that novice drivers are more prone to forget to do this.

Road safety research consistently demonstrates that young driver crashes and fatalities are influenced by numerous driver, passenger, journey, vehicle and crash variables that interact (Scott-Parker, 2010). This is illustrated in figure 15 below.

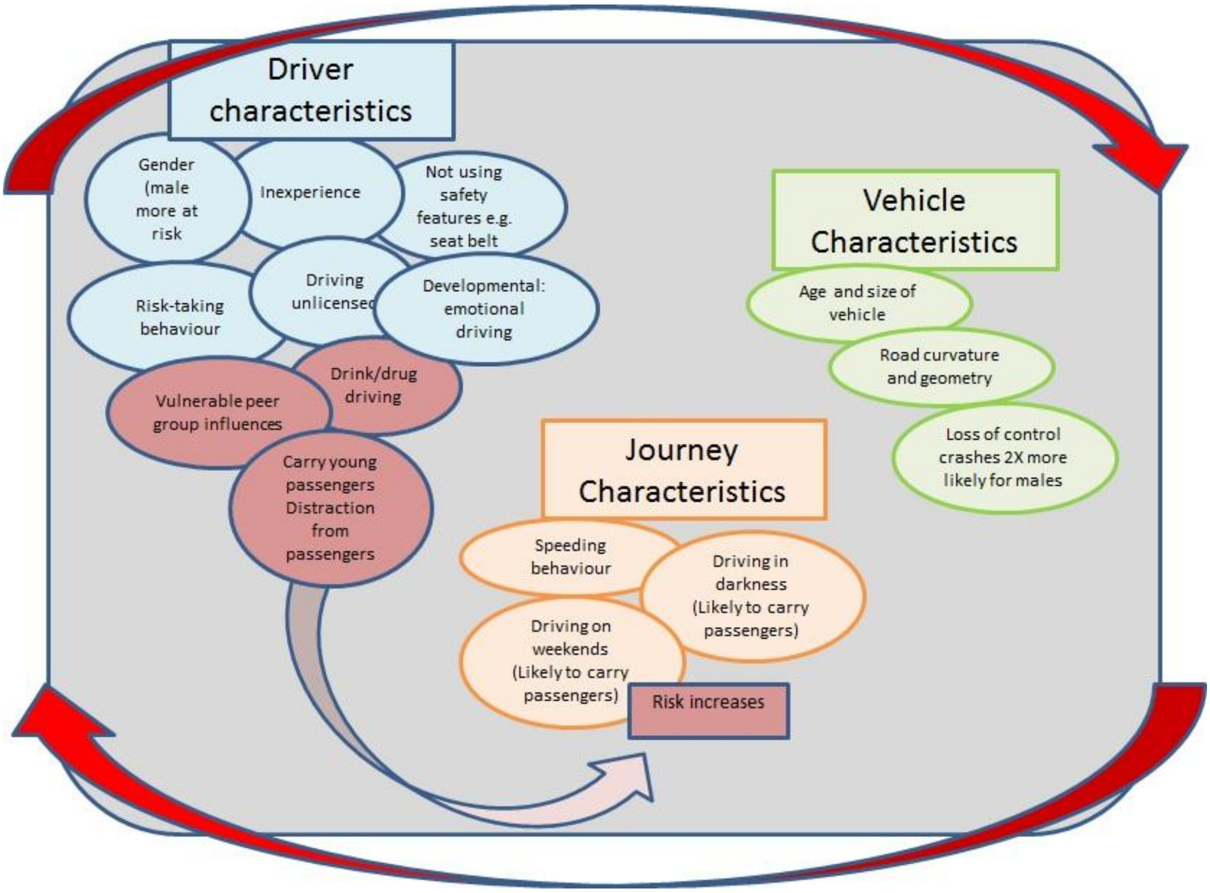

Figure 15: Characteristics of young drivers influencing road safety risk (Scott-Parker, 2010)

Based on these young driver characteristics, Scott-Parker et al (2010) developed a measurement tool for young driver behaviour. Five categories or psychometric properties are measured with this tool and include:

- Transient (fleeting moment) rule violations e.g. (exceeding the speed limit in order to overtake a vehicle)
- Fixed rule violations (e.g. not stopping at a stop street)
- Misjudgement (e.g. overtaking another vehicle and misjudging the gap to merge with traffic again)
- Risky exposure (speeding up through a yellow traffic light)
- Driver mood (e.g. anger contributing to irrational behaviour)

The authors indicated that transient and fixed rule violations, risky exposure and mood are enforcement and education issues. Misjudgement however, is associated with driving experience and hazard detection skills. These can be developed in learner driver phase by means of programmes such as the graduated licensing programmes.

Hazard perception research is classified into two aspects of skill related to the identification of hazards in traffic. These two aspects are performance based skills and cognitive and visual search skills (Figure 16 below).

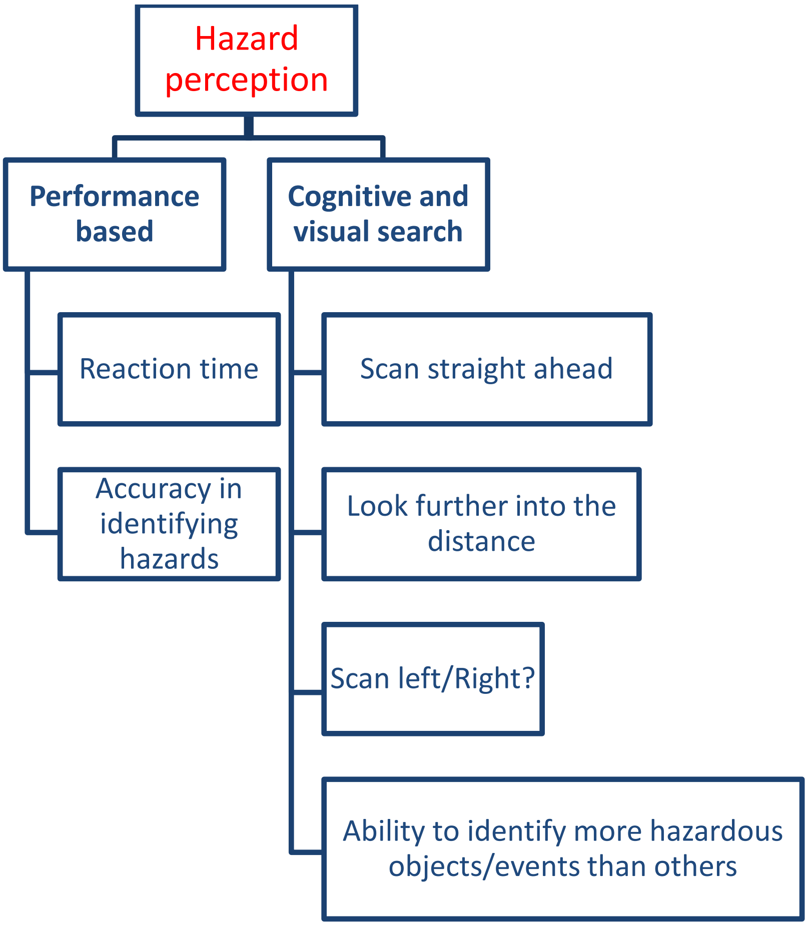

Figure 16: Hazard perception skills according to Whelan et al (2000)

The authors of the NFER project (Grayson et al, 2002) divided driving scenarios into six different types of roads (rural, urban, sub-urban, residential, single carriageways and dual carriage ways). In their study three categories of hazards were added to the typology:

- An object moving into the path of the vehicle
- Hazardous actions of on-coming traffic
- Unexpected actions from the vehicle in front

Participants were asked to look at the professional films and to react quickly and appropriately to the hazards in the pictures.

Reaction times were not used as the sole determinant because reactions to some hazards might be longer than others. Therefore if reaction times were simply added up, it would give a skewed picture of hazards a driver tends to react to over a longer period of time in contrast to that of hazards that take less time to respond to. Reaction times (on the first hit of the button) in which half of the respondents reacted was rather clustered in time intervals. From here a coding scheme (ranked 1-5) was developed for each of the scenarios.

Final items considered for the hazard perception test needed to meet the following criteria:

- The mean score of the event needed to be between 2-3 for participants
- High positive discrimination between participants
- Significantly different scores for experienced and inexperienced drivers (experienced drivers would have higher score than the inexperienced drivers.

In 1997 the hazard perception tests-film and photo tests (Vlakveld, 2002) from the 1993 project was revisited. A number of additional hazards (and better defined scenarios according to road and environment type) were developed and shown to experienced and inexperienced participants. One of the key questions was: what is seen as a hazard by an experience driver and what is seen as a hazard by an inexperienced driver? In which situations are drivers more aware and which hazards are more easily recognised or spotted than others?

Grayson et al (2002) indicate that the actual ability that needs to be measured is not the reaction time per se, but the ability to scan the road and then the time it takes for the driver to anticipate and appropriately react to the hazard. The following criteria were defined for the hazard perception items in the test:

- scenario develops into an ‘actual hazard’
- anticipation is possible for experienced driver or trained novice
- scanning ahead and/or to the side necessary
- clear and uncluttered scenario
- not simply dependent upon reaction time.

The mean scores, standard deviations and reliability scores were used to distinguish between novice and experienced drivers based on the number of perfect items in which there was significant differences in the scores from experienced and inexperienced drivers.

In the present research study, investigating novice driver behaviour using NDS, the sample size is small and it will not be possible to generalise the findings to a bigger population. However, the scenarios in which hazards are presented are identified for both the inexperienced driver as well as the experienced driver. These hazardous situations present in the video material are (based on indicator table below) clustered into topics. Reaction time, ability to scan the roadway and time to appropriate action are measured and compared between the inexperienced and experienced drivers. Crundall et al (2012) refers to dimensions of hazard perception. These include anticipation, surprise and complexity. Anticipation refers to the context of the hazard perception and the “ability to read the road and anticipate forthcoming events”. Surprise refers to a situation where the driver failed to link the precursor (anticipation) and hazard. Complexity (dividing and focusing attention scenarios) refers to the driver’s ability to monitor multiple sources and to identify a potential threat in the driving environment. Wetton et al (2010) refer to hazard identification/detection (recognising a potential threat), making a judgement on whether or not the vehicle trajectory will cause conflict,and deciding on an evasive action (hazard classification). According to Wetton et al in each of the three processes there are steps that precede the perception process. For the purpose of this classification scheme, the focus will be on the reaction of the driver once he has recognised the hazard and the evasive action taken or not taken once a potential hazard has been identified. Step 1 revolves around the driver’s ability to recognise/identifyor detect the hazard but this can not be measured based on the visual material availble to the researcher and is therefore the subject of further and future research. Use is made of step 2 (identifying possible elements in the environment that could potentially lead to hazardous situations) and step 3 (locating indicators that could suggest that there could be danger).

Table 5: Explanation of hazards and precursors (Crundall et al, 2012)		
	Critical stimuli	
	Precursor	**Hazard**
Behavioural anticipation	Child visible between parked cars Car waiting on side of road	Child steps into road Car pulls into road
Environmental prediction hazards	Parked ice cream van Blind bend	Child steps into road Broken down vehicle around the corner
Dividing and focusing attention	Parked public transport vehicle at a school where learners are exiting the school grounds Traffic lights at intersection flickering (four-way stop)	Pedestrian steps into the road way Vehicle enters intersection not obeying four way stop

In order to understand the reaction of the driver, Crundall et al (2012) investigated whether:

- the drivers look at the critical stimuli
- how quickly drivers fixated the critical stimuli after onset
- level of attention devoted to critical stimuli

Glendon et al (2007) compared different sub groups of drivers (n=2765 cases) in terms of four groups namely: non-violators, commercial violators, tailgaters and speeders. The research found that age was the best predictor of tail-gating and speeding behaviour. Vehicle age and vehicle type were the second best indicator for speeding behaviour.

"The targeted area for a driver lies in the 'conservative' and 'neutral' zones. Both extreme classifications, timid and aggressive, may constitute dangerous behaviour" (Wagner et al, 2011).

Furthermore, unsafe driving may also occur in the cautious and assertive classifications. For example, assertive driving may be classified as unsafe owing to behaviours such as tailgating, speeding above the traffic flow and rapidly changing lanes. However, cautious driving may be classified as unsafe owing to such characteristics as travelling below the speed of traffic to maintain the minimum posted speed limit, over-scanning before making turns or lane changes and not anticipating traffic patterns while maintaining vehicle speed. A normal distribution has been assumed for general driver behaviour with the percentages based on the number of standard deviations about the mean. The target zone is neutral (Table 6).

Table 6: Targeted area for a driver source (Wagner et al, 2011)

Population %	5%	20%	50%	20%	5%
Safety level	Dangerous	Unsafe	Target zone	Unsafe	Dangerous
Characteristics	Too slow; Unconfident; Disturbs traffic flow; Unpredictable	Obey speed limits regardless of traffic flow; Not instinctive Over scans	Follows traffic flow; Predictable; Confident; Proper scanning technique;	Routinely speeds; Tailgates; Under scans	Too fast; Over confident; Disturbs traffic flow - Unpredictable
Driver classification	Timid	Cautious	Conservative Neutral	Assertive	Aggressive

Table 7 below provides an overview of the concepts considered as indicators for the coding of the image material in this project.

Table 8 summarises possible indicators for speed management and other hazardous situations including lane changing behaviour, merging and so forth. For this research project the main focus was on speed management as the other behaviours necessitated the use of measuring instruments such as radar able to measure distance.

The application and operationalizing of the scheme will be discussed in Chapter 4.

Table 7: Possible indicators for hazard perception

Indicator	Reference	Definition	Novice driver behaviour	Measurement/benchmark	Experienced driver
HAZARD PERCEPTION					
Scanning behaviour	Whelan et al (2000) Grayson et al (2002) NSW (2012)	Ability to scan environment, identify specific hazards Scanning means taking in the whole scene 360 degrees around vehicle	Scan road Evaluate other drivers location Predict objects Other drivers' behaviour Use of windscreen, side windows and mirrors (& blind spots)	Angle at which the driver scans the roadway Head and eye movements (eye movements will not be measured) 60 km/h zone-this means looking up to 200 metres ahead 90 km/h 300 metres ahead Mirrors checked every 8 seconds	Wider scanning ability. More frequent scanning
Performance based ability	Whelan et a. (2000) McKenna and Crick (1994) Scialfa et al (2011)	Based on how the person performs when encountering hazards Inaccurate and narrow scanning field	Reaction time when encountering a hazard Do not have accurate internal representation of hazards.	Novice drivers 1.8s to identify and take evasive action Reaction time to sudden onset (basketball)	Faster in identifying hazards (on average)
			Accuracy in identifying hazards correctly	1.2 s associated with more accident prone drivers	Better scanning abilities
Visual search	Whelan et al (2000) Mourant and Rockwell 1972	Cognitive decision-making on how to identify hazards when in traffic	Scan straight ahead Look further into the distance Scan left/right	Eye fixations are smaller (closer to vehicle) Closer to front Closer to left/right of vehicle Pursuit eye fixations 440ms more than	Moving objects more hazardous than stationary objects

Table 7: Possible indicators for hazard perception

Indicator	Reference	Definition	Novice driver behaviour	Measurement/benchmark	Experienced driver
	Chapman and Underwood (1998)			experienced drivers Visual fixations significantly longer	
Foreshadowing element	Crundall et al (2012) Garay et al (2005)	Ability to recognise cues that draw attention to possible hazard	Forewarned more attention focused on areas where possible hazards are located.	Eye movement to establish whether foreshadowing (precursors) are seen Advance Cue: Pedestrian Ahead Sign Foreshadowing Element: Pedestrian Critical Area: Sidewalk	Better at identifying possible movements/objects that could potentially lead to a hazardous situation
Recognising traffic conflicts	Scalfia et al (2011)	Ability to recognise conflicts in traffic	Accuracy and recognition and reaction time	Scanning behaviour	Accuracy and recognition and reaction time
Turning left (stop/give way)	NSW Department of Roads and Maritime (2012)	Safe gap acceptance Turn, overtake, change lanes or cross an intersection safely No other road users should need to slow down or move to avoid NDS vehicle.	Behaviour at intersection / Traffic light	6 seconds at speed of 0 km/h (traffic light/stop/give way) or 60 km/h match oncoming traffic	Behaviour at intersection / Traffic light
Turning right **(stop/give way)**			Behaviour at intersection / Traffic light	4 seconds at speed of 0 km/h (traffic light/stop/give way) or 60 km/h match oncoming traffic	Behaviour at intersection / Traffic light
Traffic light	NSW Department of Roads and Maritime	Safe gap acceptance Turn, overtake, change	Turn, overtake, change lanes or cross an intersection	From stationary 3s gap (about 50 metres in a 60 km/h zone) between NDS vehicle and approaching traffic on right	Turn, overtake, change lanes or cross an intersection safely No other road

Table 7: Possible indicators for hazard perception

Indicator	Reference	Definition	Novice driver behaviour	Measurement/benchmark	Experienced driver
	(2012)	lanes or cross an intersection safely No other road users should need to slow down or move to avoid NDS vehicle	safely No other road users should need to slow down or move to avoid NDS vehicle	4s (about 70 metres in a 60 km/h zone), for traffic on your left (Need radar equipment or special software to analyse the gaps/safe gap acceptance) Scan behaviour	users should need to slow down or move to avoid NDS vehicle

2. 2.7.4. Identification of hazardous locations

Nel (1989) stated that traffic conflict measuring is based on the notion that observable road user interactions are "the result of decision made in situations that include elements of risk or danger". Nel further defines a traffic conflict as "a potential accident situation in which the driver brakes or swerves to avoid a collision".

Nel defined 13 hazardous situations that are briefly described below:

- **Straight ahead conflict:** Occurs when the following vehicle crashes into the front vehicle.
- **Lane changing conflict:** Occurs when one vehicle changes lanes and disturbs the vehicle in the next lane, causing one of the drivers to make a critical movement.
- **U-turn conflict:** When a driver turns his vehicle around and he or another driver has to take evasive action.
- **Exiting conflict:** Occurs when a vehicle exits a lane to turn left into a parking, street or driveway and the following driver then has to take evasive action.
- **Joining conflict**: when a vehicle joins the main traffic stream from a side street, parking area or driveway. Oncoming drivers/vehicles then need to take evasive action.
- **Right turn or left turn conflict:** Two vehicles from opposite direction enter an intersection or crossing simultaneously. If either of the drivers needs to take evasive action a conflict could occur.
- **Evacuating conflict:** Traffic lights turning from green to orange to red could potentially necessitate that drivers already in an intersection take evasive action.
- **Intersection conflict:** Red light running, when a driver ignores a red light, stop sign or yield sign controlling an intersection.
- **Approach conflict:** When a vehicle turns right into the lane of oncoming traffic from the opposite direction. If any of the drivers take evasive action, a conflict could occur.
- **Vehicle/ pedestrian conflict**: When a driver (in any direction) has to swerve or brake for a pedestrian.

- **Pedestrian/ vehicle conflict:** When a pedestrian steps in front of a vehicle forcing a driver to take evasive action.

Hazardous locations are typically areas where traffic conflicts can occur. Vorster and Van As (2008) indicated that for local authorities in SA, possible hazards might include:

- Intersections
- Vulnerable road users (cyclists and pedestrians next to the road)
- Speed management
- Road side safety and run-off-the-road safety.

The authors made use of Tshwane local municipality crash data to determine hazardous locations within the municipality. The crash data highlighted road elements in 85% of the crash data analysed. Out of the 85% usable crash data the following were found:

- 65% of the 85% crashes occurred at intersections
- 50% of the 65% intersection crashes occurred at traffic lights

The research also highlighted red running behaviour and left turns at intersections as possible hazards situations. The Ausroads Road Safety Audit Manual (2002) refers to intersections as a possible hazard from a design perspective. Included in the checklist is intersection access management, consistency, control, lay-out, gradient, auxiliary lanes, slipways and traffic circles.

Table 8: Speed approaches and management						
Indicator	**Reference**	**Definition**	**Pertaining to novice driver behaviour**	**Measurement /benchmark**	**Experienced driver**	**Measurement /benchmark**
Speed management						
Driving above the posted speed limit	Chan et al 2010 Roads and Maritime Services, 2012 Glendon et al (2007)	Fail to respond appropriately to traffic signs and road geometries which requires them to manage their speed Drivers exceeding speed limit by more than 10% more likely to commit other offences e.g. not keeping to his lane/tailgating behaviour	Brake too hard after recognising stop sign Vassallo et al 2010 Glendon et al (2007)	Driving > 25 km over speed limit Exceeding speed limit with 10% in comparison with other offences	Brake evenly after recognising stop sign	Driving > 25 km over speed limit Exceeding speed limit with 10% in comparison with other offences
Moving vehicle in same direction as the camera car						
Signal/ turn right	Scalfia et al 2011	Signal/ turn right	Possible rear-end	Time before action to avoid	Time before action to avoid	Scanning behaviour

Table 8: Speed approaches and management						
Indicator	**Reference**	**Definition**	**Pertaining to novice driver behaviour**	**Measurement /benchmark**	**Experienced driver**	**Measurement /benchmark**
			collision	collision 1.8s – or shorter.	collision 1.8s – or shorter.	(seconds) Approach to…action in seconds
Signal/turn left	Scalfia et al 2011	Signal/turn left	Possible rear-end collision	Time before action to avoid collision 1.8s – or shorter	Time before action to avoid collision 1.8s – or shorter	Scanning behaviour (seconds) Approach to…action in seconds
Parking	Scalfia et al 2011	Parking	Possible rear-end collision / side swept collision	Time before action to avoid collision 1.8s – or shorter	Time before action to avoid collision 1.8s – or shorter	Scanning behaviour (seconds) Approach to…action in seconds
Slowing	Scalfia et al 2011	Vehicle slowing down or coming to a standstill	Possible rear-end collision	Time before action to avoid collision 1.8s – or shorter	Time before action to avoid collision 1.8s – or shorter	Scanning behaviour (seconds) Approach to…action in seconds
Turning/merging into NDS V lane	Scalfia et al 2011	Vehicles turning and merging	Possible side swept collision	Time before action to avoid collision 1.8s – or shorter	Time before action to avoid collision 1.8s – or shorter Evasive action?	Scanning behaviour (seconds) Approach

Table 8: Speed approaches and management

Indicator	Reference	Definition	Pertaining to novice driver behaviour	Measurement /benchmark	Experienced driver	Measurement /benchmark
				Evasive action?		to…action in seconds
Stopped in NDS V lane	Scalfia et al 2011	Vehicle coming to a standstill in front of the ND vehicle	Possible side swept collision	Time before action to avoid collision 1.8s – or shorter Evasive action?	Time before action to avoid collision 1.8s – or shorter Evasive action?	Scanning behaviour (seconds) Approach to…action in seconds
Stopped in NDS V lane						
Crossing NDS V path from the left	Scalfia et al 2011	Crossing NDS V path from the left	Possible side swept collision	Time before action to avoid collision 1.8s – or shorter Evasive action?	Need radar equipment or special software to analyse the gaps	
Crossing NDS V path from the right	Scalfia et al 2011	Crossing NDS V path from the right	Possible side swept collision	Time before action to avoid collision 1.8s – or shorter Evasive action?	Need radar equipment or special software to analyse the gaps	
Head-on	Scalfia et al 2011	Head on collision	Possible head-on collision? Evasive action?	Time before action to avoid collision 1.8s – or shorter Evasive	Need radar equipment or special software to analyse the gaps	

Table 8: Speed approaches and management

Indicator	Reference	Definition	Pertaining to novice driver behaviour	Measurement /benchmark	Experienced driver	Measurement /benchmark
				action?		
Non-motorised transport in NDS vehicle path						
Pedestrians	Scalfia et al 2011			Time before action to avoid collision 1.8s – or shorter Evasive action?	Need radar equipment or special software to analyse the gaps	
Cyclists	Scalfia et al 2011			Time before action to avoid collision 1.8s – or shorter Evasive action?	Need radar equipment or special software to analyse the gaps	

Table 8: Speed approaches and management						
Indicator	**Reference**	**Definition**	**Pertaining to novice driver behaviour**	**Measurement /benchmark**	**Experienced driver**	**Measurement /benchmark**
'Early Merge' 'Late Merge'	(Hössinger 2011)	Encourages drivers to merge into the open lane-before arriving at the end of a queue. Reduces potential for conflict Late merge when reaching end of line (all lanes used in peak hours) problematic in off-period		Estimation of headway distance and speed difference of heading vehicles; Search of a time gap between vehicles on the adjacent lane by using the mirrors Adjustment of the appropriate speed and indication of the lane change Initiation and realisation of the manoeuvre		

Table 8: Speed approaches and management

Indicator	Reference	Definition	Pertaining to novice driver behaviour	Measurement /benchmark	Experienced driver	Measurement /benchmark
Object on road	Scalfia et al 2011			Time before action to avoid collision 1.8s – or shorter Evasive action?	Need radar equipment or special software to analyse the gaps	
Misjudgement	Scott-parker et al 2010	Erroneously take a decision in traffic that could have safety implications	Elaborate on misjudgements and categories of misjudgements?	Depending on action	Observations	

2.7.4. Grounded theory for the development of the coding scheme

2.7.4.1. Introduction

Glaser and Strauss developed the Grounded Theory (GT) in 1960's by. "A bottom-up" approach to develop theory was needed and Grounded Theory has since been applied in various social research fields. Grounded Theory is used to develop ideas and explanations about the world around us through a constant analytic procedure (Dunne, 2011). This methodology facilitates the discovery of theory from available data and has traditionally been associated with qualitative research data (Dunne, 2011).

Grounded Theory consists of methods used to facilitate a systematic approach to the enquiry. Charmaz (2012) defined coding in Grounded Theory as an inductive-deductive process which is comparative, iterative and interactive.

In essence, Grounded Theory means that the researcher stays open to all possible explanations and that there is no predefined hypothesis, theory or paradigms. The theory is developed as the research proceeds by continually comparing data, returning to where the data was collected and by reanalysing recoding and reinterpreting the data. Data collection and analysis are conducted parallel to each other whereas in other research studies the data is first collected and then analysed in order to prove or disprove a predefined theory (Dunne, 2011).

2.7.4.2. Comparative analysis

With Grounded Theory a constant comparative analysis is conducted. The text (or in this instance video) is broken into segments which are analysed and interpreted. Groups of these ideas become categories which are compared again and then ultimately will lead to abstract ideas that form the backbone of the theory being developed. According to Charmaz (2012) theory development is what differentiates Grounded Theory from other qualitative methods

The subjective information generated by the researcher is important and is contained in the memos that the researcher makes regarding his approach, constant analysis creation of categories, etc. . For this study, simple memoranda containing subjective information related to specific behaviours of the participants at specific points in the video were made. These memoranda were used to provide a context in which the video analysis was conducted. However these memoranda were very basic and for future development should contain much more information describing the different levels of analysis and comparison that have been done.

2.7.3.3. Coding

Charmaz (2012) gives the following guidelines for the coding of the data:

- Start coding immediately after data has been collected
- Code the data incident-by-incident (video) or line-by-line (text)
- Continuously compare data with codes and codes with codes
- Integrate and study emerging analysis by looking for commonalities in data sets (e.g. between novice drivers).

Figure 17 below presents an overview of how the application of Grounded Theory is understood.

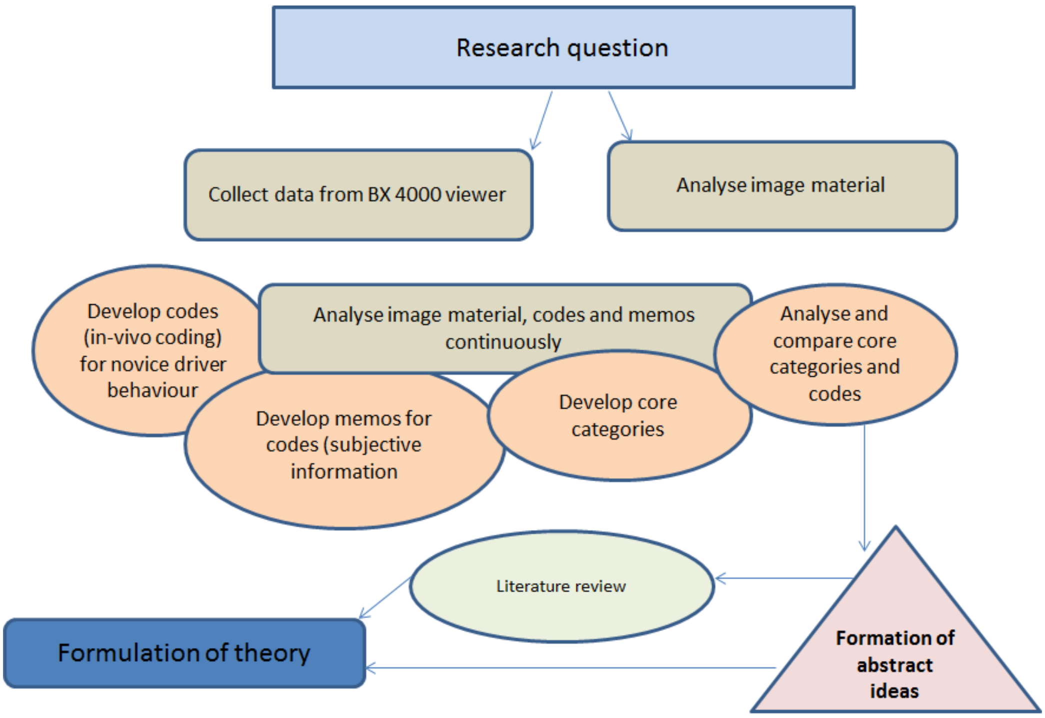

Figure 17: Grounded theory approach

2.7.3.4 Visual grounded theory

According to Konecki (2011) Grounded Theory has not traditionally been associated with visual data. However, based on the fact that the world is becoming more and more technologically orientated, visual grounded theory might be an interesting approach to explain phenomena. In fact, Konecki feels that image material has been purposefully neglected as a source for generating grounded theory.

As the name suggests, visual grounded theory relies on visual data, image material for constructing categories which could be used to explain phenomena such as novice driver behaviour.

Konecki draws on other researchers' work to define the coding process for visual grounded theory. Special reference is made to the work of Clarke (date) who defines three types of coding:

- **Locating:** Finding applicable image material that is central to the topic being studied e.g. identifying hazardous situations in video material.
- **The big picture:** Putting these images into the context of the video material and the social world from where this originates e.g. defining the context in which these were generated for example on 3 km road in Pretoria North where the participant resides along with all of the variables that might influence his behaviour in this context.
- **Specification:** Observing the images in different ways without predefined assumptions

Konecki indicates that comparative analysis of images is important to generate a theoretical code and relationships between codes. Konecki concludes that visual data opens new possibilities for Grounded Theory development which can be used to explain the world around us.

2.8. Conclusion

The literature review first focused on attributes of novice drivers and then on the utility of NDS and associated methodologies. In the first part, the fact that younger drivers are predisposed due to gender, age biology and development to be more at risk of a crash is important and might have important implications for design and implementation of training and education initiatives of novice drivers. The manner in which younger and older learner drivers are engaged in training might differ significantly. As indicated earlier in this document, it is possible (based on the RTMC crash statistics) that South African novice drivers might fall into older age categories. Developmental issues linked to different training schemes would then be relevant for a South African context. Numerous studies aimed to highlight the most prominent factors contributing to making this road user group one of the most dangerous. Some research has highlighted age as the contributing factor while other research highlights inexperience as a factor. However, there is evidence that suggests that these two factors runs parallel to each other, with inexperience weighing in as the heavier contributor to young drivers involved in fatal crashes.

Personality factors seem to influence risky driving indirectly but attitudes is a direct influence of safe driving. The fact that certain personality types have been found to be more inclined to engage in risky driving is also important. Both of these findings could have implications for driver training and education in South Africa. If this is the case, attitudes should be addressed in both theory and practical training in order to develop positive attitudes toward driving. Secondly the fact that personality types associated with risky driving differ could support a case for psychometric testing before driver training starts. Driver training at the very beginning of the learning process could potentially be designed to address at-risk personalities at the onset of the training.

Around the globe driver training takes the form of practical and theoretical testing. The number of hours spent on the different components of the learning differs from country to country. Research from different countries has however, shown that in order to become a skilful (safe) driver novice drivers not only need to master the skills associated with vehicle handling but they need to acquire experience. Programmes in which novice drivers are accompanied by older more experience drivers along with restrictions placed on certain driving behaviours or contexts are considered successful in most countries. Although these programmes might not influence crash statistics directly, it shapes attitudes and develops a sense of responsibility towards the self as well as other road users.

Novice drivers tend to engage in risky driving behaviour such as drinking/drug use and driving, dangerous overtaking, following too closely and speeding behaviour. Again coupled with other factors such as concentration and attention skills that have not yet been fully developed, these behaviours could be detrimental not only to the novice driver but to other road users as well. The skill to recognise and respond to hazards in traffic is essential.

Hazard perception skills are severely lacking in novice drivers. This ability lies at the heart of the current research study. All of the factors mentioned previously heavily influence the novice driver's ability to recognise and react appropriately and safely to hazards in the traffic environments. Again, biology and cognitive development play a role as, for example, peripheral vision and scanning abilities are not yet sufficiently developed. Personality factors, gender and age along with social norms and conformity play a role as novice drivers might be over confident in their own abilities, lack the social intelligence not to be influenced by norm or peer groups while at the same time having a desire to participate in risk-taking behaviour. These susceptibilities might inhibit the novice driver to actually recognise and respond to hazards in the traffic environment. This overview of the hazard perception abilities of novice drivers will form the basis of the development of a coding scheme for the analysis of the video material obtained in the study.

In the second part of this chapter, NDS studies have shown that it is possible to research novice driver behaviour in the context of the driver, vehicle and environment. The value of this methodology lies in the fact that risky behaviours can be traced back to specific events which can be correlated with vehicle and environmental factors.

As pointed out earlier, traditional research methods have their own advantages. NDS has the potential to provide researchers with essential information pertaining to what happens before and during a crash. It also provides researchers with an overview of what "normal driver behaviour" looks like. Although the main focus is on NDS, it should be kept in mind that traditional methods such as self-reported instruments as well as simulation studies in combination with the NDS approach could provide valuable information on the participants. This includes prior knowledge, attitude and perceptions related to driving. In this particular study self-reported questionnaires are incorporated to provide important information on for example prior perception of risk and what the participants perceive as appropriate behaviour in risk situations as well as some indication of how they perceive and identify hazards in traffic.

Road safety is considered to be the function of four elements namely: exposure to risk, factors influencing crash involvement, factors influencing crash severity and lastly factors influencing post-crash injuries while enforcement, engineering and education are considered to be the key countermeasures against road traffic crashes (Verma et al, 2011). In traditional studies, only aspects of driving have been measured. Combining and integrating NDs with traditional methods could possibly contribute to painting a more holistic picture of novice driving. NDS is deemed a suitable research methodology that can investigate and shed light on all four elements. The methodology has been tried and tested internationally with most of the developed world embracing this methodology in an attempt to holistically understand traffic crashes.

This understanding will inform the development of appropriate counter measures and interventions to prevent crashes and injuries. The drawback of working with NDS mostly revolves around the huge number of resources it would take firstly to conduct such a study and secondly to analyse the large amounts of data.

CHAPTER 3: RESEARCH DESIGN AND METHODOLOGY

3.1. Introduction

Use was made of a number of methodologies to collect and analyse the data. Different types and large volumes of quantitative and qualitative data was collected during this study.

Three types of research instruments were used to collect the data. Firstly, a before and after questionnaire (survey-based) was used to understand the participants' orientation towards risk before they started driving and then repeated after the cameras have been removed from the vehicles. The data acquisition system (experimental) which was installed in the vehicles collected qualitative and quantitative data from the vehicle, the driving environment as well as the driver.

Questionnaire data was captured in Microsoft Excel and analysed qualitatively. The data from the DAS was also captured in Microsoft Excel along with Microsoft Access (which proved to be a better tool when working with the large amounts of quantitative data which was generated from the data logger).

The qualitative data (the video data) posed a different challenge as no hazard perception testing scheme currently exists in South Africa. A coding scheme therefore had to be developed for the coding of the image material.

Analysis was conducted in Microsoft Excel and Microsoft Access. Qualitative analysis was conducted with MAXQDA © software.

3.2. Research design

This research study explored the concept of hazard perception and changes in driver skills through an observational approach. In order to test whether or not novice drivers differ in terms of their hazard perception skills it was necessary to incorporate different research methodologies and approaches in order to arrive at some conclusions regarding:

- Whether novice drivers with different levels of training and experience perceive hazards on the road differently;
- How they react and adapt to those hazards;
- Whether or not there is a difference between novice and experienced drivers in the way in which they perceive and respond to hazards on the road.

The first part of the study was designed to be survey-based (Figure 18). Questionnaires were developed to probe the participants' perception of risk when driving and participants were interviewed to probe their experience of the process and their perceptions of changes in hazard perception skills. The interviews and questionnaires were structured in order to obtain as much focused information from the participants as possible.

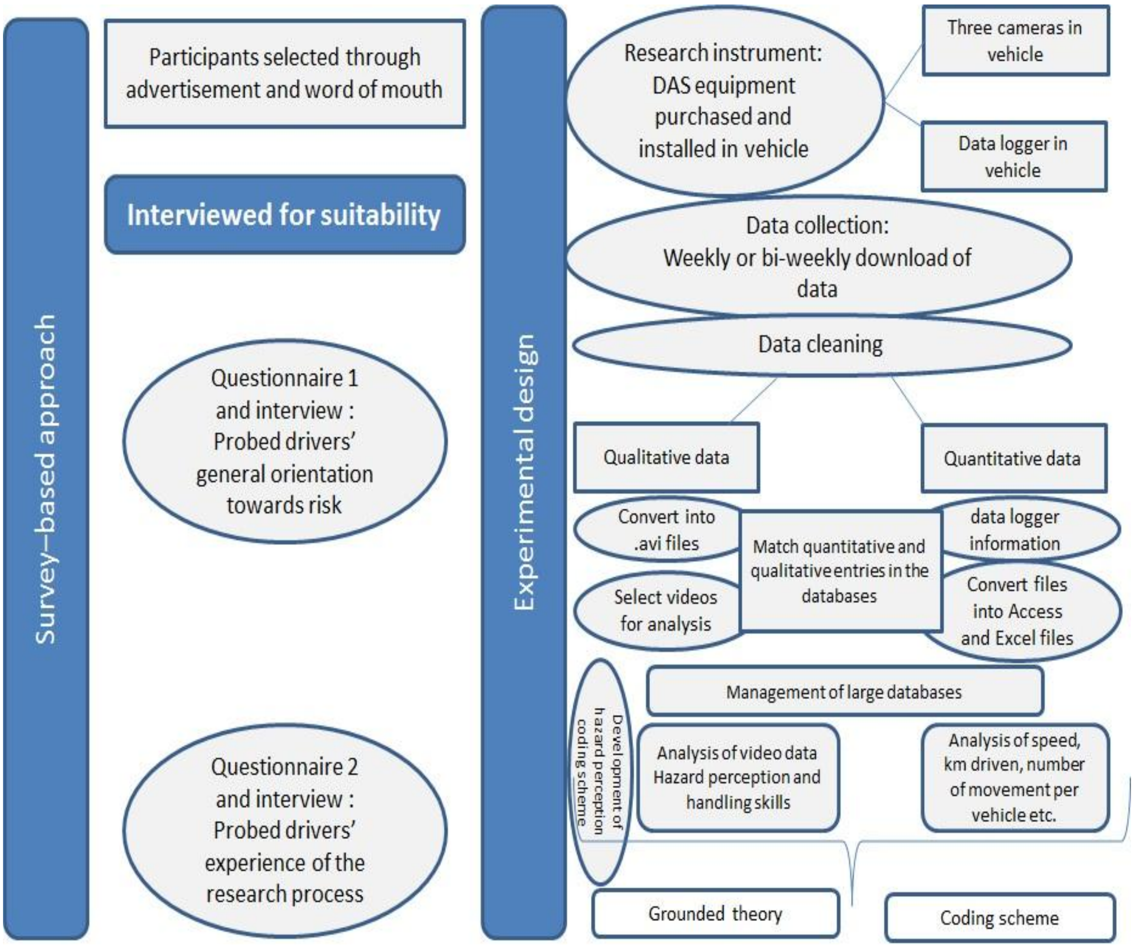

Figure 18: Research design

Figure 18 provides a detailed overview of the steps in the research process.

The main approach used in this study is the Naturalistic Driving Study approach where driving information is collected unobtrusively from the participants in the study. This approach is exploratory and experimental in nature.

3.3. Strengths and weaknesses of this research design

3.3.1. Survey-based research

Surveys and interviews can be powerful tools to obtain information related to knowledge, attitudes and perceptions of specific and sensitive topics. The questionnaires used in this study provided important insight into the participants' beliefs about their own skills, their orientation towards risk, etc. The questionnaires were designed specifically for this project and due to the small sample size the findings can't be generalized. The information obtained from the participants is self-reported information and might therefore contain some bias towards skills.

3.3.2. Field experiment

NDS has never been used in a South African setting before. In line with the Backer-Grøndahl (2009) classification of ND studies, this study could be considered as a baseline/normative/exposure study where the aim is to investigate novice driver behaviour and performance.

The positive and negatives associated with using this study approach have been highlighted in the literature review. Based on this study the following can be highlighted:

- It was possible to directly observe the behaviour of the drivers.
- It provided in-depth driving information in a range of settings. As highlighted earlier in the literature, it was indicated that some concerns exist regarding participants' reactions and consequent behaviours when the initial recording of the driving began. In order to ensure that the participants were comfortable with the cameras, a selection of image material was only included from each participant's second driving week onwards.

- Furthermore, due to the fact that this topic (novice driver behaviour) and the concept (hazard perception) have not been tested previously it was necessary to develop additional tools to categorise and analyse the data collected.
- It was not possible to control external independent variables such as weather, other drivers' behaviour, on the road routes etc. It was also not possible to control who drove with the driver in the vehicle and this resulted in more than the driver of a vehicle being recorded.

It was not possible to code driving behaviour during hours of complete darkness as the quality of the outside images (and often the driver images) was too poor to properly code the images. An attempt was however made to include early morning (dawn) and late afternoon (dusk) image material.

A large body of data was collected which required significant human resources to transcribe, code and analyse it.

3.4 Research method

Naturalistic Driving Studies (NDS) is a novel approach to the way that road safety research can be conducted in South Africa. As explained earlier, the term "naturalistic driving studies" refers to as unobtrusive approach to studying driver behaviour. This 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 significantly alter by being observed over the long term and that such studies therefore reflect natural driver behaviour over time.

The image material recorded in the vehicle along with other in-vehicle technologies (DAS) that also collect data about the road environment and other vehicles give valuable insight into driver behaviour in different driving situations. Internationally this methodology has been embraced by the US, Europe and more recently, Canada. South Africa has the unique opportunity, through participation in the international NDS project, to contribute to this important research study by delivering data that reflects the nature of intrinsic road safety aspects from a developing country's perspective.

3.5. Sampling and population

3.5.1. Selection of participants

During November 2012 and January 2013, secondary schools in the Pretoria area were approached to solicit support for the research. All of the schools declined to be involved as permission needed to be obtained from the National and Provincial Departments of Education, the scholars as well their parents. In the interest of time it was decided to place an advertisement in local newspapers (Appendix A). Friends and colleagues were informed of the project and were asked to refer possible candidates to the researcher.

3.5.2. Demographic information of participants

Requirements for participants stipulated that one of the drivers needed to be a novice driver. The ideal situation would have been to recruit novice drivers whom had very recently obtained their licenses. The participants who were ultimately recruited had their licenses between 4 and 6 months.

In February 2013 the researcher was contacted by the first potential participants. These participants were interviewed and were deemed suitable for the research. The combination of participants was a mother and son from Pretoria North. The Novice Driver (1) is a twenty-year old male. At the time of the interview he had been in a possession of a license for approximately six months. He was unemployed. He assisted his mother with driving tasks such as fetching his brother from school, shopping and so forth. He had been in one accident as a passenger. His grandmother had been driving at the time of the accident. Novice driver (1) indicated that he attended five driving school lessons in order to pass his driving test. His mother, Experienced Driver (1), is 41 year old female who has been driving for more than twenty years.

The second set of participants was subsequently recruited through the CSIR. This combination composed of a father and daughter. Novice Driver (2) is a nineteen year old female who at the time of the interview had been in possession of a license for four months. She has never been involved in a crash. When Novice Driver 2 began with the test drives she still lived at home (a rural setting/farm in Donkerhoek – approximately 20 km from Pretoria East). In June 2013 however, she began studying and subsequently moved to Centurion.

Experienced Driver (2) is fifty three 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. Experienced Driver (2) has more than 30 years of driving experience.

Installations of the NDS equipment were done at the CSIR Built Environment in Pretoria.

Although the two Novice Drivers were not as recently licensed as would have been ideal, they still fell within the 18 month high risk period for newly licensed driver.

3.5.3. Vehicles used in the study

Participants' own vehicles were used for the study and the instruments were installed in these vehicles:

- Novice driver 1 drove: Nissan Micra (2010)
- Experienced driver 1: Nissan Livina (2009)
- Novice driver 2: Hyundai i20 (2013)
- Experienced driver 2: Honda Accord

3.5.4. Period of research

The DAS was installed in two vehicles (parent/child combinations) for a period of 2 months each. The equipment was installed by the suppliers' (Rock Solid Industries) technician in participants Group 1 on 13 March 2013. The equipment was installed by the suppliers' technician in participants Group 2 on the 6 June 2013.

3.6. Data collection: research instruments

This project was collaborative in nature and the grant to purchase the equipment was provided by the Department of Electrical and Electronic Engineering (providing funding for the DAS equipment) at the University of Stellenbosch.

3.6.1. Questionnaires

The literature review informed the development of the driver behaviour questionnaires. These questionnaires were administered to the participants after they had given signed consent for participation in the study.

Two driver behaviour questionnaires were developed for use in the project. The items included in the questionnaire measured general tendencies pertaining to skill and risk. The information derived from the questionnaires reflected pre- and post-information related to, among others:

- Perceived level of skill/acquired level of skill;
- Perception of risk while driving before/after acquiring a licence;
- Inclination to engage in risky driving behaviour before and after acquiring a licence;
- Travel behaviour before and after acquiring a licence.

3.6.1.1. Driver behaviour questionnaire 1

The novice drivers were asked to complete a driver behaviour questionnaire (Appendix B). This questionnaire probed demographic information, experience (number of lessons/time practicing), challenges experienced in practicing for the driving test, attitude towards risk and self-perceived readiness to successfully complete the driver test. The questionnaires were only administered to the novice drivers. This approach was followed in order to obtain specific information related to the novice drivers' perception of risk which was deemed important in order to understand their approach to hazardous situations in traffic.

The experienced drivers were interviewed on safe practices such as the wearing of seatbelts, talking on a cellular phone while driving and so forth. The questionnaires were not administered to the experienced drivers because the questionnaires were more applicable to the novice drivers.

3.6.1.2. Driver behaviour questionnaire 2

After completion of the test drive period participants were interviewed with the use of a short structured questionnaire (Appendix B). This interview probed issues such as their experience of the NDS process, lessons learnt and recommendations for future participants.

3.6.2. Data Acquisition System (DAS)

Three cameras were installed in the vehicles. The cameras were installed inside the vehicle, facing the front seats while observing driver and passengers. Another camera was installed inside the vehicle facing the outside front of the vehicle and a third faced the outside back of the vehicle. An on-board computer was required for storing and logging the video data as well as the vehicle performance data (GPS, speed etc.). The most suitable system for the NDS was considered to be the Smarty Black Box BX4000. This system was purchased from and installed by Rock Solid Industries (RSI). The company also provided technical support to the researcher.

The most important features of this system (figure 19) are illustrated and described below.

The memory card: 4G SD Memory Card

Event recorder:

- 3 Cameras recording, namely records front, interior and rear view
- Secure video recording with enough capacity to ensure that the recording proceeds without failure in the event of power loss or abnormal power shut down

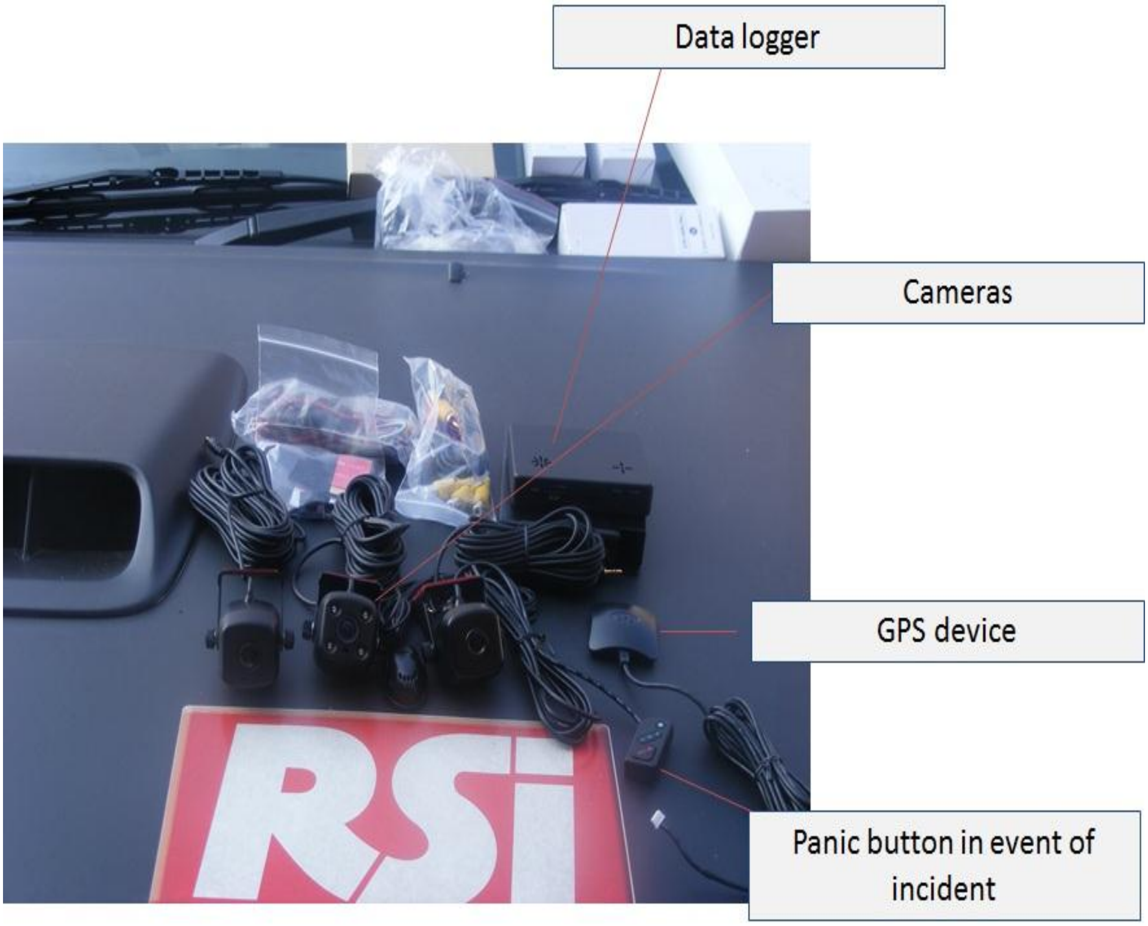

Figure 19: Data acquisition system

The cameras recommended for this research were:

- Inside observation of driver and passengers: STR 100IR (x2)
- Outside observation for the front and rear of the vehicle: STR-100 (X2)
- Data logger and display of information: an external GPS links the video recordings to the speed and location information of the vehicle, route and driver (figure 20).

All of this information was linked to Google Maps. The recording includes location and content of the incident. This information can be displayed simultaneously.

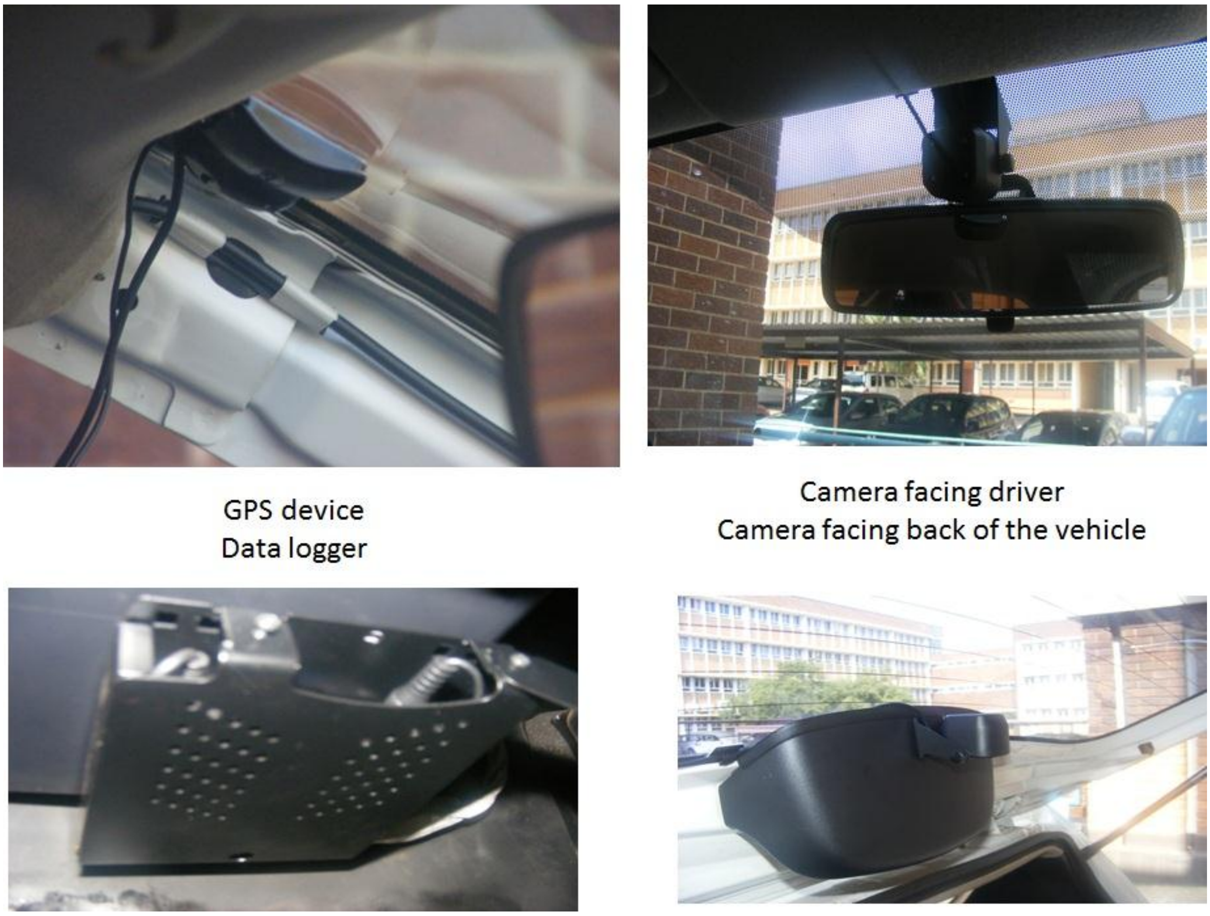

Figure 20: DAS installed in the vehicle

3.6.3. Data storage

Raw databases were prepared for the storing of visual as well as quantitative data collected from image recording devices and the sensors connected to the vehicle.

Separate databases were established for the analysis of the quantitative as well as quantitative data.

All information was stored on external hard drives in order to comply with the prerequisites as stipulated by the ethics committee.

3.7. Data management and analysis

3.7.1. Questionnaires

a) Questionnaires: To determine the driver's attitude toward driving Questionnaire 1 was administered to the two novice drivers before the installation of the equipment and interviews were conducted with the experienced drivers. The second interview was conducted after the removal of the cameras. The information was used to determine how the driver experienced the process and whether or not he believes that he has changed his driving during the time that the equipment was installed in the vehicles.

Because of the sample size the questionnaires could not be analysed statistically and the data was assessed based on its qualitative content. If administered to a larger group of participants, the findings from the questionnaires might have statistic significance but in this instance the sample was too small. It was also deemed appropriate as the first questionnaire aimed to understand how the novice drivers felt about taking risks and whether or not they would generally be inclined to sensation seeking behaviour such as speeding or reckless driving and how they felt about breaking road rules and regulations.

The second exit interview was used to debrief the participants and to get their perceptions of the research process and the behavioural changes they felt might have occurred during the study.

Selected questions from three traditional driver behaviour questionnaires: Driver Behaviour Questionnaire (Parker et al, 1996; Ozkan et al, 2006); Driving Style Questionnaire (French et al, 1993) and the Sensation Seeking questionnaire (Zuckerman, 1971) were used in the survey form. All of these surveys require participants to rank their perception regarding the question on a scale of 1-5. As this was a qualitative analysis (normally a factor analysis would be conducted in a larger sample) the questions from the different questionnaires were clustered according to the following categories

The question numbering was kept as in the original questionnaire. The ranking was considered necessary in order to show the strength of the decision made and to make it comparable between novice drivers.

Ranking	1	2	3	4	5
	Never	**Rarely**	**Sometimes**	**Often**	**Always**
Aggression tendencies					
Impatience/tolerance for other road users					
Competing behaviour					
Attitude towards road rules & regulations					
Risk-taking tendencies					
Sensation/thrill seeking tendencies					
Distraction					

The results from these questionnaires are discussed in Chapter 4 and used in Chapter 5 to provide a behavioural context or orientation for the interpretation of findings for the novice drivers.

3.7.2. Methodology followed for the management of BX4000 Data

The DAS (Figure 20) consisted of:

- *A data logger* that recorded time, trip speed, acceleration and deceleration, global positioning coordinates (GPS).
- *Video recordings* obtained from three different camera angles (driver, outside front and outside back of the vehicle).

Analysis of the collected quantitative data was carried out using statistical programmes namely Microsoft Excel and Access.

Qualitative data was analysed making use of video analysis software. A uniform approach was developed to ensure that the data is analysed consistently and that the methodology would be replicable.

3.7.2.1. Data management-data logger

The data was downloaded in weekly intervals. Dates for the downloading are noted in Table 9 below:

Table 9: Dates of weekly downloads	
Participants 1 & 2	
28 March 2013	Included in analysis
16 April 2013	Only experienced driver included in analysis
23 April 2013	Included in analysis
30 April 2013	Included in analysis
9 May 2013	Included in analysis
14 May 2013	Included in analysis
21 May 2013	Included in analysis
28 May 2013	Included in analysis
Participants 3 & 4	
14 June 2013	Only novice driver included in analysis
22 June 2013	Included in analysis
26 June 2013	Only novice driver included in analysis
03 July 2013	Included in analysis
13 July 2013	Included in analysis
22 July 2013	Included in analysis
30 July 2013	Included in analysis
14 August 2013	Included in the analysis

Novice Driver 1 was the sole driver of his vehicle. Novice Driver 2 shared her vehicle with three other drivers. The videos for Novice Driver 2 therefore had to be separated from the other drivers. Vehicle movements were considered for all the drivers and the vehicle movements for the selected videos were analysed for Novice Driver 2.

The first week for both participant groups was eliminated from the analysis in order to compensate for the observer effect that might have been present during the first week of the test drives.

Uncontrollable circumstances such as drivers going on holiday, visiting other provinces or being in hospital influenced the collection of data and such infrequencies resulted in no data being collected for some of the participants.

The data from the data logger contained the following values:

1	2	3	4	5	6	7	8	9	10	11	12
2009.08.18 23:00:01	152	88	1064	Y	37.412602	127.133527	84	42	305	3/16 (2.60)	2009.08.18 13:59:59

1) System Time - Local Time

2) G-Sensor X - Measured in mGal (unit of acceleration)

3) G-Sensor Y - Measured in mGal (unit of acceleration)

4) G-Sensor Z - Measured in mGal (unit of acceleration)

5) Satellite Fix Status - A value of “Y” indicates that a fix is currently obtained, whereas a value of “N” indicates that a fix is not obtained.

6) Latitude - Represents the current distance north or south of the equator. (A value of "+" indicates north and "-" indicates south.)

7) Longitude - Represents the current distance east or west of the Prime Meridian. (A value of "+" indicates east and "-" indicates west.)

8) Altitude - Antenna altitude above/below mean sea level, measured in meters.

9) Speed - Indicates the current rate of travel over land, measured in km/h.

10) Heading - Indicates the current direction of travel, measured as an "azimuth".

11) Satellites - Number of satellites in use/total number of satellites in view (HDOP – indicators relative accuracy of horizontal position).

12) GPS Time (UTC) - Date and time calculated from GPS satellite signals.

After the data was downloaded from the BX viewer it was saved in a Microsoft Excel file. This file was adapted to include the headings as indicated above. The log files were matched to the video files. This served the purpose of ensuring that the video and data and the recorded values from the data logger could be matched in the event that an incident or anomaly was detected in either of the files.

After the initial download, the researcher discovered that the first column of data (1-System time – local time) which should show the same as the GPS date and time, differed from the GPS time. This time stamp is also assigned to the videos. The timestamps on the videos were therefore not correct. The videos had to be matched to the GPS time and date stamps (Figure 21). The reason for this error seems to be that the system continuously recorded time and did not reset itself every time the system was turned on or off. The GPS date and time (column 12) were correct and for the rest of this study use was made of the GPS time and date which provided the researcher with a continuous stream of data for every second, minute and hour that the system was turned on. Examples of the coded behaviour are available in Appendix E.

3.7.2.2. Data management-video recordings

Video recordings were categorised and identified by the identifiers below:

1	2	3	4	5	6	7	8	9
Driver	Download	Date	Trip ID in log file	ID in video file	Length of video (minutes)	Time begin	Time end	length of trip (km)

1) Driver Identification

2) Date on which the data was downloaded

3) Date on which the video was generated

3) Trip identification number in log files (from data logger)

4) Video identification in video (normal file)

5) Length of video in minutes

6) Start time of video

7) End time of video

8) Length of trip per video.

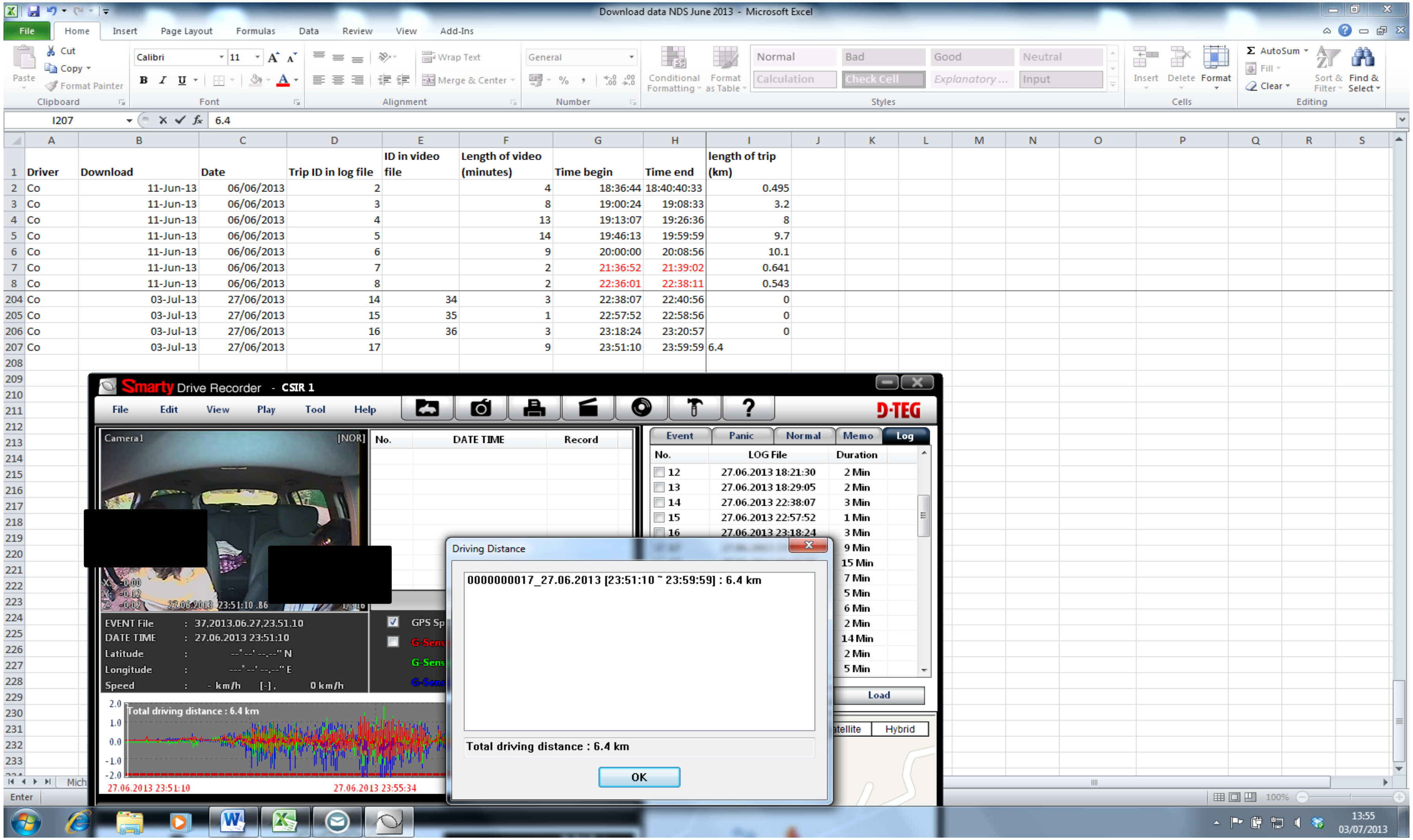

Figure 21: Inconsistency with the date and time-manually matched with video files

Due to the time error experienced in the log files the "start and end" times generated on the videos were incorrect. These were corrected by matching the log file (GPS date and time - column 12) with the corresponding videos.

3.7.3. Methodology followed for the analysis of BX4000 data

The following two sections provide an explanation on how the quantitative and qualitative data were analysed.

3.7.3.1. Analysis of data logger information

The statistical information from the video files was analysed making use of Microsoft Excel and Microsoft Access. Summary statistics for each download week have been prepared and will be discussed in Chapter 4: Findings.

Steps in the downloading and analysis of the data were as follows:

Step 1: Download the data at weekly/bi-weekly intervals

Step 2: Download data log files per week (generated as CSV files)

Step 3: Transcribe data log (CSV) files into Microsoft Excel files

Step 4: Correct GPS date and time columns by importing into Microsoft Access

Separate GPS Date and Time

Transfer back to Microsoft Excel

Step 5: Analysis - prepare pivot tables for each downloaded date and week

Step 6: Download video file log per event

Step 7: Match video files (video identification) with corresponding data log files.

Quantitative information was analysed making use of Microsoft Access and Microsoft Excel for summary statistics for the movements generated by the vehicles.

3.7.3.2. Analysis of video and image material data

Not all the videos were related to driving and some of the videos have been eliminated in instances where the vehicle was not moving but the engine was running (ignition on). The video data included for the analysis were only videos in which the participants were driving. Clips were reduced by watching the selected videos and eliminating videos in which the vehicle was switched on and standing still, videos shorter than 10 minutes or where less than 10 kilometres were travelled. It was deemed important to include video image material in which passengers were present as well as night time driving. Novice Driver 1 drove significantly shorter distances than Novice Driver 2.

At first the criteria for inclusion of videos for coding were extended to the novice drivers driving for more than 10 minutes or more than ten kilometres. This strategy was revised later on to include specific driving scenarios where potential hazards situations could evolve. Four scenarios depicting situations (present in both novice driver image materials) were identified for analysis. These included:

- Behaviour at traffic lights
- Behaviour at traffic circles
- Behaviour at stop streets
- Turning behaviour and intersections

Samples of the four situations were selected for both novice and experienced drivers and compared.

Other behaviours identified and compared included: highway/urban/rural driving distracted driving, fatigue, traffic offences, etc.

The download of the data was done at different intervals and in order to keep the representation of the data consistent reference is made to download per week. The videos used in the analysis were also selected per download week and an attempt has been made to ensure that the videos selected were representative of that week in which the data was downloaded. A video from each download week was included in the analysis. The data logger depends on satellites to log information about dates, time and location. In some instances the satellite signals could not be immediately found when vehicles were switched on which resulted in error reading and no data for those periods. These missing values were substituted with “No Value” code and the analysis will refer to NV when no values were present in particular downloads.

Each video in the BX 4000 system had to be transcribed into a “readable” .avi file. Each BX 4000 video generated 3 .avi files (driver, front and rear camera).

The actual videos were coded making use initially of Microsoft Excel and later with open source software called Élan. The Elan software was able to import all three channels into the programme. However the coding and time stamps were not accurate. A learner license for MAXQDA software was purchased and coding commenced (Figure 22).

Figure 22 displays an example of a video being coded in MaxQda ©. At the top left of the screen, the document groups can be observed. At the bottom left of the screen the codes are generated and displayed in a list. On the multimedia browser the timestamps and video in seconds are displayed.

Steps in downloading and coding the videos/image material:

Step 1 Transcribe videos from BX4000 system into .avi files.

Step 2 Select videos per week for coding

Step 3 Activate and load the video in MAXQDA

Step 4 Look through video material in MAXQDA (2 cameras driver and front)

Step 5 Assign time stamps to possible hazardous situations and events

Step 6 Code each scenario allocated a time stamp

Step 7 Export codes and memos to Excel spreadsheet

Step 8 Correlate coded behaviour with the vehicle movements recorded in the data logger

Step 9 Analyse according to frequency, escalation of observable behaviour

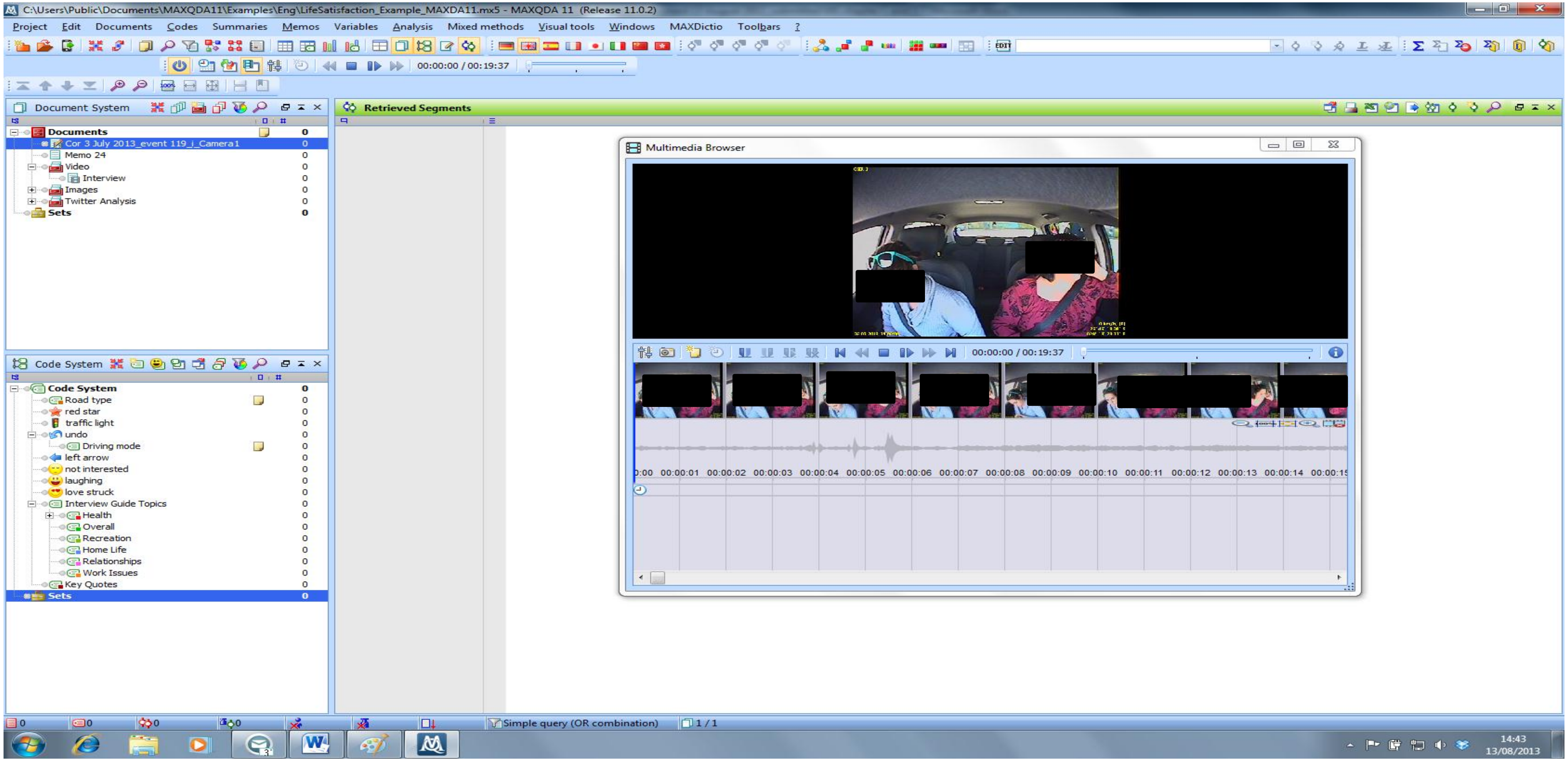

Figure 22: Example of video prepared for coding in MAXQDA

3.7.3.3. Development of a coding scheme for image material using Grounded Theory

In order to code the video data, a hazard perception coding scheme was developed. This coding scheme was elaborate and incorporated as much detail as possible. The same coding scheme was applied to both novice and experienced drivers. In terms of the video data, guidelines were developed for the coding and analysis of this data. These guidelines initially included specific markers that reflect the novice drivers' new driving skills as well as the inclination towards taking risks. Potentially this included identification of:

Performance: Manoeuvring of vehicle through traffic (potential conflicts in traffic environment with other vehicles/road users such as cyclists/pedestrians or animals; stopping and pulling away at traffic signals and signs; cutting corners, turning in front of vehicles);

- Scanning behaviour
- Speeding behaviour on different types of roads;
- Checking of side- and rear view mirrors.

Initially a general (fixed) coding scheme was developed for the coding of the video material. However as the coding progressed, additional codes and observations explaining certain aspects of behaviour that might influence hazard perception emerged from the video material. The NDS data collected consists of different types and large volumes of data. At the outset of the project it was not possible to predict what this data will look like or how this coding scheme was going to be applied to the data. The goal however, was to investigate the manner in which hazard perception and skills in novice drivers change over the course of the project and whether or not any change would be observable.

It was necessary to re-evaluate the coding scheme that was quickly becoming an open coding scheme. Applying a Grounded Theory approach was deemed suitable for analysing and understanding the emerging themes (not previously coded) found in the data. A classic Grounded Theory allowed for the development of an explanation on behaviour that is being observed. In terms of the changes in hazard perception and skills observed in novice drivers it was deemed appropriate to use GT because so little information is known about the relationships between the threads of behaviour that could potentially indicate an improvement in skill and perception. Although hazard perception is internationally measured by means of psychometric tests (Grayson and Sexton, 2002) no known methodology has been developed for detecting and quantifying these changes through the use of video data.

Grounded Theory approaches the understanding of a phenomenon from an inductive rather than deductive approach (Griffiths 2013). One of the benefits of using a Grounded Theory is that the researchers are able to approach the problem with an "open-mind" (Griffiths 2013). According to the researcher, applying a Grounded Theory approach would assist in facilitating an understanding of the patterns of behaviour embedded in the video data. One of the requirements for successfully applying Grounded Theory revolves around the fact that it needs a large numbers of cases or examples in order to be fully functional.

The objective is to generate a theory about how "something" in the social world works. In this instance a Grounded Theory approach will be used to build a theory (if any) related to hazard perception and skills changes in novice drivers.

This will be discussed in more detail in Chapter 4.

Lingard, Albert and Levinson (2008) state that the use of Grounded Theory is appropriate when trying to explain social interactions and experiences in order to explain a phenomena, rather than to prove an existing perception or theory.

3.8. Ethical considerations

3.8.1. General considerations

All prospective participants were interviewed for selection purposes. Signed consent was obtained from the participants. Participation in the study was voluntary and all information pertaining to the participants is kept confidential.

All ethical considerations as required by the University of Stellenbosch were adhered to. All ethics documentation was prepared and administered to the participants:

- Research ethics committee application form
- University of Stellenbosch Informed Consent Form: Novice drivers
- University of Stellenbosch Informed Consent Form: Experienced drivers

Driver behaviour questionnaire and interview to be administered before and after the NDS experiment.

This research project entails observation of human behaviour for which the Human Science Research Council (HSRC) provides four guidelines for research projects involving human subjects:

The principle of respect and protection

"...Research and the pursuit of knowledge should never be regarded as the supreme goal at the expense of participants' personal, social and cultural values. If the participants are under the age of 18 years, consent from a legal guardian or parent needs to be obtained."

In this research project, written consent was obtained from the participants for two separate processes. The first process included informed consent confirming that the individual was participating in the study as a driver and secondly consent that his or her vehicle could be instrumented with the DAS system for a period of two to three months. If at any stage the driver felt that he or she does not want to continue to participate in the study, the equipment would be removed from their vehicle and the participant would end their participation in the study. Participants were older than eighteen years. In addition to participants' consent, consent was also obtained from the parents and insurers of the vehicles.

"Information obtained in the course of research that may reveal the identity of a participant or an institution should be treated as confidential unless the participant or institution agrees to its release. Research findings relating to specific individuals should

be reported in a way that protects the personal dignity and right to privacy of participants".

This study made use of video images that could be linked to a specific participant. In order to limit exposure and identification of drivers, the drivers were referred to as Novice Driver 1 and 2. All of the image material was stored on an external hard drive to minimise the possibility of image material ending up on the internet. Findings on and comparisons between drivers are made without reference to names. Gender, race and other demographic characteristics are discussed only as part of the general demographic information of the participants.

"Participants may be suitably recompensed on condition that all participants are offered similar rewards and that such rewards are related to the sacrifices required of them to make their contribution, e.g. transport costs, meals, and tokens of appreciation, thereby observing the norms of justice and the avoidance of detriment".

The participating drivers were offered an incentive token of appreciation (GPS) for participating in the project.

b) The principle of transparency

"Before undertaking any research the researcher should ensure that the participants are clearly briefed on the aims and implications of the research as well as the possible outcomes and benefits of the research. Participants should also be informed of any additional factors that might reasonably be expected to influence their willingness to participate".

Participants were informed of the study objectives as well as the benefits of the study before they signed the consent forms.

"Should the methodology of a research project necessitate the concealment of information, the researcher should before conducting such a study determine whether the use of such a methodology is justified by the project's prospective scientific, educational or applied value, determine whether alternative procedures that do not require the concealment of information could be used instead, and ensure that the

participants are given the reasons for the concealment of information as soon as is practically possible".

One of the issues that needed to be clarified revolved around the question "what if criminal activity is observed?" There is also the question of what the consequences would be if the recordings show an accident, etc. One of the most significant concerns was around the legal issues and whether or not this image material could be used as evidence in a court of law. A legal opinion was obtained from the CSIR's legal services department regarding the legal aspects of the study. The legal advisor indicated that unless the data is subpoenaed by a court of law the data cannot be made available for any other requests, processes or purposes.

"In the communication of their findings, researchers should subscribe to the principles of honesty, transparency and scrutiny by the public and their peer. No financial or other inducement should be offered to participants, whether children or adults, or parents/guardians of children, to ensure a particular research result".

Both the positive and negative results of the study were dealt with scientifically and in a professional and transparent manner.

"The researcher should always be aware of the potential conflict inherent in the principle of transparency stated above and a participants request for total confidentiality in the reporting of research results".

The purpose of the research as well as the envisaged end result (thesis and academic research papers) was explained to participants at the onset of the project. Permission to use anonymous results was part of the signed consent that participants gave at the start of their participation.

c) The principle of scientific and academic professionalism

"Researchers should conduct their research, if applicable, in accordance with the professional code of the association of which they are members

Researchers should not misuse their positions or knowledge as researchers for personal power or gain

Researchers should at all times strive to achieve the highest possible level of scientific quality in their research"

This study was conducted in a scientific manner. All processes including documentation, analysis etc. followed scientific methods and results were communicated through the submission of this thesis and future research papers.

d) The principle of accountability

"Researchers should ensure that they have an explicit written research mandate from the in which the general conditions and terms of the research or service are set out clearly. The acceptance of a mandate should be sealed by a legally binding written contract/agreement between the parties specifying the terms agreed upon."

The researcher was accountable for ensuring that this research process which included the collection and analysis of data is conducted in a transparent and scientific manner. The agreement between the University and the researcher will govern the research conducted.

3.8.2. Ethics committee stipulations

The research proposal was submitted to the ethics committee of the University of Stellenbosch in August 2012. The research proposal and study were approved with the following requirements:

- Driver behaviour questionnaires were to be submitted to the Ethics Committee.
- Driver consent forms were to be submitted to the Committee.
- An informed consent form for the vehicle owner needs to be prepared.

All of these stipulations have been adhered to and copies of the forms are available in Appendix B (Questionnaires) and C (Consent forms).

The second cause of concern was that the proposal indicated that the study would not make use of US students and the concern was that if the study did take place in Stellenbosch it would be difficult to manage this. However due to the logistics and costs involved in travelling from Pretoria to Stellenbosch on a weekly or bi-weekly basis, the study area was moved to Pretoria where the researcher resides.

3.9. Conclusion

Mixed methods were used in the research design of this project. Both quantitative and qualitative approaches were considered in order to address all the different data aspects of the research. The research instruments were developed in order to collect demographic, attitudinal, behavioural as well as vehicle and environmental information. The management of the data was particularly challenging and guidelines had to be developed in order to properly manage the data. The need for a strategy to manage large databases like this was identified and forms part of recommendations for future research.

CHAPTER 4: APPLICATION OF THE CODING SCHEME

4.1. Introduction

This chapter provides a brief overview on how the coding scheme was developed (based on the guidelines from the literature) and how the codes were applied to the image material. Initially it was thought that the coding scheme would be predefined and then used to code the behaviour in image material. A basic coding scheme was developed in Microsoft Excel which covered, for example time of day, type of road, etc. When the coding commenced it became clear that the predefined codes were not adequate. It was then decided to turn to *in vivo* coding (coding as you go along) and to make use of Grounded Theory in order to explain novice driver behaviour.

As explained in chapter 3, the coding was done with MAXQDA mixed analysis software.

4.2. Document groups and codes

Each video file was assigned to a document set. Each document set consisted of the three videos which was prepared with the BX 4000 system. The first batch of videos coded for novice driver contained 797 new codes that consisted of behaviour, road type, road furniture, speed limits, etc.

Currently there are 41 document groups with 3 video files each resulting in 123 documents and approximately 2585 codes that are associated with the document groups.

The document groups were clustered according to novice driver and experienced drivers, according to the download week.

4.3. Process and coding

Video files can be imported into MaxQDA. There are some restrictions on the size of the files that can be imported. For every participant three videos were generated in the Bx4000 system. Two videos (driver and front facing camera) were coded for this study.

The main objective was to identify situations that could potentially lead to a hazardous situation and this was done by making use of the front-facing camera. After the hazardous situations have been located, the accompanying driver behaviour was coded. This meant that the front facing cameras image material was watched and coded in terms of possible hazardous situations identified. The second video was watched and although the focus was on identifying the behaviour exhibited by the participants in these hazardous situations, the videos were coded from beginning to end in order to create a timeline from beginning to end. Examples of the coding schemes can found in Appendix E.

Each code or code group were assigned a colour to make the coding and sorting of the codes more efficient. The codes were each assigned a beginning and end timestamp. The same was done for the driver behaviour and the time stamps allowed for comparing the behaviour with the associated event or possible hazardous situation identified in the front and driver facing videos.

As indicated in the previous chapter, Grounded Theory was used to explain the phenomena of novice driver behaviour. The coding was therefore *in vivo*. This means that new codes were assigned to the videos each time a new event or a new feature appeared in the video. Memoranda were created to explain the reason for the creation of each and every code.

As the coding progressed, the number of codes grew, especially when the videos from novice driver 2 and experienced driver 2 were added. This is due to the very different driving environment the second group of participants functioned in. For example, Novice Driver 1 drove mainly short distances around his neighbourhood. Therefore initially the codes generated for Novice Driver 1 revolved around traffic circles, stop streets and so forth. When behaviour for Novice Driver 2 was coded, codes generated included driving on rural roads and in rural settings as well as highway driving. Memoranda were created for drivers as well as situations and were used in conjunction with the findings to draw conclusions regarding novice driver behaviour.

In figure 23 the list on the left provides an indication of the main themes or topics under which behaviour was coded. The blue dots appearing in the lines adjacent provide an overview of the relationships of the codes in relation to each other, how many times they were used and in which documents (videos).

The coding was conducted by observing the environment from camera 1 (the front facing camera). From camera 1, the possible hazardous situations were coded as an intersection, approaching a stop street, traffic light, junction or traffic circle. Camera 2 (focused on the driver) was then used to code the behaviour the driver exhibited in response to the potential hazardous situations. This behaviour was coded in terms of looking straight ahead, right, left, etc.

Figures 23 to 29 give an overview of selected themes which were coded as well as the sub codes and the frequency these sub codes were used.

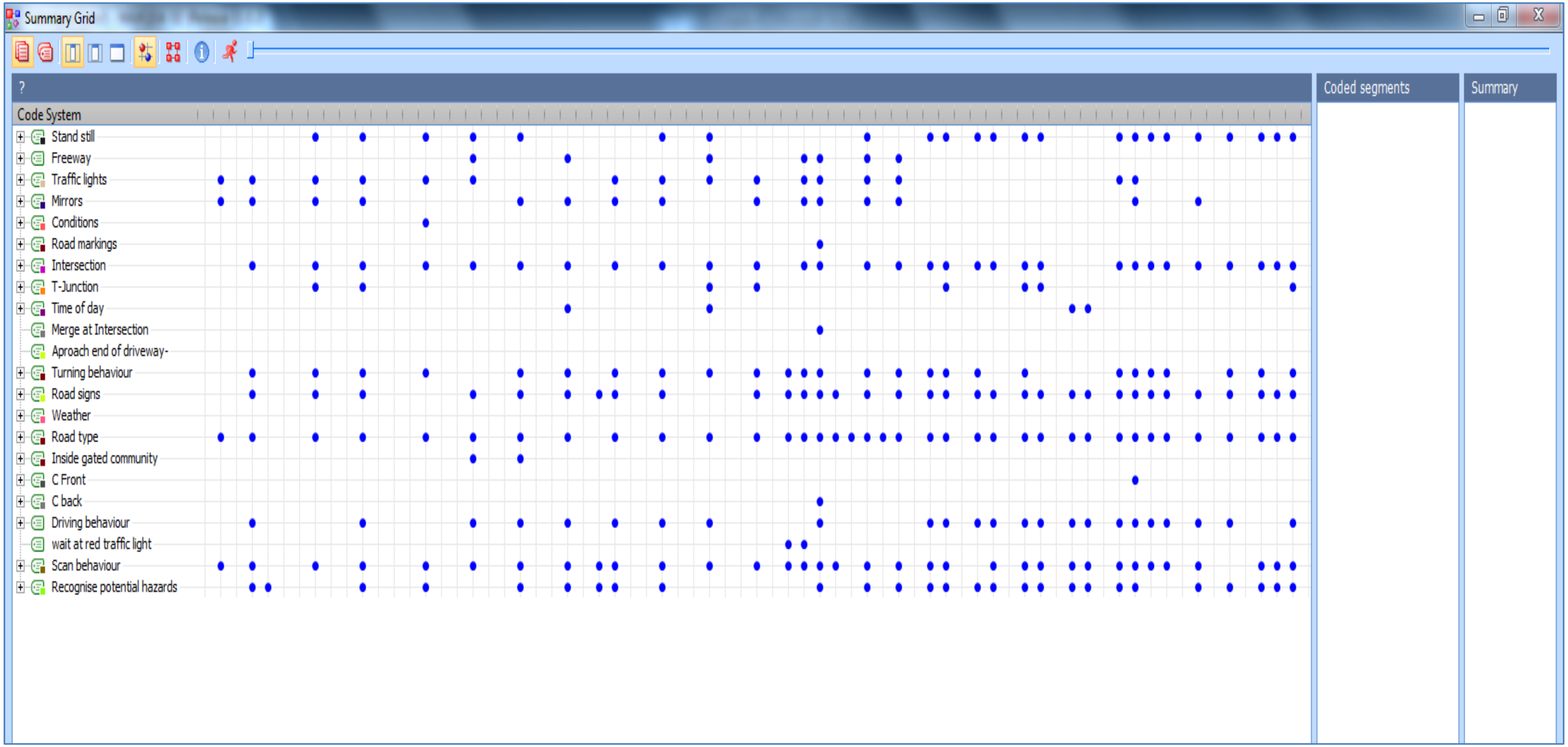

Figure 23: Activated codes per document and associations (blue dots)

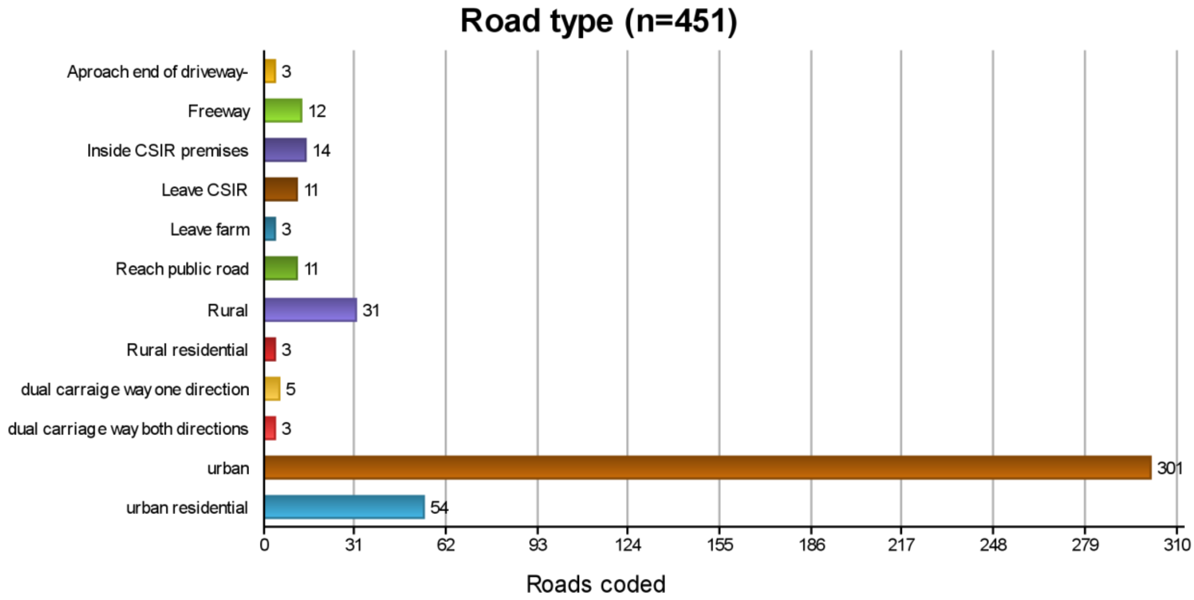

Figure 24: Road type coded

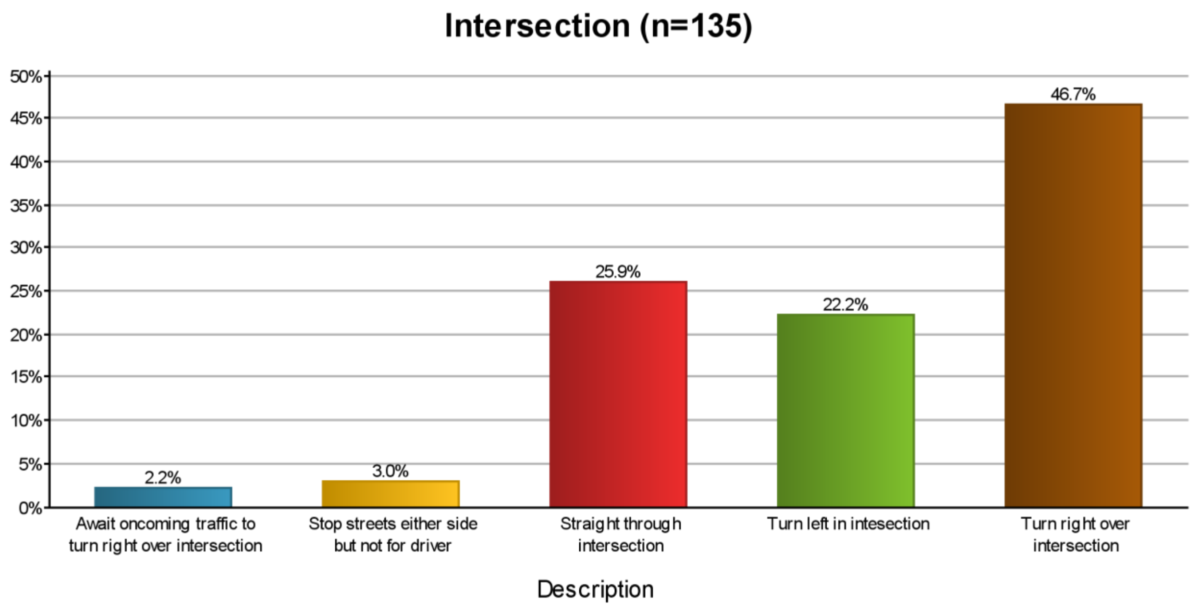

Figure 25: Intersections coded

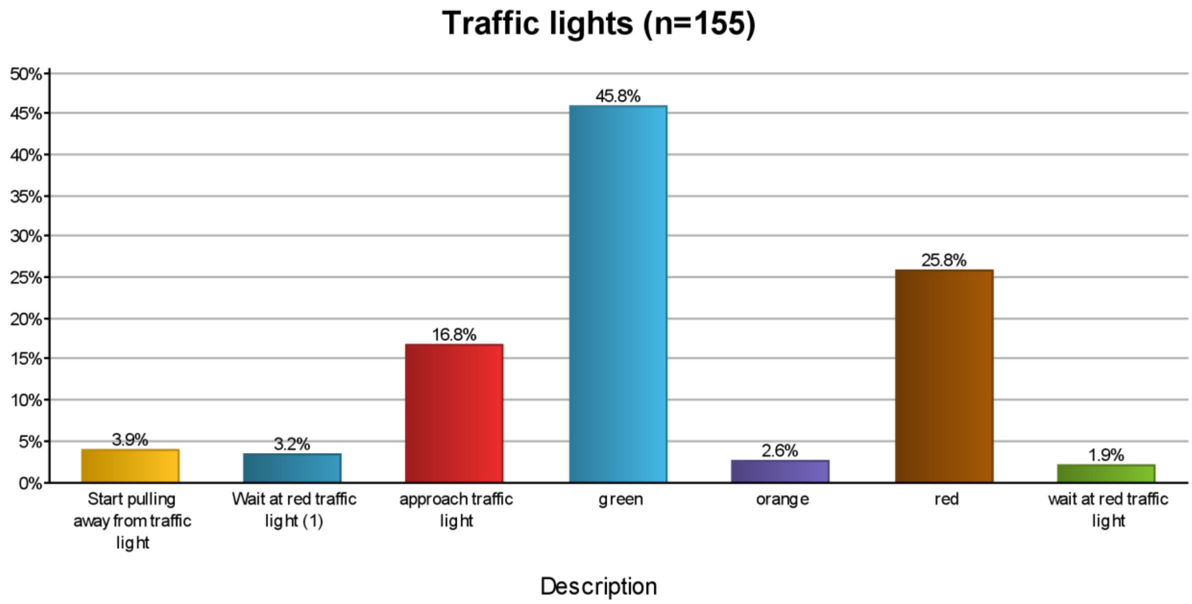

Figure 26: Traffic light coded

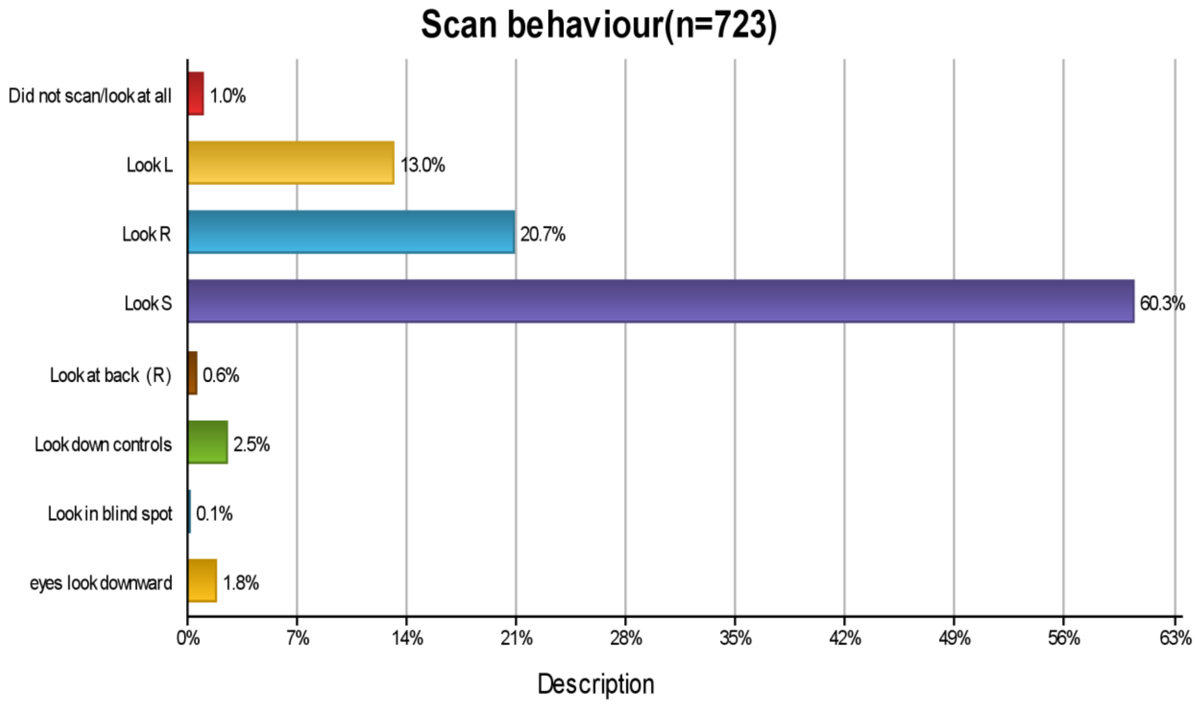

Figure 27: Scan behaviour

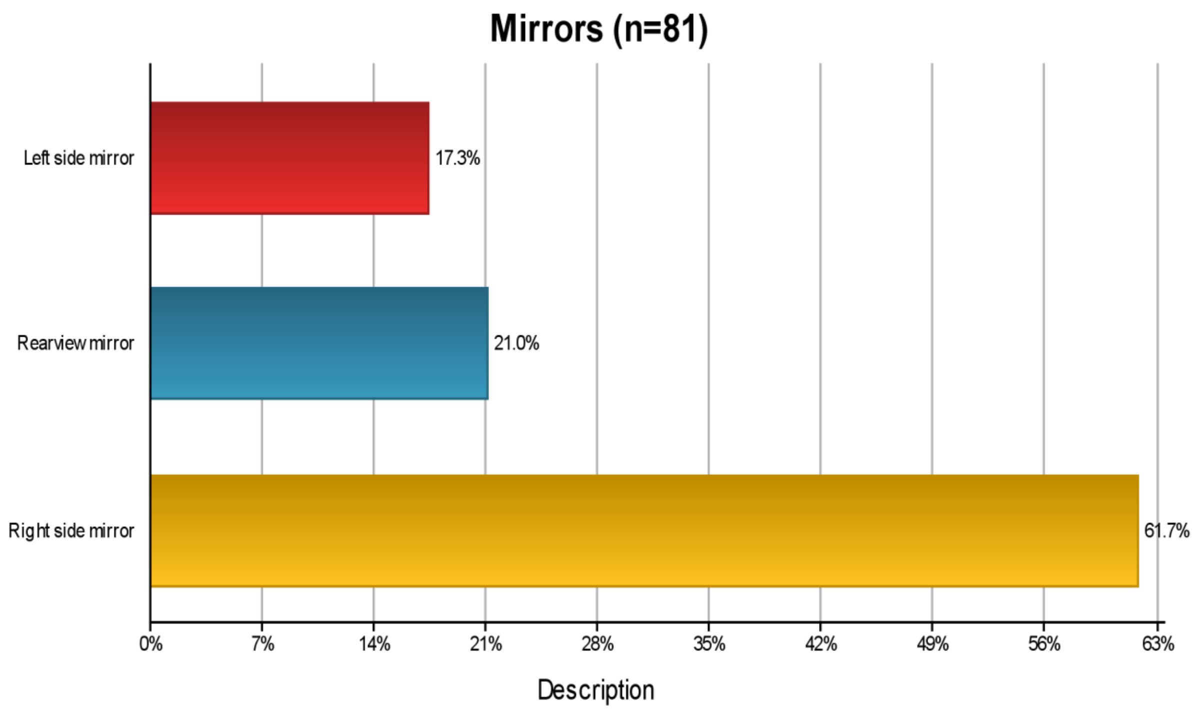

Figure 28: Mirror codes

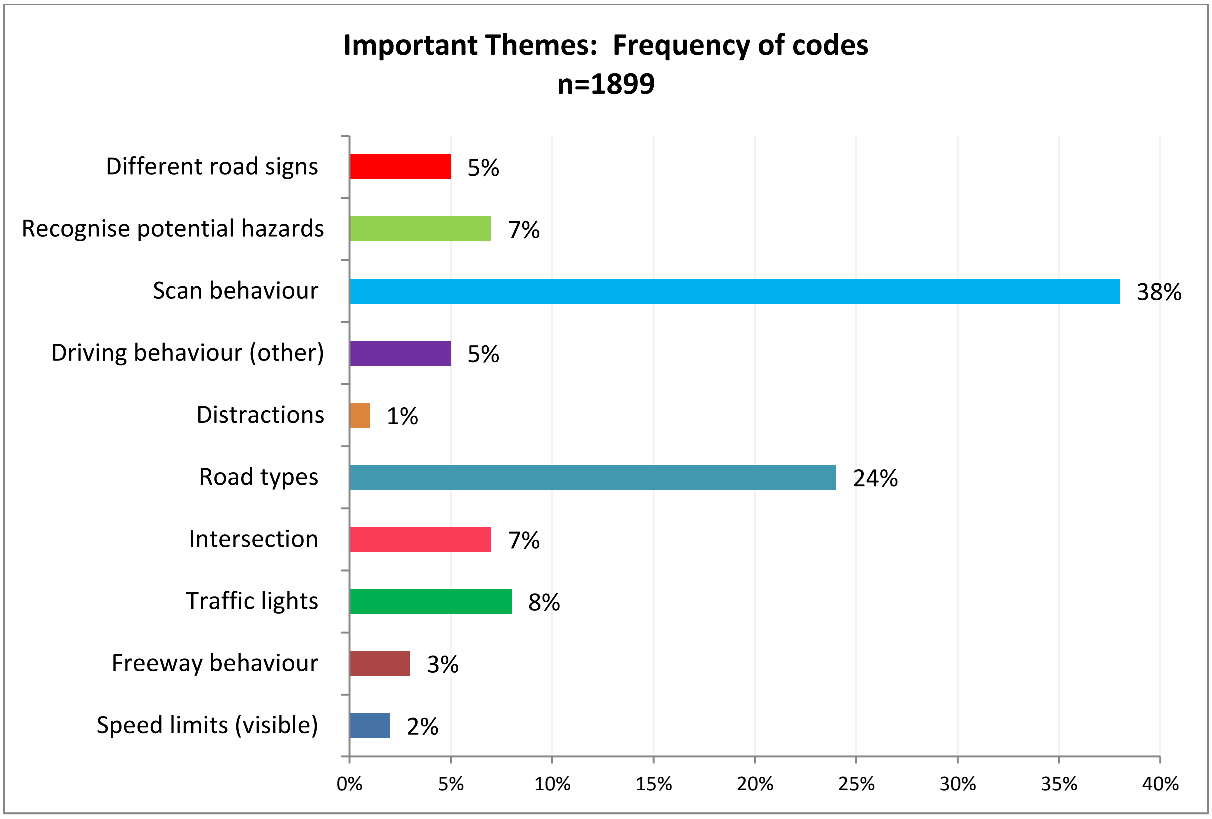

Figure 29: Summary of important themes coded

The coding was conducted by observing the environment from camera 1 (the front facing camera). From camera 1 the possible hazardous situation was coded as an intersection, approaching a stop street, traffic light, junction or traffic circle. Camera 2 (focused on the driver) was then used to code the behaviour driver exhibited in response to the potential hazardous situations. This behaviour was coded in terms of looking straight ahead, right, left, etc.

4.4. Conclusion

This project could not be executed without the development of a preliminary coding scheme which could be applied to the selected videos. However, this coding scheme is still very elementary and will be further developed. In order to make the coding scheme useful in determining severity of behaviour, criteria and guidelines should be developed. Weights should be assigned to the different topics, codes and associated behaviours.

Depending on the length of the video and the quality of the image material (dark, sun from the front etc.) each video took between 2 and 3 and half hours to code. The resources needed to do this are intensive and time consuming. It is therefore recommended that a team of researchers should be working on a project of this magnitude.

There are also reliability issues such as how accurate the coding of just one person is and how biased the decisions regarding open coding and application to behaviour is. Although having one person working on the coding did ensure consistency in the coding, it is recommended that in future the coding should be conducted by more than one person. Clear criteria and guidelines need to be developed and rigorously applied to the coding of image material. It is important that beginning and end timestamps be correct as the image material then needs to be linked to the vehicle movements. The vehicle movements are precise and the coded video needs to correspond with the data logger times, or the data might not make sense. The coded video would for example, show a scenario where the driver is standing still in traffic at a traffic light, but the corresponding data in the data logger shows speeds of 80 km/h. Precision and verification of the coding is therefore extremely important in order to ensure reliability of this work.

CHAPTER 5: DISCUSSION OF FINDINGS

5.1. Overview

This chapter contains the main findings from the research. As explained in the methodology section of this document, the data was collected with different instruments which resulted in different types of databases. Therefore the first part summarises the information and findings from the data logger and video equipment as separate “entities”. The second part of the chapter provides an overview of the combined findings from the data logger and the video material after the qualitative analysis was conducted. In the second part of the chapter the codes as developed in the coding scheme were applied to the selected video material and integrated with the data from the data logger.

5.2. Summary of the findings from equipment

5.2.1. Data logger information

The novice drivers drove around with the equipment in their vehicles for 51 days (Novice Driver 1) and 68 days (Novice Driver 2) respectively.

Experienced Driver 1 drove around with the equipment for 66 days and Experienced Driver 2 for 53 days.

More than a million movements were recorded for the four vehicles (table 10). These movements include the date, time of day, acceleration, deceleration as well as speed profiles.

Table 10: Number of days driven and the number of movements collected on each vehicle.

	Nr days driven	Nr of movements
Novice Driver 1	51	135106
Novice Driver 2	68	341219
Experienced Driver 1	66	296455
Experienced Driver 2	53	511373
Total collected	238	1284153

Table 10 above provides an overview of the days as well as movements per vehicle and participant.

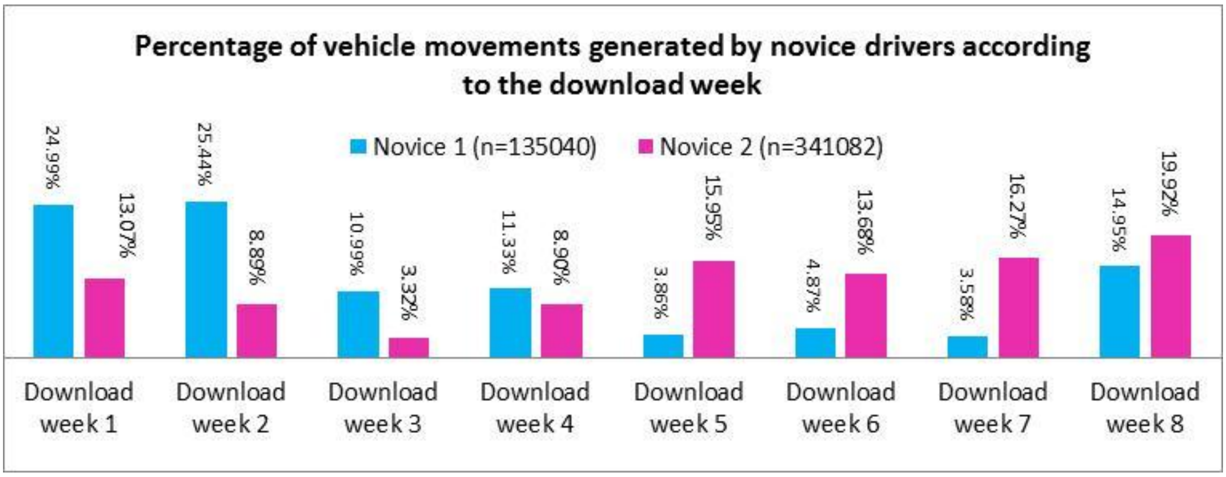

Figure 30: Novice drivers-vehicle movements according to the download week.

From figure 30 above, it seems as if in the first four weeks Novice Driver 1 drove around most while Novice Driver 2's vehicle movements increased significantly in the second half of the study. This is probably due to the fact that she relocated to another part of the city to start her studies.

Figure 31 below shows a similar picture for vehicle movements when comparing the novice and experienced drivers' vehicle movements. However Experienced Driver 1 had a fairly equal distribution throughout the study. In future this information might be useful to study travel patterns.

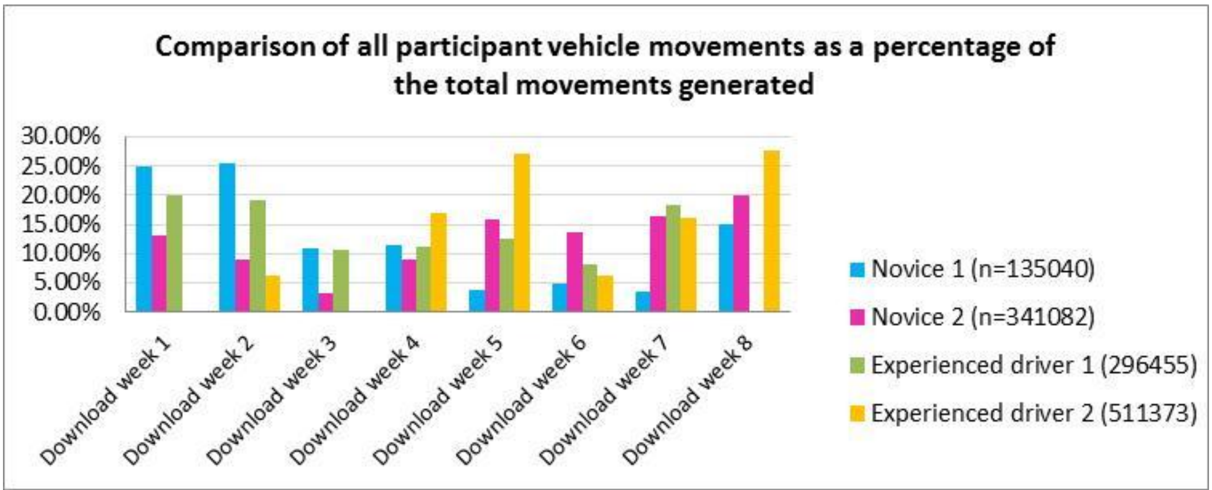

Figure 31: Comparison of all vehicle movements according to the download week.

5.2.2. Video files information

A large number of videos were generated by the participants. Table 11 below provides an overview of the number of videos generated per participant.

Table 11: Number of trips (videos) per download week

	Novice Driver 1	Novice Driver 2	Experienced Driver 1	Experienced Driver 2
Download week 1	64	91	111	0
Download week 2	76	62	55	46
Download week 3	38	36	65	0
Download week 4	36	65	59	103
Download week 5	12	57	49	0

Table 11: Number of trips (videos) per download week				
Download week 6	23	51	61	123
Download week 7	12	46	61	81
Download week 8	39	53	60	120
Total	300	461	521	473

The total number of videos generated over the past 7 months amounts to 1755 videos. Table 12 provides an overview of the hours of video data generated throughout the study. Approximately 255 hours of videos have been generated in this project.

Table 12: Hours of videos generated during the study period

Drivers	Hours
Novice Driver 1	35.7
Novice Driver 2	82.0
Experience Driver 1	113.9
Experience Driver 2	23.73
Total hours	**255**

Novice Driver 2 and Experienced Driver 1 generated the most videos. This is presumably because they work and study quite a distance from where they live.

Experienced Driver 1 also used her vehicle to travel to Mbombela during the April holidays. The total kilometres travelled during the study period was 14 119 km (Table 13 and Figure 32).

Table 13: Sum of length (km) of trips per download week

	Novice driver 1	Novice driver 2	Experienced driver 1	Experienced driver 2
Download week 1	207.4	535.1	1875.0	0.0

Table 13: Sum of length (km) of trips per download week				
Download week 2	258.0	317.4	604.1	177.5
Download week 3	105.2	137.4	652.3	0.0
Download week 4	92.0	284.0	615.7	538.2
Download week 5	40.9	711.9	558.4	0.0
Download week 6	46.6	550.2	603.9	976.3
Download week 7	28.3	780.0	640.2	580.7
Download week 8	177.7	873.9	666.6	484.1
Total kilometres travelled	956.1	4189.8	6216.3	2756.8

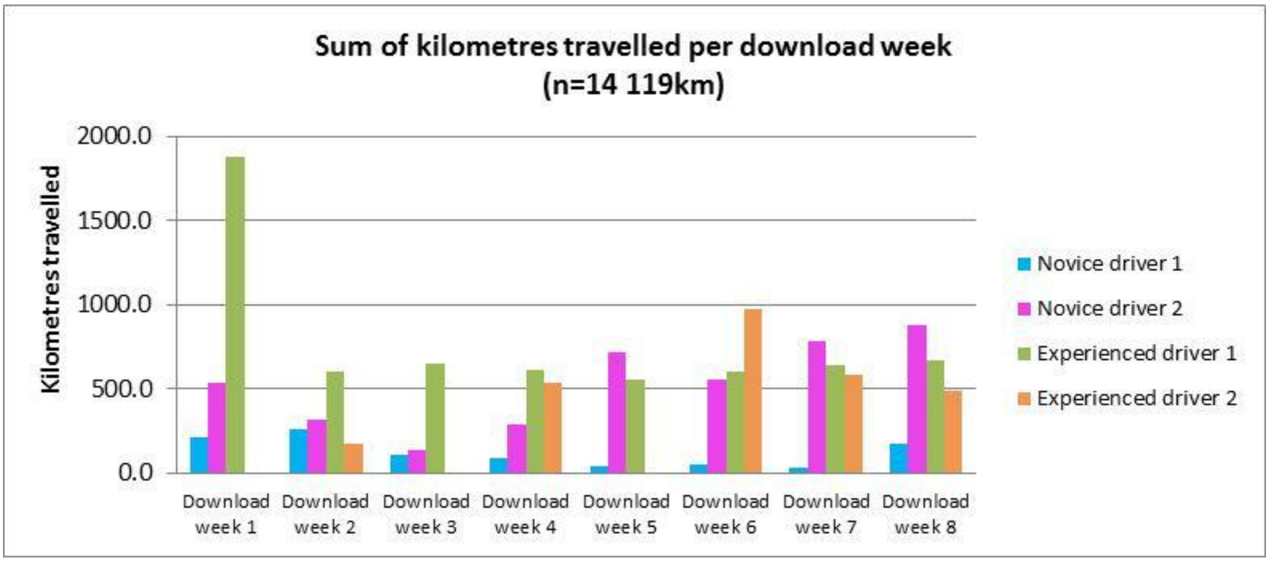

Figure 32: Comparison of kilometres travelled during the study period

Novice Driver 1 and Experienced Driver 1 only used their own vehicles. Therefore all the videos generated in the first part of the study were of the participants themselves. However, Novice Driver 2 and Experienced Driver 2 both had other drivers who also generated videos. Tables 14 and 15 below provide an overview of the other drivers who made use of the participants' vehicles as well as the number of videos generated and the kilometres travelled.

Table 14: Other drivers driving novice driver 2's vehicle

Driver	*Videos generated*	*Total kilometres travelled*
Novice Driver 2	438	4116.81
Mother	9	25.1
Sister	1	0.002
Experienced Driver 2	1	0.0885
Employee 1	9	0.584
Employee 2	3	46.432
Total	*461*	*4189.0*

Novice Driver 2 generated 438 videos which amount to approximately 4116.8 km travelled (table 14) while Experienced Driver 2 generated 443 videos and 2505.km travelled (table 15).

Table 15: Other drivers driving experienced driver 2's vehicle

Driver	*Videos generated*	*Total kilometres travelled*
Experienced Driver 2	443	2505.1
Employee 3	1	7.1
Novice Driver 2	3	9.9
Daughter (other)	26	234.8
Total	*473*	*2756.9*

Only the videos from the participants were considered for selection in the analysis.

Table 16 below provides an indication of the average length per trip per download week. Videos for the novice drivers were selected to ensure that the download weeks were represented in order to show progression in terms of skills being developed. Secondly in order to compare novice and experienced driver behaviour, videos depicting similar hazardous situations the novice drivers experienced were selected for analysis.

Table 16: Average kilometres travelled per download week

	Novice Driver 1	Novice Driver 2	Experienced Driver 1	Experienced Driver 2
Download week 1	3.24	5.9	16.9	0
Download week 2	3.39	5.1	11.0	3.9
Download week 3	2.77	4.8	10.0	0
Download week 4	2.56	3.7	11.2	5.2
Download week 5	3.41	15.7	11.9	7.6
Download week 6	2.03	10.6	9.9	0.0
Download week 7	2.36	17.0	10.5	7.2
Download week 8	4.56	16.7	11.1	4
Average length per trip	3.2	9.9	12.1	3.5

Figure 33 below provides an overview of the average time per trip over the course of the study for Novice Driver 1.

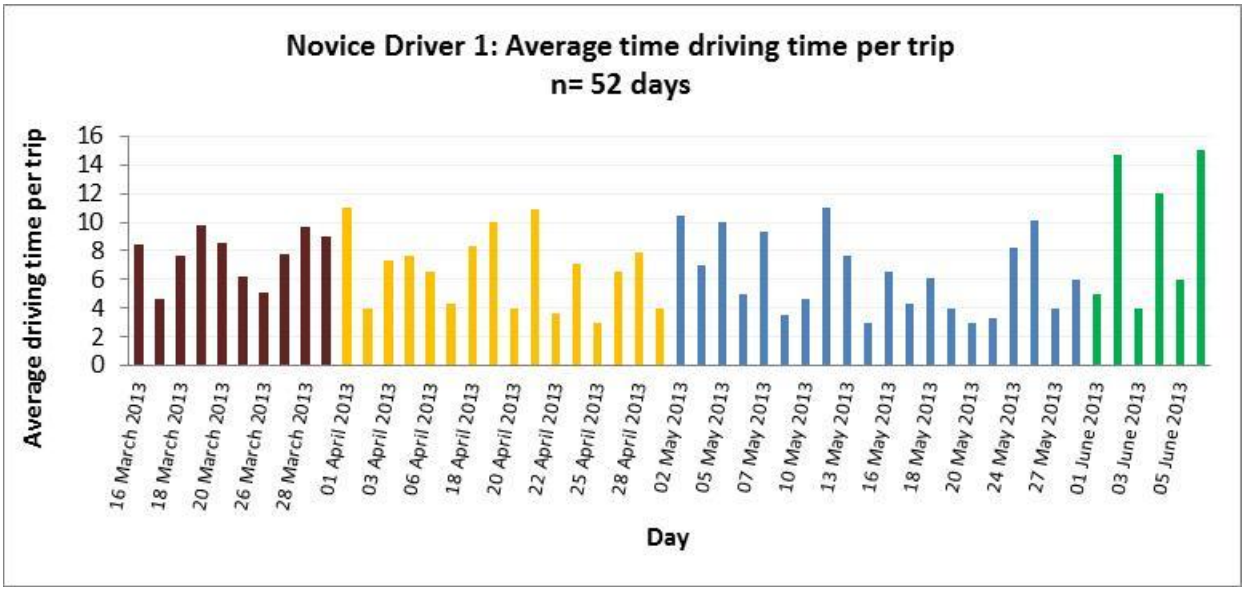

Figure 33: Average driving time per trip per day-Novice Driver 1

From the figure above, the typical driving time per trip ranged from 3 minutes to 15 minutes. It is interesting to see that the average driving time per trip became longer towards the end of the study.

For Novice Driver 2 it ranged from less than a minute to 45 minutes (Figure 34).

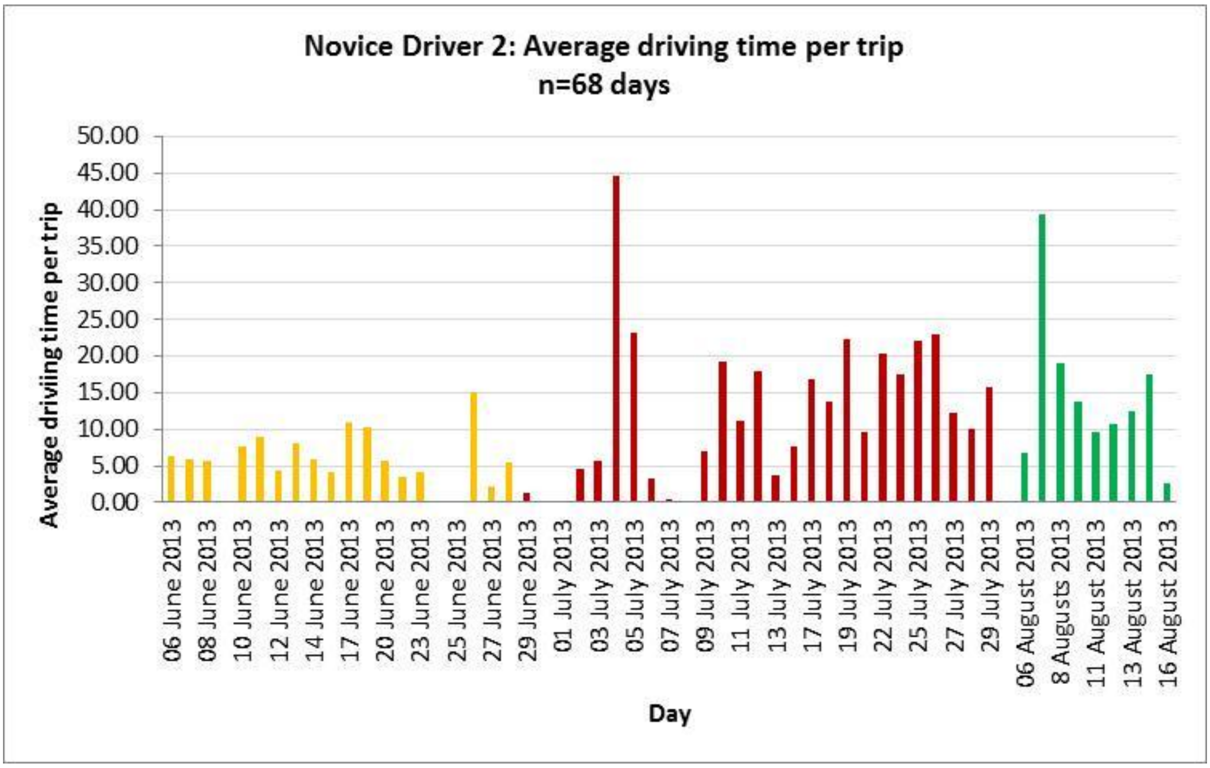

Figure 34: Average driving time per trip per day-Novice Driver 2

5.2.3. Selections of videos

Only a limited number of videos were analysed. Novice driver videos were selected based on two criteria:

a) The videos should depict behaviour at the selected hazardous locations.

b) Representation of the study period (in other words, videos were selected from each of the download weeks during the 3 months study period). This was done to ensure a continuous measurement of possible behaviour change.

Experienced driver behaviour videos were selected for the corresponding hazardous locations identified for the novice drivers. An effort was made to select videos from each download week during the 3 months study period, consistent with that of the novice drivers.

5.2.3.1. Selected videos for novice drivers

Novice Driver 1 is an 18 year old male who drove around with the equipment for 52 days. Three hundred videos were recorded for Novice Driver 1. The total number of kilometres travelled by Novice Driver 1 was 956.10 km.

Novice Driver 2 is an 18 year old female who drove around with the equipment for 68 days. Four hundred and sixty one videos were recorded for Novice Driver 2. The total number of kilometres travelled by Novice Driver 2 was 4 189.8 km.

Table 17 below gives an indication of the total time per driving month selected for analysis.

Approximately two hours of driving time was coded for each of the novice drivers.

Table 17: Length of videos selected (minutes)

	Novice driver 1	Novice driver 2
Month 1	62	70
Month 2	23	38
Month 3	22	23
Amount of minutes	**107**	**131**

As indicated earlier, Novice Driver 1 drove short distances mostly around his neighbourhood. Novice Driver 2 drove much longer distances as she resided first on a farm outside of Pretoria and later on in Centurion. Table 18 provides an overview of the kilometres travelled in these months.

Table 18: Length of trip (km)

	Novice Driver 1	Novice Driver 2
Month 1	36.7	71.4
Month 2	12.3	28.4
Month 3	10.2	15.8
Total number of kilometres	**59.2**	**115.6**

The videos selected for the novice drivers included specific locations where possible hazardous situations could develop. These included:

- Intersections (Vorster et al, 2008; Labett et al, 2006)
- Traffic circles
- Stop streets

- Traffic lights (Vorster and van As, 2008)

Specific behaviour coded at these possible hazardous locations included:

- Scanning behaviour (Scalfia et al, 2012)
- Turning behaviour (Vorster et al, 2008)
- Recognition of possible hazards such as oncoming traffic, vulnerable road users next to the road and so forth.

5.3.2.3. Selected videos for experienced drivers

Fifteen videos were selected for each of the experienced drivers. Approximately two hours of videos with selected hazardous locations were used to compare novice and experienced drivers' behaviour. Table 19 provides an overview of the time selected for each experienced driver.

Table 19: Length of video (minutes)

	Experienced Driver 1	Experienced Driver 2
Month 1	31	7
Month 2	18	14
Month 3	16	22
Amount of minutes	65	43

Table 20 indicates the distance accumulated for the selected videos.

Table 20: Length of trip (km)

	Experienced Driver 1	Experienced Driver 2
Month 1	28.6	7
Month 2	14.2	15.1
Month 3	6.7	24.5
Total number of kilometres	49.5	46.6

5.3.2.4 Description of routes

Description of routes: Novice Driver 1 tended to stay within the proximity of where he lives. Novice Driver 1 rarely drove more than 4 kilometres per trip (figure 35 and 36).

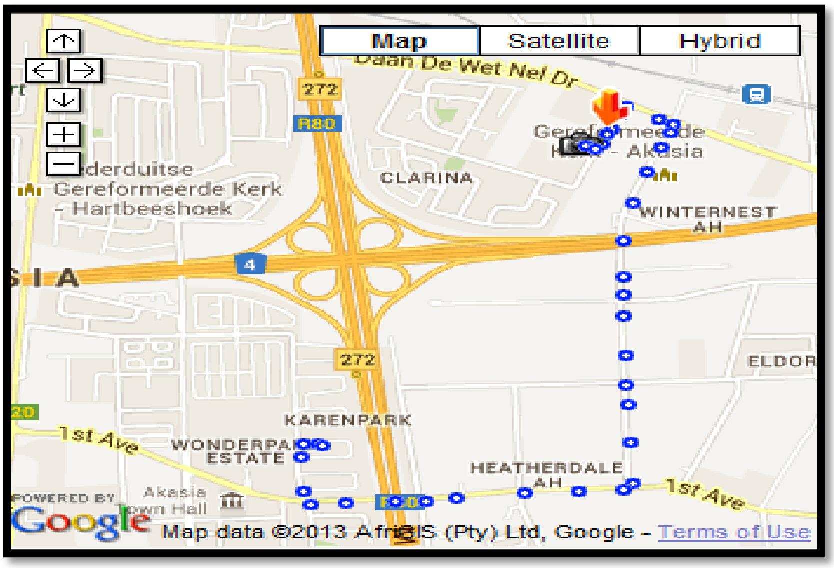

Figure 35: Novice Driver 1- route 1 urban residential, traffic circles and stop streets

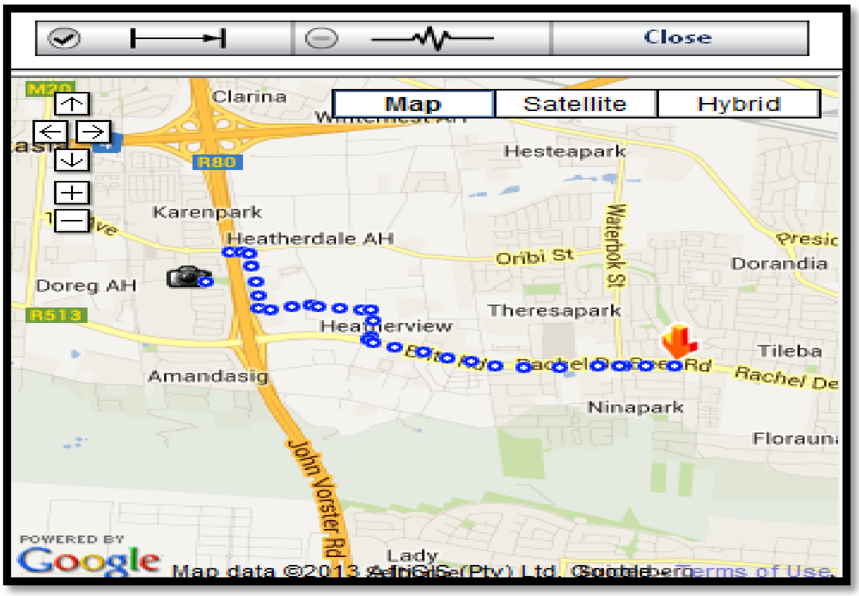

Figure 36: Novice Driver 1- route 2 urban residential, traffic lights and 80km/h urban road.

Description of route: During the first part of the study Novice Driver 2 stayed on a farm on the outskirts of Pretoria East. During the second half of July Novice Driver 2 moved to Centurion which is on Johannesburg's side of Pretoria. Both of these areas are quite a distance from Pretoria and in both instances Novice Driver 2 made use of the freeways surrounding Pretoria to get around. Figures 37 and 38 below provide an overview of the videos selected for analysis for Novice Driver 2. Less video material was selected for Novice Driver 2 because the distance Novice Driver 2 drove was significantly longer than that of Novice Driver 1.

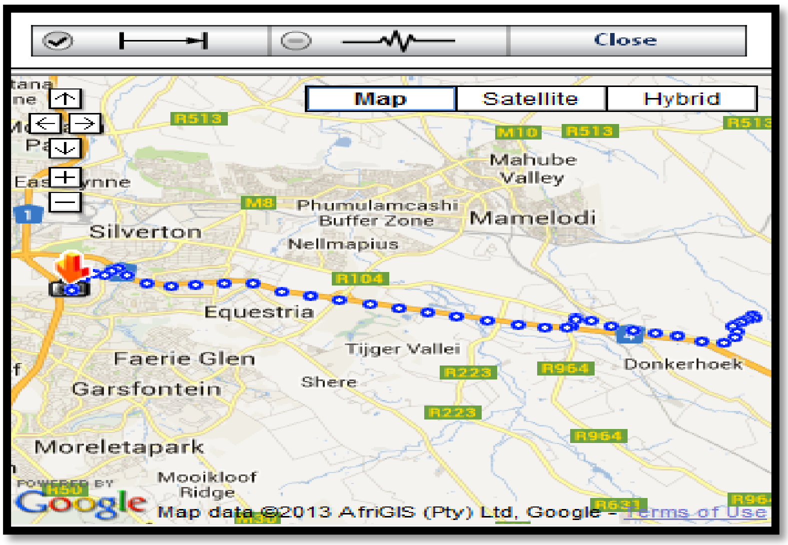

Figure 37: Novice Driver 2- route 1 urban residential, traffic lights and freeway

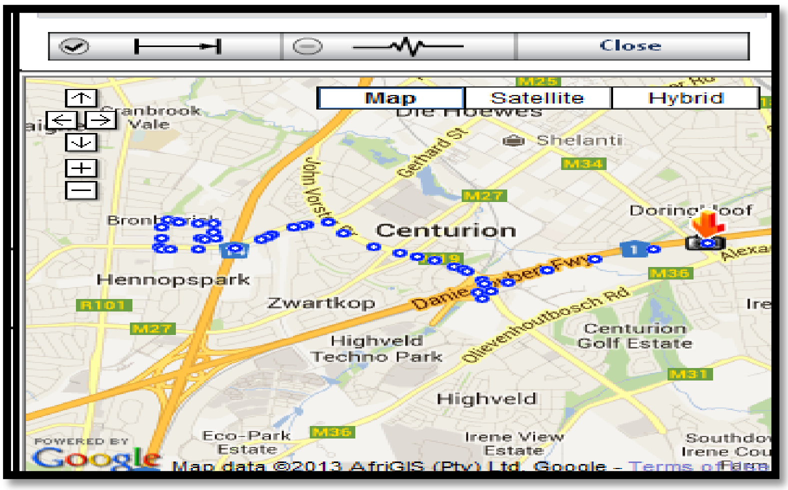

Figure 38: Novice Driver 2- route 2 urban residential, stop streets, traffic circles and freeway

5.3. Perceptions and attitudes of novice drivers

5.3.1. Overview

The first questionnaire consisted of selected questions taken from three well-known traffic psychology questionnaires. The questionnaires were: Driver Behaviour Questionnaire (Parker et al, 1996; Ozkan et al, 2006); Driving Style Questionnaire (French et al, 1993) and the Sensation Seeking questionnaire (Zuckerman, 1971) .The questions were selected to provide an indication of the novice drivers' attitudes and perceptions of the following personality aspects and behaviour as highlighted in the literature review:

- Aggression
- Competing (peer pressure)
- Risky driving practices
- Attitude towards road rules and regulations as well as compliance
- Sensation seeking

Although the questions were presented in the context of the original questionnaire, for analysis purposes the questions was clustered according to themes. The rankings of the questions were used to determine the strength of the novice drivers' attitude or perception regarding the topic. Tables 21 to 27 below provide an overview of the clustered questions (the first row of the table refers to question number in the questionnaires included in Appendix B)

The five rankings (never, rarely, sometimes, often, always) were simplified to three (seldom, sometimes and frequently).

The questionnaires were not analysed statistically, although in future, with a bigger sample a factor analysis could provide valuable insight in the attitudes and perceptions of a larger South African novice driver group.

5.3.2. Findings from questionnaires

Aggression towards other drivers was probed with the following questions in (Table 21)

Table 21 : Aggression tendencies

Q Nr		Novice Driver 1	Novice Driver 2
1	I drive when I am angry or upset	2	3
2	I lose my temper while driving	2	2
4	I flash my headlights when I am annoyed at other drivers	2	4
5	I make rude gestures towards other drivers that annoy me	2	2
6	I verbally assault drivers that annoy me	1	2
7	I deliberately use my vehicle to block drivers who tailgate me	1	1
8	I would tailgate drivers who annoy me	1	2
11	I feel it is my right to strike back if I feel another driver has been aggressive to me	2	1
16	When someone cuts me off I feel I should punish them	1	2
18	Passengers in my vehicle tell me to calm down	1	1
26	I feel I may lose my temper if I have to confront another driver	4	2
4	Do you normally remain calm in traffic	4	4
6	Do you respond to pressure from other drivers?	3	3

Key	1 Never	2 rarely	3 sometimes	4. Often	5. Always

Both drivers indicated that in general they are calm and collected even if other drivers annoy them. Novice Driver 2 seemed to be more aggressive towards other drivers that annoy her than Novice Driver 1.

Impatience was probed with the questions in Table 22 below. From the responses it seems as if Novice driver 2 is less inclined to feeling impatient except when in a hurry while Novice Driver 1 indicated that he often feels impatient with other drivers when stuck in traffic.

Table 22 : Impatience

Q nr		Novice Driver 1	Novice Driver 2
3	Consider the action of other drivers to be inappropriate or stupid	1	4
12	When stuck in traffic I get irritated	3	1
17	I get impatient when I fall behind schedule when I am driving	1	5
19	I get irritated when the vehicle in front of me slows down for no reason	4	1
22	I feel passive drivers should learn how to drive or rather stay home	4	1
5	Would you describe yourself as highly strung in traffic	3	3
3	I would...patiently wait in a long queue	3	1
17	I would ...order something familiar in a restaurant	4	3

Key	1 Never	2 rarely	3 sometimes	4. Often	5. Always

Neither of the novice drivers had specific tendencies to compete with other drivers in traffic. This might implicate that these drivers would feel less inclined to impress their friends or to succumb to peer pressure when driving (Table 23).

Table 23 : Competing behaviour (secondary aggression)

Q nr		Novice Driver 1	Novice Driver 2
9	I race other drivers at intersections to get in front of them	1	1

13	I will race a slow moving train to a railroad crossing	1	1
21	I feel it is my right to go where I want to go as quickly as possible	4	1

Key	1 Never	2 rarely	3 sometimes	4. Often	5. Always

In terms of road rules and regulations (Table 24) Novice Driver 1 seems to be more compliant than Novice Driver 2. In most instances Novice Driver 1 indicated that he would not commit a traffic offence with the exception of overtaking on a yellow line and breaking the speed limit in built-up areas. Novice Driver 2 on the other hand felt strong about NOT overtaking on a yellow lane, drinking and driving as well as barrier line offences.

Risk-taking behaviour yielded a variety of answers from the novice drivers (Table 25). Novice Driver 2 had a much higher tendency to engage in risky behaviour than Novice Driver 1.

Table 24 : Attitude towards rules and regulations

Q nr		Novice Driver 1	Novice Driver 2
10	I will illegally pass a truck or car that is moving to slow	1	2
14	I will weave in and out of slower traffic	1	2
15	I will drive even if I feel intoxicated	1	1
20	I will cross solid and yellow barrier lines in order to move slow moving traffic	1	1
23	I will drive on the shoulder lane or median to get around slow moving traffic	1	3
24	when passing a vehicle on a two lane road I will barely miss oncoming vehicles	1	2
25	I will drive after I had a few drinks	1	1
28	Traffic laws are mostly suggestions	1	3

Table 24 : Attitude towards rules and regulations

3	Do you exceed the speed limit in built up areas?	3	3
11	Do you overtake vehicles on the yellow lane?	3	1
12	Do you drive in the yellow/emergency lane of the road	1	3
13	Do you ever drive through a red traffic light?	1	3

Key	1 Never	2 rarely	3 sometimes	4. Often	5. Always

Despite the fact that Novice Driver 2 indicated that she engages in risky traffic behaviour she reported that she is always cautious. Novice Driver 1 on the other hand seems to be cautious prefers to plan ahead although he does engage in some risky driving elements such as breaking the speed limit (Table 25).

Table 25 : Risk-taking behaviour

Q nr		Novice Driver 1	Novice Driver 2
27	I consider myself a risk-taker	1	3
1	Do you normally break the speed limit	3	5
2	Do you normally drive fast?	3	4
7	Do you drive cautiously?	5	5
10	do you plan long journeys in advance/	4	5
1	I would like to .. marry someone from a foreign country	1	4
2	I would like to...swim in very cold water	3	4
5	...make as few plans as possible for an upcoming trip	1	1
7	I would like to...to speak in front of a group of people	3	3
9	I would like to...travel to strange places	1	4
10	I would like to gamble with money	1	1

11	I would like to...explore an unknown land	2	4
14	I would like to...work better under pressure	3	4
18	I would like to...look down in a high place	3	2
	Key: 1 Never, 2 rarely, 3 sometimes, 4. Often, 5. Always		

Lastly, in terms of sensation seeking behaviour, again Novice Driver 2 exhibited much more inclination towards seeking sensation than Novice Driver 1 (Table 26).

Table 26 : Sensation/thrill			
Q nr		Novice driver 1	Novice driver 2
4	Listen to load music	4	4
6	I would like to...watch frightening movies	1	4
8	I would like to...go on fast rides in an amusement park	1	4
12	I would like to...watch movies with explosions etc.	4	3
13	I would like to...eat spicy foods	4	4
16	I would like to...see a car crash	1	2
	Key: 1 Never, 2 rarely, 3 sometimes, 4. Often, 5. Always		

In conclusion, both novice drivers in general seem to be calm and collected when driving although they both indicated that they might get impatient with other drivers or when in a hurry.

Neither of the novice drivers had a strong tendency to compete with other drivers. Although Novice Driver 2 indicated that she does engage in dangerous driving practices she feels that she does so cautiously. This is reinforced by the answers from the sensation seeking questions which implies that Novice Driver 2 would like to experience excitement and adventure.

Table 27 : Summary of inclination towards typical novice driver behaviour			
Aggression	**Seldom**	**sometimes**	**Frequently**
Novice Driver 1	10	3	1
Novice Driver 2	9	2	1
Impatience	**Seldom**	**sometimes**	**Frequently**
Novice Driver 1	2	3	3
Novice Driver 2	4	3	2
Competing behaviour	**Seldom**	**sometimes**	**Frequently**
Novice Driver 1	2	0	1
Novice Driver 2	3	0	0
Rules and regulations	**Seldom**	**sometimes**	**Frequently**
Novice Driver 1	10	2	0
Novice Driver 2	7	5	0
Risk taking	**Seldom**	**sometimes**	**Frequently**
Novice Driver 1	7	6	2
Novice Driver 2	3	3	10
Sensation seeking	**Seldom**	**sometimes**	**Frequently**
Novice Driver 1	3	0	3
Novice Driver 2	1	1	4

Based on these observations it is considered likely that both of these novice drivers have Type "B", rather than Type "A" personalities which in literature has been highlighted to engage in risky and irresponsible driver behaviour.

5.4. Hazard Perception

5.4.1. Introduction

Throughout this document hazard perception skills have been described as one of the main differences between experienced drivers and novice drivers. It is therefore expected that experienced drivers should have better scanning abilities, better perception regarding the recognition of potential hazardous situations and should engage less in activities that could potentially distract them from the driving task. This chapter explores the differences and similarities found for novice and experienced drivers pertaining to these factors.

5.4.2. Methodology followed to summarise observations

5.4.2.1 Proportion of time spent on scanning behaviours.

From the selected video, 11 595 observations were recorded for the novice driver group. Observations were measured in seconds and therefore 11 595 seconds amount to 193.25 minutes or 3 hours and 22 minutes of observed behaviour. A total of 4 726 observations were made for Novice Driver 1 - this amounts to approximately 1 hour and 30 minutes of observations for Novice Driver 1.

A total 6 869 observations were made for Novice Driver 2, amounting to almost two hours of observations for Novice Driver 2.

Despite the fact that more videos were coded for Novice Driver 1, he still had fewer observations than Novice Driver 2.

Four thousand nine hundred and seventy one observations (4 971) were recorded for the experienced drivers. This amounted to 1 hour and 30 minutes of driving time.

Approximately 45 minutes of behaviour per experienced driver were analysed.

For each of the hazardous locations identified, the proportion of time spent by novice and experienced drivers to scan their environment was estimated and presented as a percentage of the total spent to scan their environment.

5.4.2.2. Establishing differences between novice and experienced drivers' behaviour at the hazardous locations

For each of the participant groups, summary statistics were compiled in order to compare the means of the observed behaviours at the different hazardous locations with each other. P-values were calculated per scan behaviour using a t-test. A t-test was deemed the most appropriate statistical test as the sample sizes were relatively small.

5.4.2.3. Speed profiles

For each participant group, speed profiles are highlighted. These profiles consider speed behaviour per location and give an indication of minimum, maximum and average speeds on approach to the hazardous locations.

Speed profiles according to road type are discussed below.

5.4.3 Speed behaviour over the study period

5.4.3.1. Overview

From the literature review it is evident that inappropriate and high speeds are considered as one of the errors novice drivers tend to make. Peer pressure and a lack of skill to control the vehicle at high speeds have proven to often be a recipe for disaster.

In the analysis average speeds when approaching potential hazardous situations were used as a benchmark in order to assess the level of caution exhibited by the novice drivers when approaching potentially dangerous situations.

5.4.3.2. Average speed according to road type

Neither novice nor experienced drivers had a high average speed for driving on the freeway. Novice drivers in general had lower average speeds while travelling on 60 km/h, 70 km/h and 80 km/h roads. What could be of concern is the higher average speed that novice drivers have when travelling in urban (built-up) residential areas. These residential areas are typical neighbourhoods where people live and one would expect high pedestrian and cyclist activities as well as other drivers entering and exiting their driveways.

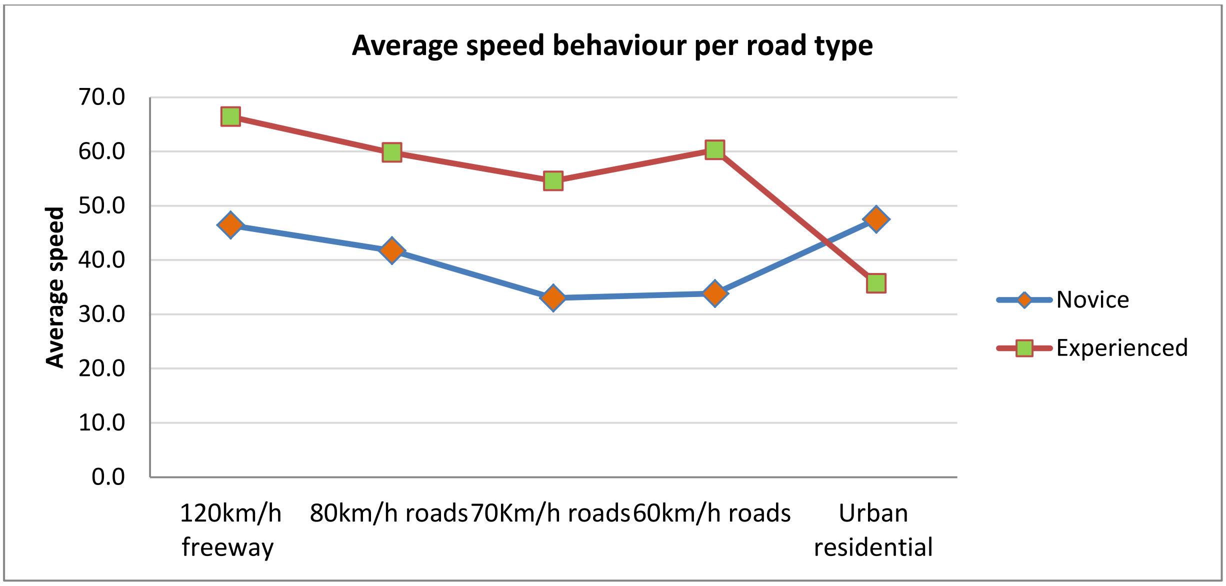

Figure 39: Average speed according to road type

Figure 39 illustrates the average speed maintained by novice drivers and experienced drivers over the study period, for each road type they travelled on.

5.4.3.2. Maximum speed according to road type

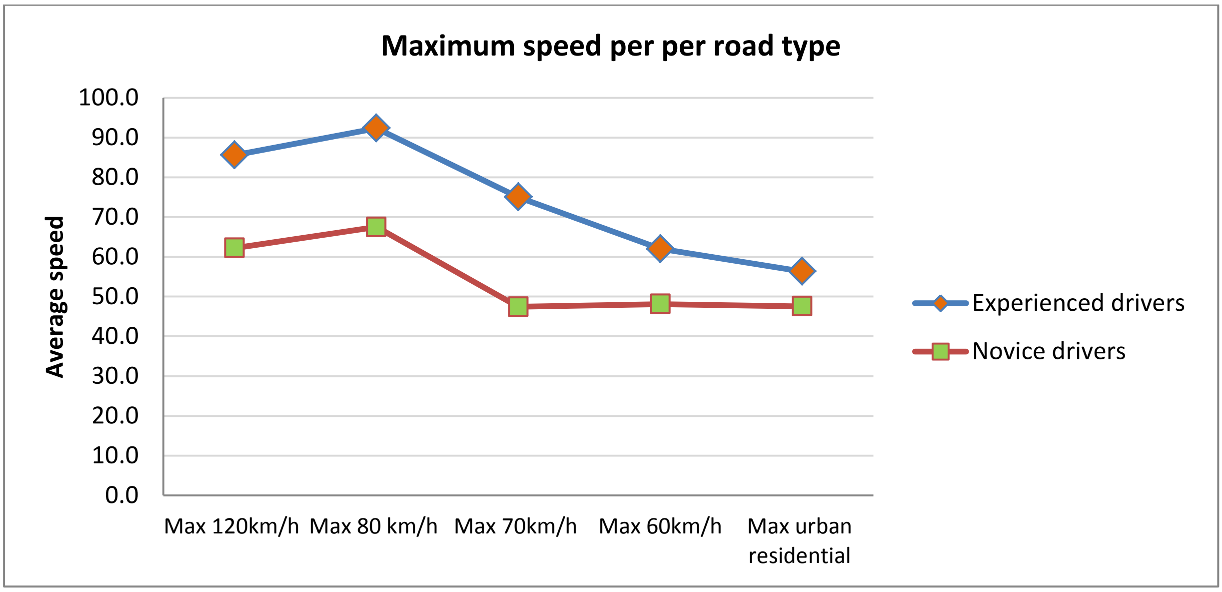

Figure 40: Maximum speed according to road type

Again, experienced and novice drivers stayed well within the speed limit when travelling on the freeway. The experienced drivers however (contrary to the literature review that stated that novice drivers tend to speed) had much higher maximum speeds on 80 km/h, 70 km/h and 60 km/h roads. Novice drivers tended to keep to speed limits, travelling well below the posted speed limits of 80 km/h, 70 km/h and 60 km/h posted speed limits.

5.3.3. Average speed on approach to selected hazardous locations

When approaching intersections with a right turn as well as intersections with a left turn, novice drivers had a lower average speed. The novice drivers however had higher average speeds on approach to traffic lights and intersections.

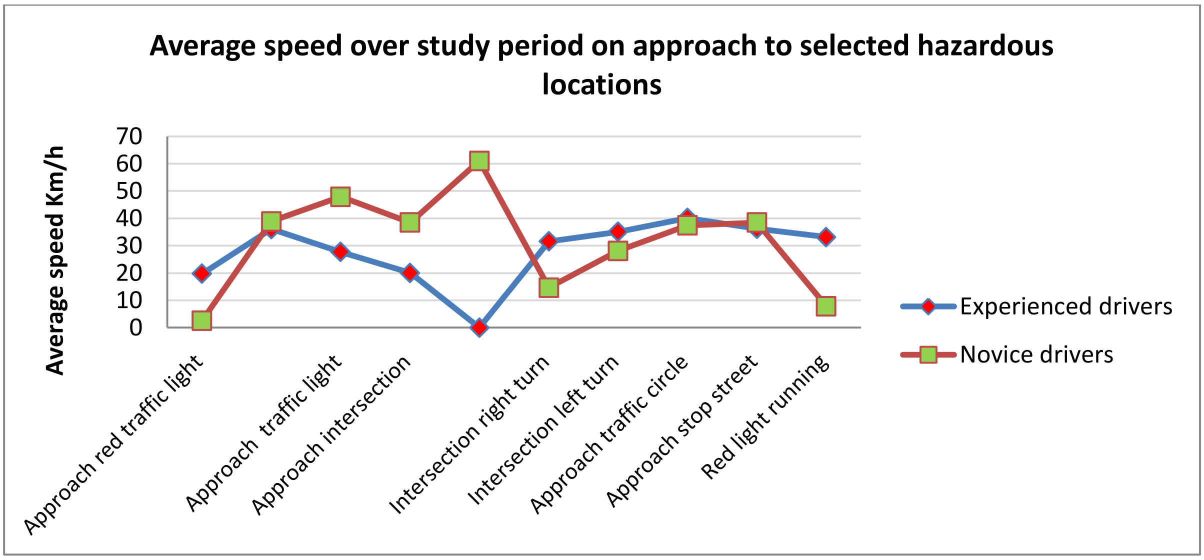

Figure 41: Average speed on approach to the hazardous location

Similar average speeds were found for approaches to traffic circles and stop streets. In the two events where novice drivers did run a red light it was at a much lower average speed than that of experienced drivers.

5.4.4. Scan behaviour over the study period

5.4.4.1. Overview

Scan behaviour has been highlighted by a number of authors (Whelan, 2000; Scalfia, 2012) as an indication of the degree to which hazard perception skills are developed in novice drivers. For this project, scan behaviour was coded as:

- “Scan straight”: Eye fixations for long periods of time and close in-front of the vehicle.
- “Scan right”:Eye and head movements scanning the environment right from the vehicle.

- “Scan left”: Eye and head movements scanning the environment left from the vehicle.
- Side mirror use: Scanning of side mirrors every few (8) seconds.
- Rear view mirror use: Scanning rear-view mirror.

5.4.4.2. Intersections and stop streets

a. Stop streets

When approaching an intersection and stop signs, a driver is required by law to come to a complete stop. Hazards within and around intersections and stop signs may include pedestrians crossing, other vehicles approaching and not stopping in the intersection, etc. It is therefore important that novice drivers should be able to not only obey the law but should be able to recognise hazards associated with stop streets. Scan behaviour especially to the left and the right is considered important to cross and clear the intersection safely.

In terms of how much time was spent scanning by the drivers on the approach to a stop street, the novice drivers in the study had an average scanning period of approximately 8.1 seconds compared to experienced drivers’ 4.3 seconds. This shows clearly that on approach to the stop street, novice drivers on average took longer to scan their environment.

The next question was how much of the scanning time was allocated to different tasks.

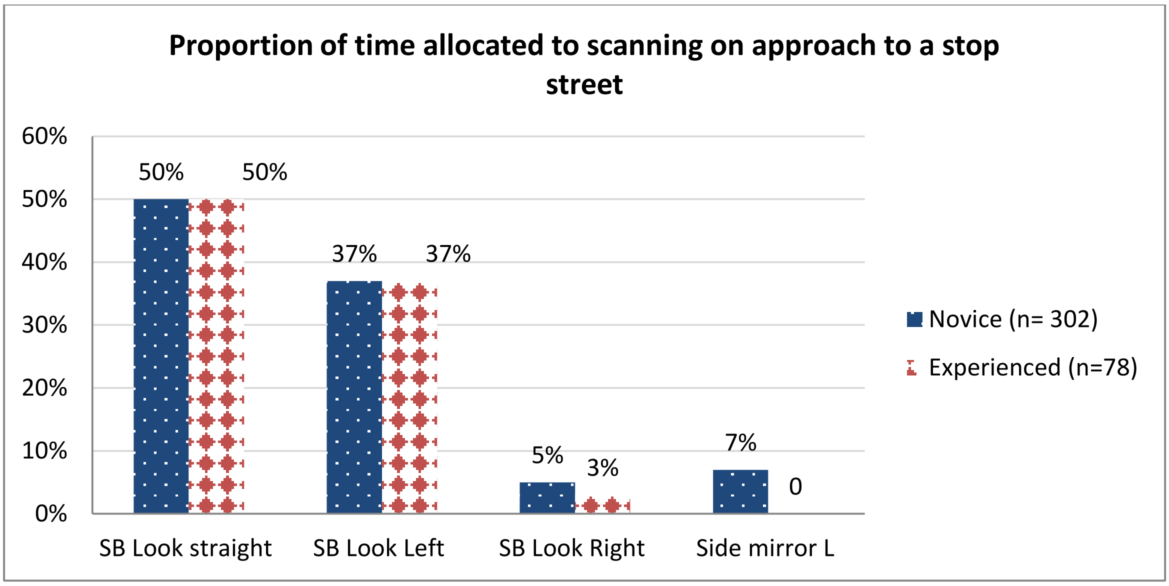

Figure 42: Proportion of time spent on scanning the environment on approach to a stop street.

Figure 42 shows that novice and experienced drivers spent exactly the same proportion of time scanning the environment directly ahead of them as well as to the left of the stop street. Novice drivers took more time to scan their environment to the right and their left side mirror whereas experienced drivers did not make use of any of their mirrors.

When a t-test was performed comparing means of the different behaviours the p-values indicated that there were no significant differences in experienced and novice drivers' approaches to stop streets.

b. Intersections

Behaviour at intersections was divided into behaviour where the novice driver approached and continued through the intersection and secondly where the novice driver turned either left or right at the intersection. The first section considers scanning behaviour where the novice driver was approaching the intersection and then travelled straight through the intersection. The second part considers scanning behaviour when turning at intersections.

As indicated earlier, intersections are typically areas where traffic conflicts can occur. Vorster et al (2008) and Nel (1989) indicated that in SA, possible hazards included intersections, speed, etc.

According to Tshwane Municipality crash data, out of the 85% usable crash data it was found that 65% crashes occurred at intersections and 50% of the 65% intersection crashes occurred at traffic lights.

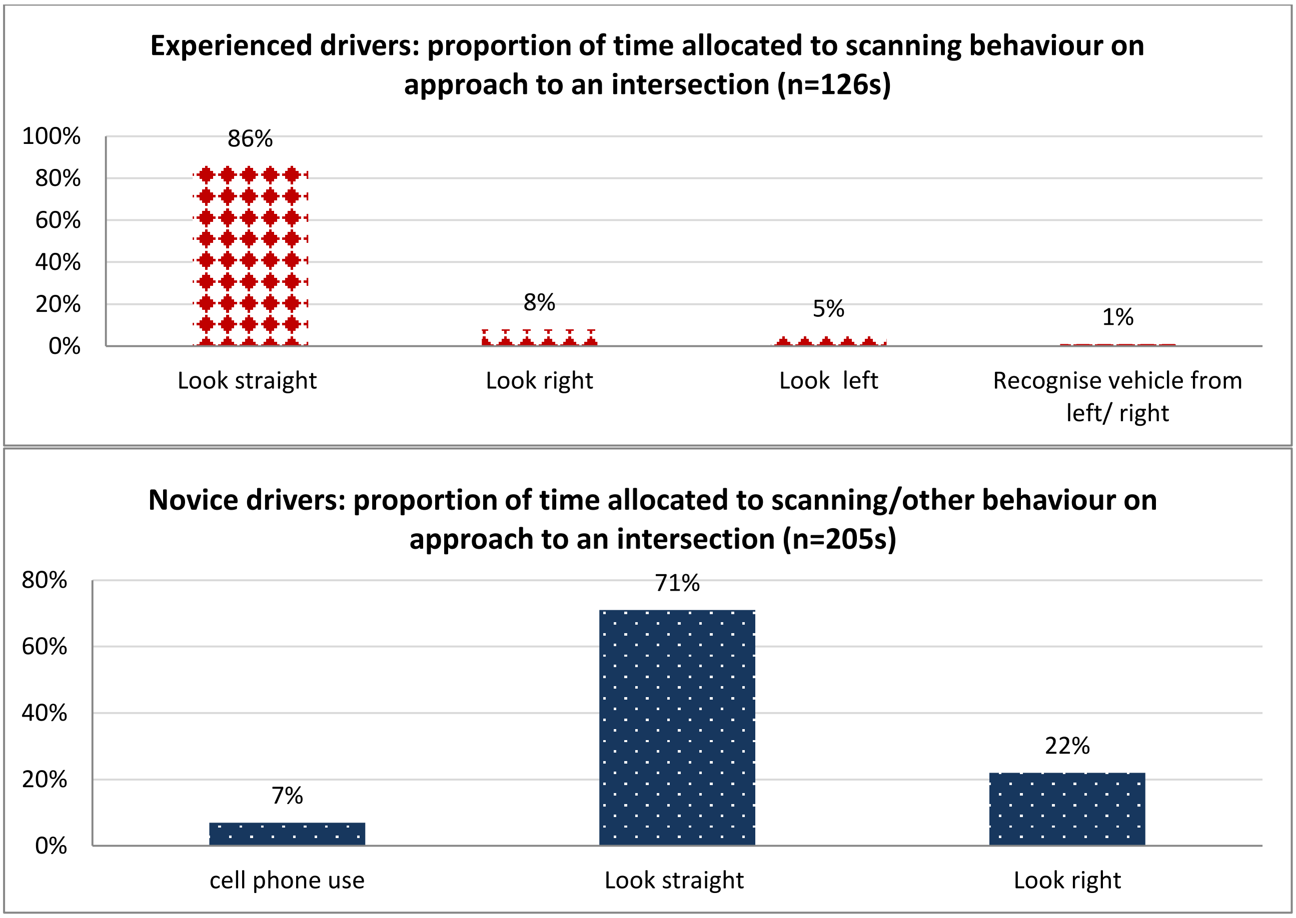

Figure 43: Behaviour on approach to an intersection

Novice and experienced drivers mostly scanned the road ahead of them on approach to an intersection. Novice drivers did not scan the environment left of them at all, while the experienced drivers scanned both the left and right environments. Experienced drivers also acknowledged vehicles by looking either left or right of the intersection. In 7% of the time (n = 14.35 seconds), novice drivers were making use of cell phones while approaching the intersection. This is potentially dangerous as it could influence their ability to appropriately react to hazards manifesting from either the right or left hand side of the intersection.

In line with the discussion above the t-test that was performed on the means of the two groups indicated that there is a significant difference in the manner in which the novice and experienced drivers approach intersections. Table 28 below illustrates the difference. Furthermore the t-tests applied to determine differences in straight, left and right scanning behaviour indicated that there are no significant differences in left and right scanning behaviour between the two groups but that there is a significant difference in straight scanning behaviour (means significantly different at 95% confidence interval, p-value= 0.04796).

Table 28: Approach to intersection

Variable	Mean	Standard error	N	Standard deviation	Variance	t-value	p-value
Novice drivers	8.189672	2.084739	39	13.02	169.499	2.96	0.00527
Experienced drivers	3.322683	0.799359	11	2.65	7.029		
Result =	**Means significantly different at 99%**						
*** p<0.01, ** p<0.05, * p<0.1							

With regards to right turning behaviour in intersections, it can be seen that novice drivers scanned the right for longer than experienced drivers. Experienced drivers on the other hand also made use of their rear-view mirror possibly to determine if there are vehicles approaching from the back when the drivers are waiting to turn in an intersection.

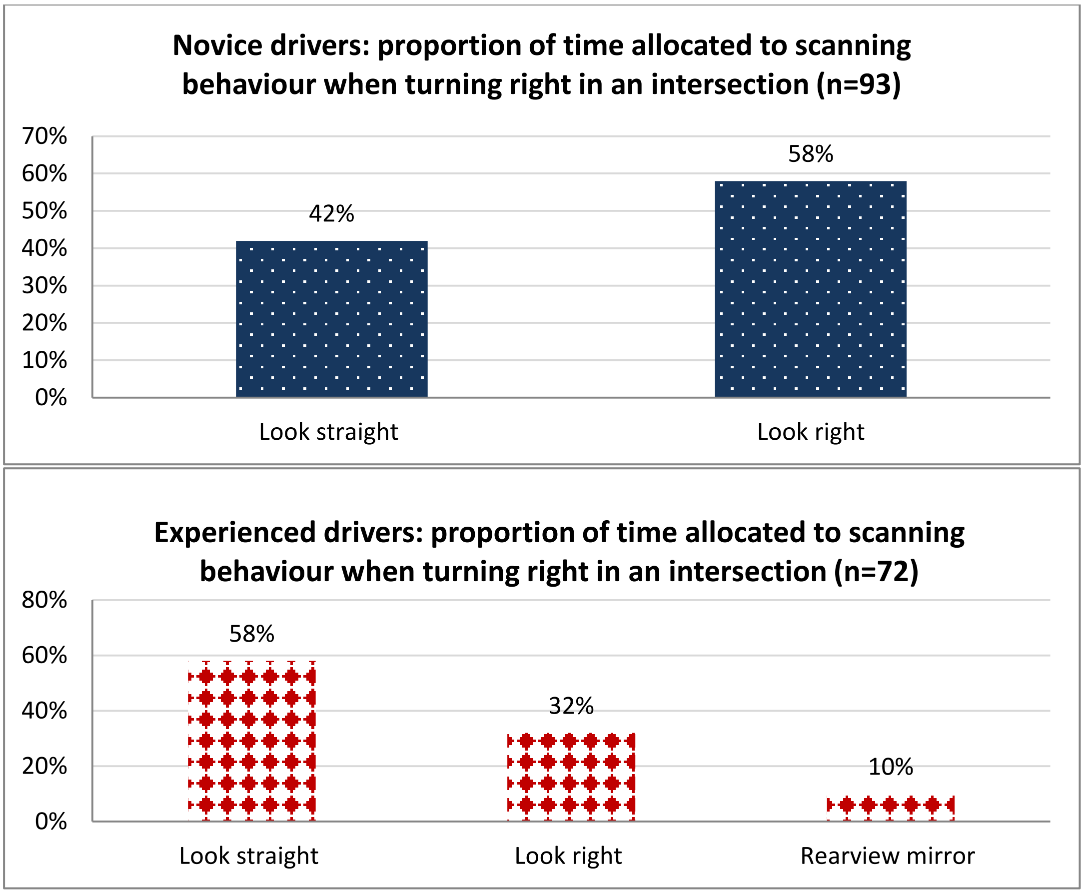

Figure 44: Behaviour when turning right over an intersection

Again a significance difference in behaviour was found for right turns in intersections (Table 29).

Table 29: Right turn in intersections

Variable	Mean	Standard error	N	Standard deviation	Variance	t-value	p-value
Novice drivers	7.671532	2.962043	20	13.25	175.474	1.91	0.07150
Experienced drivers	3.943673	0.882669	8	2.50	6.233		
Result =	**Means significantly different at 90%**						
*** p<0.01, ** p<0.05, * p<0.1							

No significance difference in behaviour was found for left- turning behaviour at intersections. In terms of the proportion of time spent scanning the environment before turning left in an intersection it again seems as if experienced drivers spent more time scanning their environment than novice drivers (Figure 45)

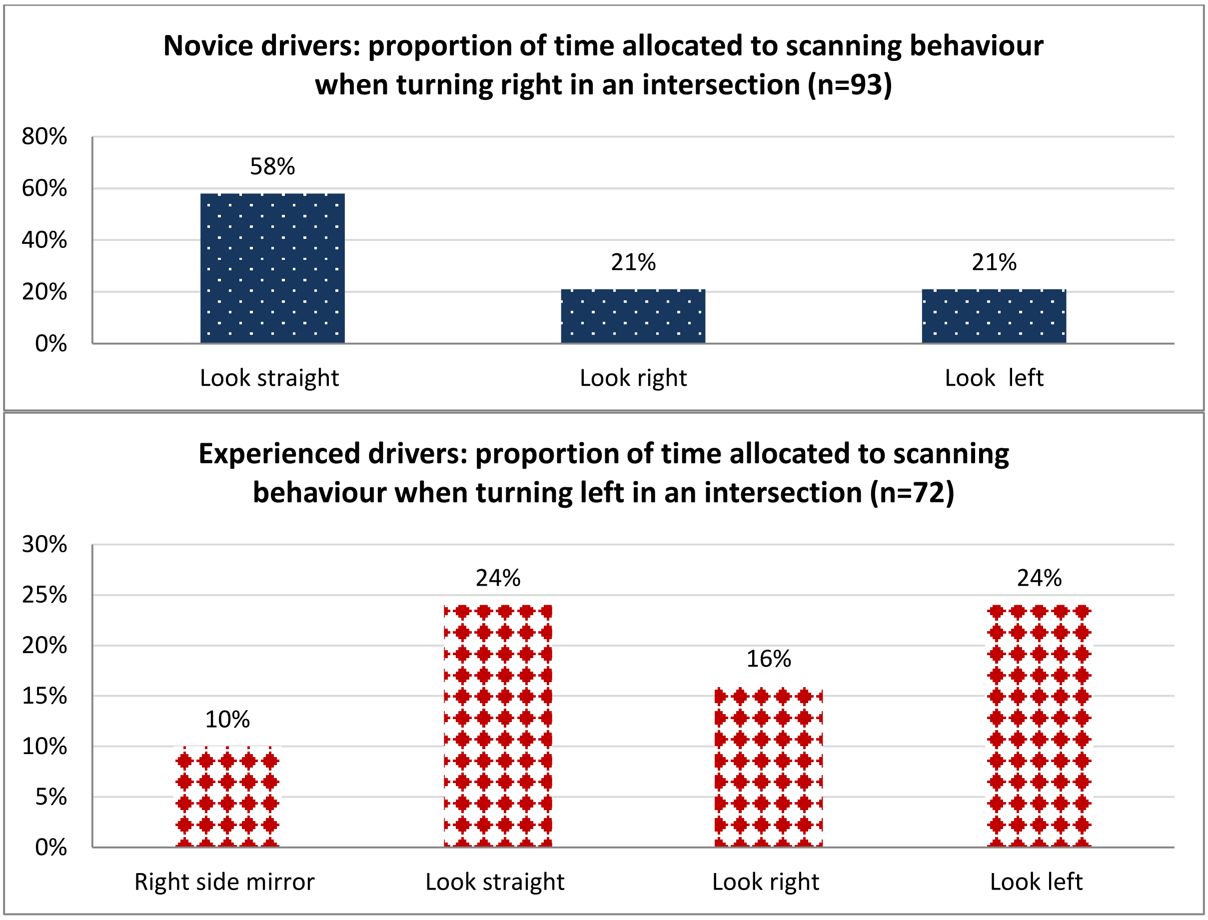

Figure 45: Behaviour when turning left at an intersection

5.4.4.3. Traffic lights

Traffic lights regulate traffic at busy intersections. Different types of behaviour are regulated ranging from simple straight traffic to turning behaviours either left or right in intersections. Traffic lights are potentially dangerous as there are many different stimuli to which the driver needs to pay attention.

Novice drivers mainly scanned the road in front of them while approaching a traffic light. Right scan behaviour (looking at something directly next to the vehicle) was evident in only 1% of the time.

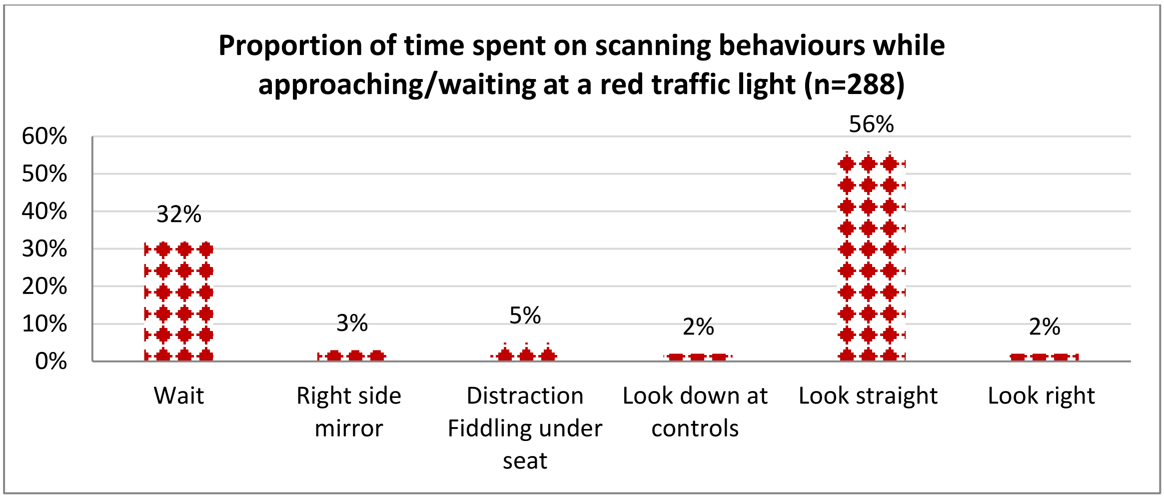

Figure 46: Experienced drivers time spent on scanning at red traffic lights

Experienced drivers spent some time on scanning right, the ride side mirror and looking down at controls. No time was spent on scanning the left side of the vehicle or the left side mirror. Experienced drivers tended to use approaches to or waiting at the red traffic light to look down, search for things under seat and so forth (figure 46).

A similar amount of time was allocated by both novice and experienced drivers scanning straight in front of them on approach to green traffic lights (figure 47).

Here, experienced drivers allocated time to look left and right or to scan the rear-view mirror. Novice drivers tended to scan the environment right of vehicle, neglecting the left. However novice drivers made much more use of the rear-view mirror.

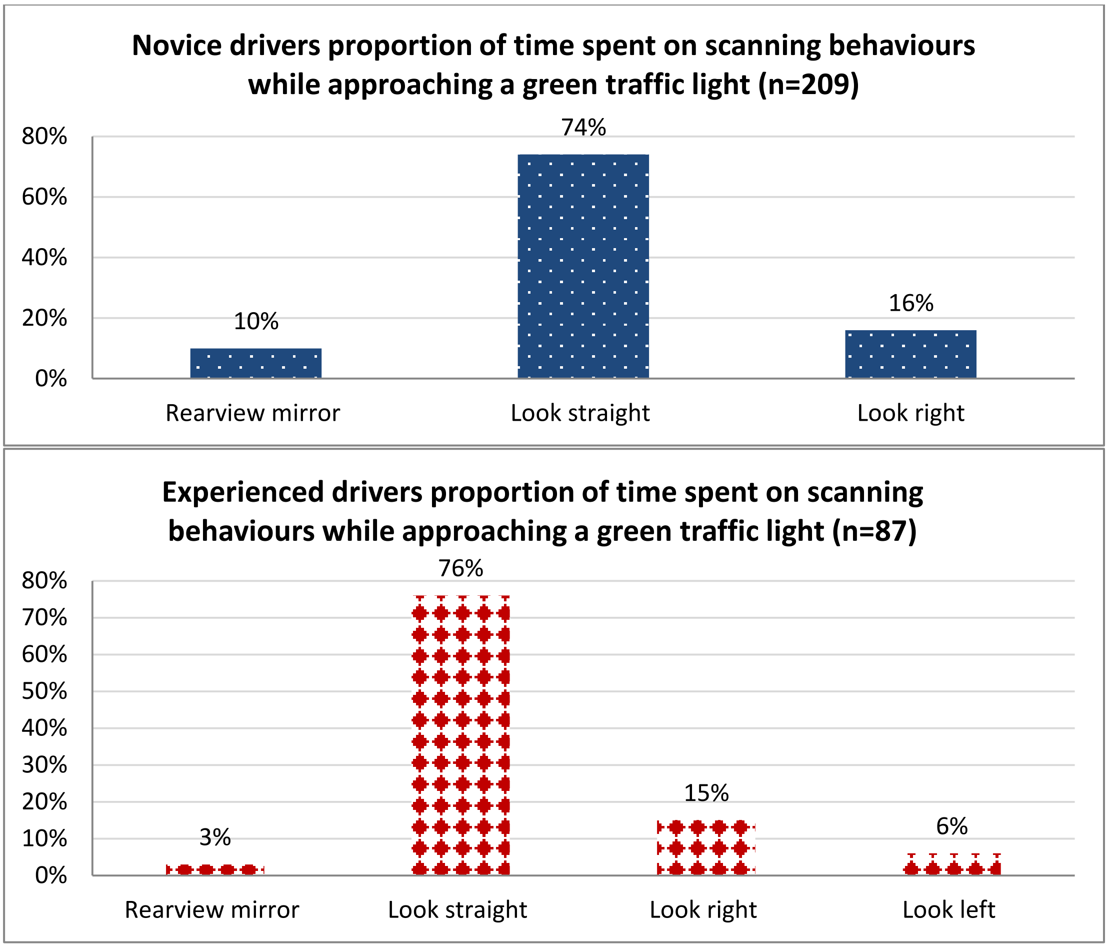

Figure 47: Proportion of time spent on scanning behaviour at green traffic lights

No significant differences were found in behaviour on approach to traffic lights, either green or red. Nor were any significant differences highlighted in terms of straight, left or right scanning behaviour.

5.4.4.4. Traffic circles

A traffic circle assists with the flow of traffic and although a complete stop is not required, this traffic situation requires special vigilance from a driver as vehicles might be entering and exiting the circle at various points (legs). The novice drivers should therefore be able to recognise potential hazards such as these and should adapt their behaviour accordingly.

Figure 48 below provides an overview of the proportion of time each of the participant groups spent scanning behaviour before entering the traffic circle.

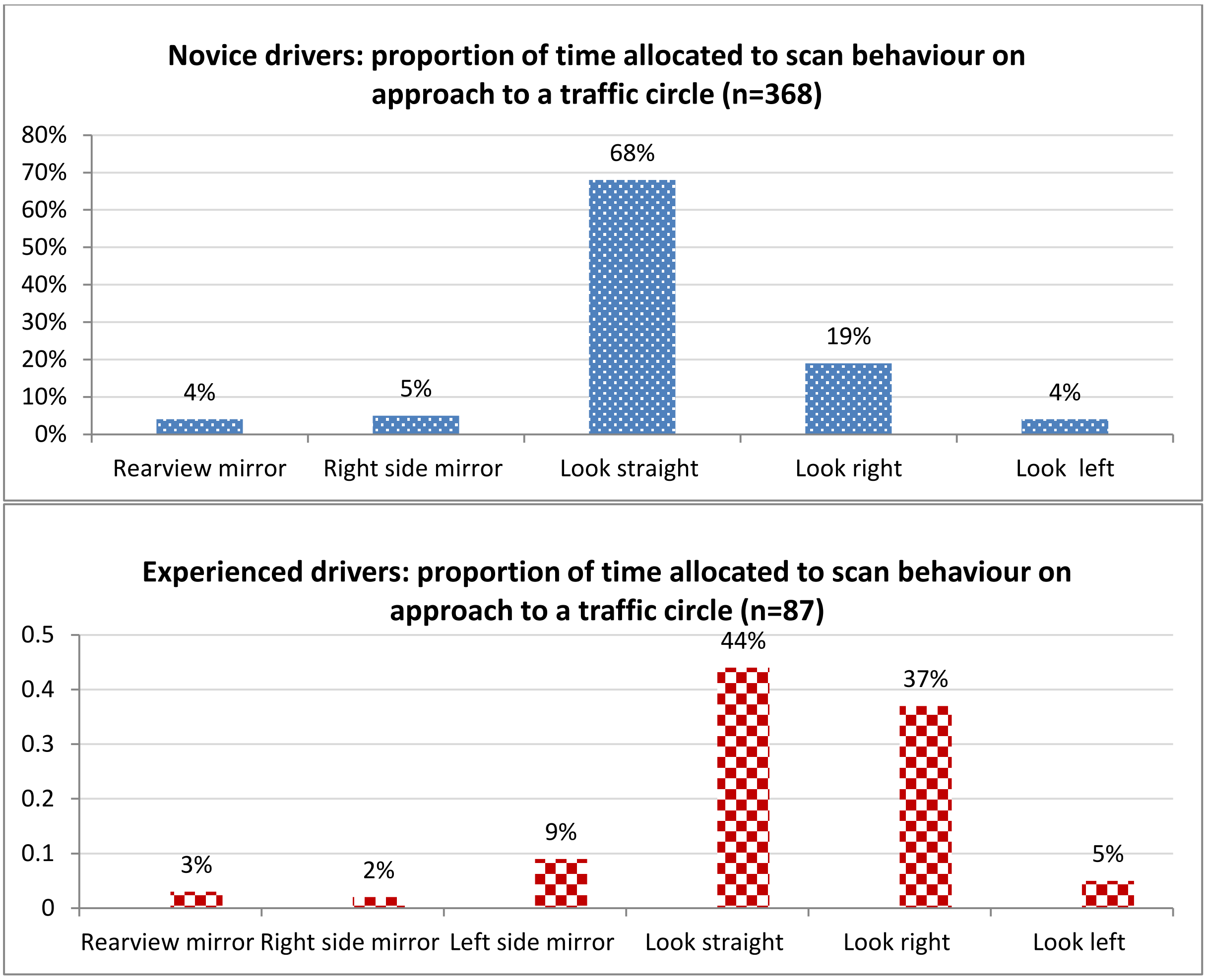

Figure 48: proportion of time allocated to scan behaviour

Novice drivers allocated much less time scanning their environment compared with experienced drivers. Both novice and experienced drivers scanned their right side and rear-view mirrors briefly, but only experienced drivers scanned their left side mirrors. Experienced drivers also spent much longer scanning the environment to their right for oncoming traffic than novice drivers.

Despite not scanning as effectively as they should, novice drivers had a much lower average speed (32 km/h) on approach to the traffic circle than experienced drivers (41 km/h).

When a t-test was applied to various scan behaviours, the results indicated that the means for the approach to the traffic circle, scan behaviour looking straight, right and left were not significantly different. This means that the experienced drivers' scan behaviour does not differ significantly from that of the novice drivers.

5.4.5. Additional behaviour analysed

5.4.5.1. Overview

Additional behaviours coded included time spent on tasks that could potentially be distractions in traffic. These behaviours differed between the two novice drivers as well as from the experienced drivers. These behaviours are discussed separately as they were not detected in all participants' videos. Behaviours included signs of fatigue, distraction such as eating and drinking, cell phone use etc., eyes being averted, looking for things in the vehicle, passengers, etc.

Other behaviours analysed included seatbelt use, distracted behaviour and behaviour in parking lots (malls), where there is a potential of high pedestrian activity, and any other behaviour that was deemed as a potential hazard.

5.4.5.2. Seat belt behaviour

In the thirteen videos coded for Novice Driver 1, he wore his seatbelt in only one of the videos coded. His sibling also did not wear their seatbelts in any of the seven videos (none of the time) coded for Novice Driver 1. Friends of Novice Driver 1 did however; wear their seatbelt when driving with him. Experienced Driver 1 only wore her seatbelt when driving on the freeway. In the videos where she drove a similar route to Novice Driver 1, Experienced Driver 1 also did not comply with seatbelt regulations. This in contrast to Novice Driver 2 and Experienced Driver 2 who always wore their seatbelts, irrespective of the type of road they drove on.

5.4.5.3. Distracted behaviour

A number of distracted behaviours were observed. Table 30 below provides an overview of the number of distracted behaviours identified.

Novice drivers tended to engage in cell phone activities more frequently than the experienced drivers. A t-test applied to the cell phone behaviour of novice and experienced drivers indicated that there is a significant difference between novice and experience drivers at a 90% confidence interval (p- value=0.151).

Table 30: Number of distractions observed for novice and experienced drivers

Novice drivers		Experienced drivers	
Cell phone use	4	Cell phone use	1
Eyes averted	3	Eyes averted down	2
Applying make-up	1	Applying make-up	0
Eating and drinking	1	Eating drinking	1
Look for something under the seat	1	Light a cigarette	2
Recognise someone outside vehicle	3	Smoking	3
Fatigue - yawn	2	Fatigue – yawn	1
Sneeze	1	Look for something under the seat	1

Novice and experienced drivers did engage in some of the same distracted behaviour. Experienced Driver 2 smoked which was considerably longer than any other distracted behaviour.

Experienced drivers also tended to keep their eyes averted as discussed in the traffic light sections. This behaviour was found mostly at red traffic lights.

Eating and drinking behaviour when driving were found in image material for both novice and experienced drivers. For the novice driver the event lasted 14 seconds at a speed of 131 km/h on the freeway. For the experienced driver the event lasted 7 seconds at an average speed of 7 km/h on an urban (80 km/h) road.

Cell phone use was mostly found among the novice drivers (4 events). One cell phone event was found among experienced drivers. The amount of time that the experienced drivers spent on the cell phone while driving was 0.67 seconds (standing still in a driveway). In comparison, novice drivers spent approximately 1 minute and 18 second on the cell phone. While talking on a cell phone, novice drivers maintained an average speed of approximately 22.9 km/h.

Table 31: Distractions observed for experienced drivers according to type of road, behaviour, time spent on behaviour and average speed.

Type road	Type distraction	Time in seconds	Average speed
Travel in middle of high ways	Fatigue	6.02	112.4
80 km/h road	Eyes averted	25.72	35.7
Driveway	Talking on cell phone	0.66	0
Urban residential	Eyes averted	13.5	40
80 km/h road	Distraction-look for something under the seat	3.7	18
Approach red traffic light	Look for something under the seat	2.8	14
Travel middle lane of freeway	Light cigarette	1.0	113
Travel middle lane of freeway	Smoking	42.2	108.5
80 km/h road	Light cigarette	1.0	39
80 km/h road	Smoking	15.14	50.04

Table 31 provides an overview of the type of distraction according to the road and time in seconds and the average speed maintained while engaged in that behaviour.

Experienced drivers were distracted mostly on 80 km/h roads, experienced drivers tended to look down (away from the road) for up to 25 seconds.

Lighting and smoking cigarettes occurred mainly on the freeway.

Table 32: Distractions observed for novice drivers according to type of road, behaviour, time spent on behaviour and average speed.

Type of road	Type of distraction	Time in seconds	Average speed
80 km/h road	Cell phone use	1.89	11.5
80 km/h road	Cell phone use	2.7	58.5
Turn Left at intersection	Cell phone use	11.1	34.0
Approach stop sign	Cell phone use	1.7	31
Through intersection	Cell phone use	8.0	0
Approach stop sign	Eyes averted downward	3.4	0
80 km/h road	Sneeze	3.5	24.75
Freeway 120 km/h	Eyes averted downward	0.83	127
Freeway 120 km/h	Distraction eating and drinking	24.3	131.8
Urban residential	Applying make-up	7.6	20.4
Urban residential	Looking for something under seat	7.2	52.9

Table 32 provides an overview of where novice drivers experienced the most distractions.

From Table 32 it is clear that novice drivers tend to experience distractions in a number of road environments. Cell phone use is the distraction most observed although distractions including eating and drinking and applying make-up while driving constituted large amounts of time where the novice driver would not have been in full control of the vehicle.

5.4.5.4. Parking lot behaviour

Parking lots are in general, areas where high pedestrian activities can be expected. Extra vigilance is therefore expected from the drivers to observe their environment.

In this study, parking lot behaviour was observed in four instances, namely in two novice and two experienced drivers' videos.

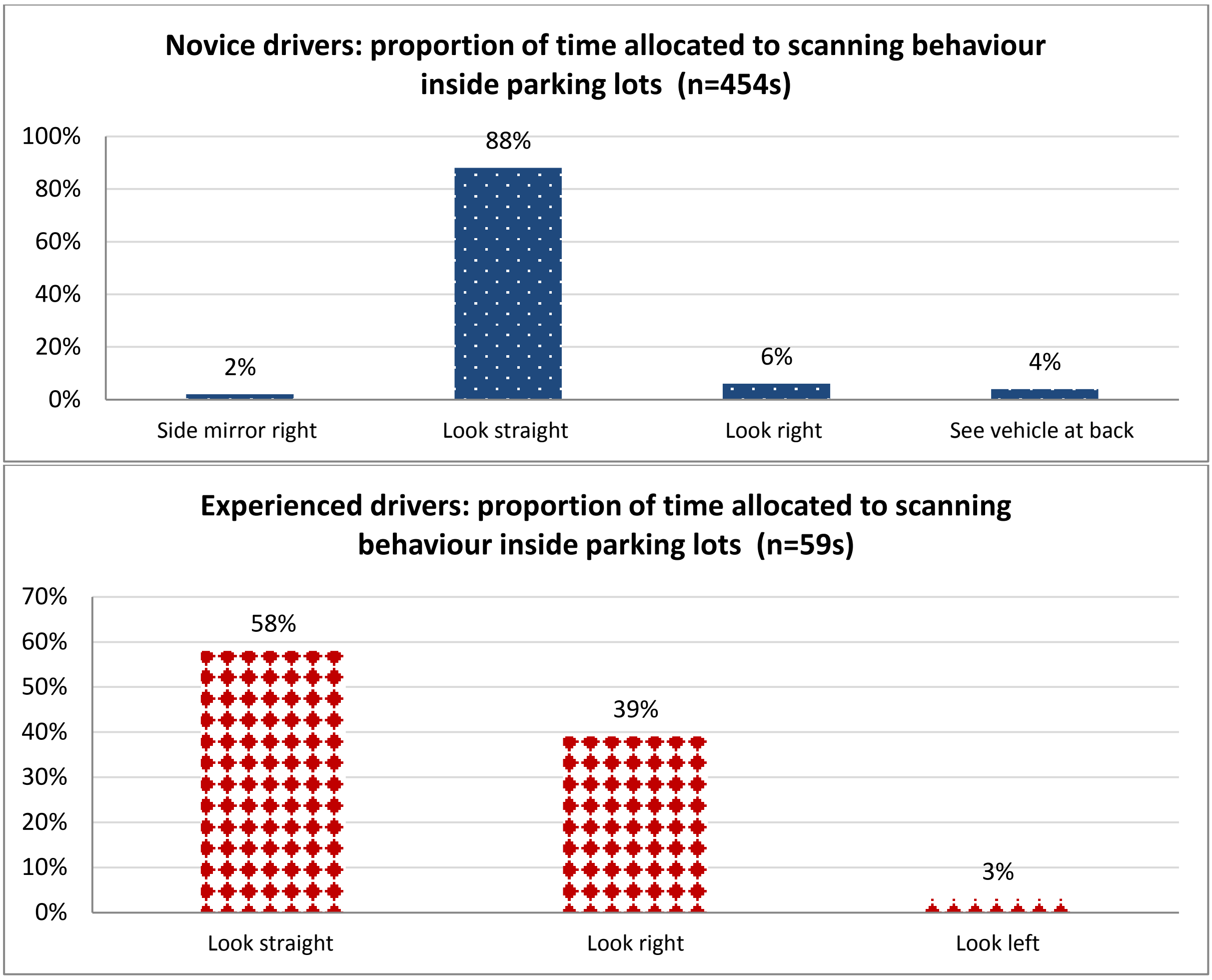

Figure 49: Proportion of time allocated to scanning behaviour inside parking lots.

Novice drivers spent time to scan the environment to the right and to the back of the vehicle. Experienced drivers spent less time scanning their environment although they did scan in both directions where novice drivers again tended to scan only the right side of the vehicle.

5.4.5.5. Road works

Behaviour through road works was recorded in videos related to Novice Driver 2 and Experienced Driver 2. The experienced driver only scanned the area in front of the vehicle while the novice driver made use of her side mirror as well. The average speed of the experienced driver was 34.1 km/h while the novice drivers' average speed was 49 km/h. The novice driver therefore was speeding in this potential hazardous location where the speed limit for the duration of the road works was 40 km/h.

5.5. Conclusion

Four main scenarios which could potentially be hazardous situations were identified and used for the analysis. These scenarios included four way stop streets, traffic circles (as well as yield signs and slipways), intersections where drivers did not turn as well as turning behaviour at intersections. These scenarios were selected because they were present in most of the participants' videos and therefore allowed for comparison between the drivers. Coding of the behaviour commenced at the first instance where a road sign such as a stop street or stop line appeared in the video frames for the first time.

On average neither the experienced nor novice drivers exceeded the speed limit when travelling on the freeway. Maximum speed profiles however indicated that experienced drivers tend to speed on 60 km/h, 70 km/h and 80 km/h roads. Experienced drivers did however, drive much more cautiously on residential area roads where there might be more children, cyclists and pedestrians present in the area.

The findings suggest that there are small differences in scanning behaviour that can be observed for novice and experienced drivers. The amount of time that both novice and experienced drivers allocated to scanning their environment was also similar.

For intersections, differences were detected in terms of the approach to the intersection and when the drivers turn right across the intersection. These differences might be attributed to the fact that experienced drivers based on their driving experience, know that intersections are potentially dangerous areas and that caution is needed before proceeding through an intersection or in instances where a driver needs to vigilant in recognising and responding to oncoming traffic before turning right across an intersection.

No significant differences were found in behaviour on approach to traffic lights, either green or red, nor were any significant differences highlighted in terms of straight, left or right scanning behaviour. However in terms of the proportion of time novice drivers tend to spent on scanning their environment, it was again found that they neglect to scan the left side of the intersection.

On approaching traffic circles, novice and experienced drivers scan the environment to the left and the right but experienced drivers spend longer on the left and right scans. Experienced drivers also make more use of their side and rear-view mirrors.

Distracted driving behaviour novice drivers engage in include cell phone use. Novice drivers also tend to engage in distracted behaviour for much longer than experienced drivers.

Novice driver behaviour at road works were considered risky as no scanning behaviour was evident and the novice driver exceeded the speed limit for the work zone.

Lastly, parking lots with potentially high pedestrian activity as well as vehicles pulling out of and into parking bays were considered a hazardous area. Novice drivers did acknowledge vehicles at the back of them but again only scanned the left hand side of the environment.

CHAPTER 6: CONCLUSIONS AND PRELIMINARY RECOMMENDATIONS FOR FUTURE RESEARCH

6.1 Introduction

The research proposal explained that this study would investigate two topics. The first of these is South African novice driver behaviour in terms of hazard perception and driving skills or skills in handling of the vehicle. The second topic is the application of the NDS methodology in a South African context. However due to the fact that the methodology had not yet been used in South Africa, the research study had unexpected spin-offs, namely the development of a coding scheme and consequently adding the notion of using Grounded Theory in order to explain and understand novice driver behaviour in a South African context.

This chapter summarises the main findings of the study. It also presents some recommendations pertaining to future research.

6.2. Conclusions regarding novice driver behaviour explored in this research study

6.2.1. Overview

In South Africa very little information is available on novice driver behaviour. Available publications also seem to be at odds with each other regarding the actual statistics which outline the magnitude of the novice driver problem in South Africa. However research is strongly indicating that unless the learner driver and driving school industry in South Africa are regulated and guided, the quality of drivers produced by the system will be questioned for many years to come.

6.2.2. Demographic factors

The most important demographic factors highlighted in the literature include gender, age, living standard and opportunities for education or training (Shope et al, 2007). Male novice drivers have, for example, been found to engage in risky driver behaviour more readily than female novice drivers. The participants in this study included one male and one female novice driver. They were both 18 years old when they started the study. Qualitative analysis of the driver behaviour questionnaires showed differences in perceived risk between the two participants. Contrary to the literature, Novice Driver 2 (female) was found to be more sensation orientated and someone who would more easily engage in activities that excite her. This is in line with the findings of Trimpop et al (1999) who indicated that some people plan carefully before taking risks. Although the male participant indicated that he would engage in sensational behaviour, the strength of his attitude was much less than that of the female driver. Both of the novice drivers however indicated that they were willing to take risks and break some traffic laws and regulations, depending on what these were. The only traffic law both felt strongly about was driving under the influence of alcohol or other substances.

Although they still fell within the 18 months period, which is considered a crucial and dangerous time for newly licensed drivers, both of them had some experience and was therefore not “fresh” recruits straight out of the Driver License and Training Centre (DLTC). A limitation of the study was that the novice drivers were not racially representative. Family circumstances, living standards and income groups were also not considered in the selection of these participants.

Despite this, it would seem that both the novice drivers indeed showed some characteristics which in general have been associated with novice driver behaviour.

6.2.3. Developmental and personality factors

Developmental factors were not considered in depth for this study. Both of these novice drivers were responsible for specific tasks (such as helping with family business and transporting siblings and employees) that required driving. Both novice drivers indicated that they tended to be goal-orientated (planning ahead for trips and routes). According to the literature this trait is found among less risk-taking novice drivers who had a higher need for personal control and therefore exhibited less risk-taking in their behaviour.

Personality factors or rather attitudes on risk taking behaviour, compliance with traffic laws and legislation as well as sensation seeking tendencies were explored for each of the novice drivers before they started to participate in the study.

Despite the fact that both of these drivers already had some experience in driving before participating in the study, both still displayed characteristics which might be associated with risky novice driver behaviour including aggression, impatience and a willingness to commit traffic violations. Analysis of the video material supported the notion that both were willing to commit traffic violations as both engaged in some types of behaviours that are considered risky. This includes distracted behaviour (eating, drinking and talking on a cell phone or putting on make-up), red light running and stop street violations. Red light running and continuous stop street violations clearly showed intent to commit a traffic violation.

The Theory of Intent (Mahardika et al, 2009) be more applicable to this theory than the Theory of Planned Behaviour (Yagil, 2001) The TPB as discussed in this document, is used to explain delinquent novice driver behaviour and although the novice drivers did engage in some risky behaviour the initial assessment indicated that both novice drivers have a clear idea of “which” rules and regulations they are prepared to transgress.

As indicated in the literature review, the Theory of Intent stipulates that the intent to do something (such as as committing certain offences) is a major factor in making decisions related to either to perform or to not perform the targeted behaviour (offence). The ‘before’ questionnaire highlighted that overtaking on a yellow line/shoulder and speeding was generally (during the before interviews) considered to be acceptable in circumstances such as, “when you are late”, by the novice drivers. The behavioural expectation was therefore that this might be behaviour that the novice drivers would engage in. However novice drivers did not in general engage in speeding behaviour. Behaviours which were detected in the videos included cell phone use as well as stop and traffic light violations.

6.2.4. Social learning and interaction

Gras et al (2007) indicated that the type of driver could be a factor influencing seatbelt use. Both drivers in participant group (1) did not wear their seatbelts when driving around their familiar neighbourhood. Imitation (following an example of a significant other) is also highlighted by Gras et al as a predictor of seatbelt use.

Both drivers drove with passengers. Passengers did not seem to influence the driver behaviour directly, however Novice Driver 1 seldom wore his seatbelt and it seems that passengers (sibling) driving with him were also less inclined to put their seatbelts on. Experienced Driver 1 wore her seatbelt when driving on freeways but not when driving on the same routes where they (Novice and Experience Drivers 1) reside. These findings might suggest and support the notion that novice drivers follow the example of, and are influenced by, significant others such as parents. On the other hand, the fact that friends and siblings also followed Novice Driver 1 behaviour in not wearing a seatbelt might again be an indication of peer influence, not on the driver but of the driver on his passengers. Parents and older siblings can potentially play a significant modelling role to positively influence novice drivers. However Fleiter et al (2006) found that peer group influences were much stronger than family influences on behaviour. They concluded that the strong influence of friends should be incorporated in interventions aimed at preventing risky driving. In line with the Social Learning Theory it could be theorised that Novice Driver 1's seatbelt behaviour was possibly shaped by his parents' behaviour. Experienced Driver 1 only wore a seatbelt on the freeway. The fact that there has not yet been a serious consequence for this behaviour might have influenced Novice Driver 1's perception that it is acceptable not to drive with a seatbelt on familiar routes.

The same is true of cell phone use while driving. During the exit interview Experienced Driver 1 indicated that she only started using a "hand-free kit" after the equipment was installed in her vehicle. Again Novice Driver 1's cell phone use while driving might be due to the example that was previously set.

6.2.5. Speed profiles

Wagener et al (2011) stated that the target zone for safe driving is in the middle range or the conservative neutral range. Wagener et al also indicated that behaviour related to speed that is either too slow such as driving well below the speed limit or driving too fast, could be equally dangerous. In the novice speed profiles, the average speed for most type of roads were well below the speed limit which could potentially be just as hazardous as driving too fast for prevailing conditions. On 80 km/h roads novice drivers had an average speed of 41 km/h, on 70 km/h and 66 km/h roads they maintained an average speed of 33 km/h. On all of these roads, it seems as if the novice drivers might be too slow, falling in the dangerous or timid category as categorised by Wagener et al (2011).

6.2.6. Differences in skills and hazard perception in terms of the perceived environment

Although both novice drivers had had some experience prior to the study, there were still elements of their scanning behaviour that have not yet been fully developed.

In none of the behaviour or situations that were coded was there evidence of immediate danger, near-collisions or actual crashes. The locations selected were deemed important as it is these traffic contexts that have the potential to develop into serious traffic conflict situations.

In terms of the literature, smaller horizontal scans (Scalfia et al, 2012) were evident as the novice drivers did not scan their environment 360 degrees and most of the time neglected to scan the environment to the left of them. The only selected hazardous location where novice drivers did scan to the left was at traffic circles. Novice Driver 1 seemed to have a much smaller horizontal scan than Novice Driver 2. Both experienced drivers scanned their environments much more frequently and effectively than the novice drivers. Although the experienced drivers did scan their environment more effectively, they also scanned the left of their environment less than would be expected. This is an interesting finding as the drivers drove separate routes but still exhibited the same behaviour. On enquiry during the last interview, both experienced drivers indicated that they are not aware that they do not scan the road on the left-hand side. One explanation could be that movement or vehicles on the right hand side pose a bigger danger as vehicles from the left should be able to see and recognise the vehicle as closest and therefore less of a danger. The literature (Whelan et al, 2000; Grayson et al, 2002) indicated that experienced drivers tended to have a wider scanning ability to observe hazards 360 degrees in the environment. That would imply that the experienced drivers would scan the roadway left and right as well as make use of their side and rear-view mirrors which in a much more effective manner. This was not evident here.

Both novice drivers looked closely in front of the vehicle. They tended to scan the area directly in front of them for long periods of time (directly in front fixating on objects in front of them as described by Chapman et al, 1998).

The two novice drivers also scanned the area on the left which might suggest that driving habits such as neglecting to scan the environment quickly before crossing the stop street might not yet have been developed. Therefore the novice drivers might still perceive traffic from the left as hazardous situations.

Also in line with literature review findings, was the fact that the novice drivers checked their mirrors much more infrequently than experienced drivers. Experienced drivers did make use of left and right as well as rear-view mirrors.

In terms of the specific hazardous locations selected for study:

No significant differences between novice and experienced drivers were found for stop streets. The time both allocated to scanning their environment was very similar. An interesting finding was that experienced drivers tended to acknowledge other vehicles from either side by looking in the direction from where the vehicles were coming, where novice drivers gave no such indication.

In contrast, behaviour at intersections yielded different results. The difference could particularly be observed in novice and experienced drivers' approach to intersections and in instances where they had to turn right across the intersections. In both of these instances experienced drivers allocated much more time to scanning their environment effectively in all directions (including the rear-view mirror) whereas novice drivers tended to scan the environment to the right but not necessarily to the left. In terms of the observed differences in skill, it seems likely that experienced drivers have a better perception of the dangers associated with intersections such as oncoming traffic from the back, while waiting to turn (rear-view mirror use), possible traffic from either side of the intersection and oncoming traffic which could potentially cause conflict if a turning driver should cross their path.

In terms of traffic lights, no significant differences could be found between novice and experienced drivers behaviour. However, experienced drivers spent much more time scanning the environment around them in all directions whereas novice drivers only made use of their rear-view mirrors. No left scanning behaviour was observed for novice drivers.

Traffic circles were the only hazardous location scenario where novice drivers were observed scanning the left of the vehicle. No significant difference was found between novice and experienced drivers' behaviours.

6.3. Conclusions regarding the methodology

5.3.1. Coding behaviour

Coding of the behaviour commenced at the first instance where a road sign such as a stop street or stop line appeared in the video frames for the first time. As indicated it was initially planned that the coding scheme would be predefined. However during the coding phase it was realised that by coding *in-vivo*, much richer information could be added than just focusing on predefined behaviours.

The second issue that needs to be considered in terms of coding is that there should definitely be more than one person responsible for coding the same video material. It is important that the manner in which the coding takes place is consistent and that it could be verifiable (two researchers coding behaviour the same) in order to lend scientific credibility to findings.

Even if a Grounded Theory approach is used in the coding, the researchers responsible for coding the material should be able to discuss and flesh out the details and criteria which could be used in such a scheme.

In terms of the literature it is clear that there are many different components and aspects which should be included when coding novice driver behaviour. This study focused on speed and scanning behaviour at selected locations. The coding scheme should therefore be further developed and operationalized to include all possible indicators of hazard perception skills in novice drivers.

6.3.2 ND Methodology

Almost all the aspects of this study were new (except for the topic) and a fair amount of learning had to be done in terms of the methodology, the mixed methods used in the process, analysis and management of all the different components of this study.

More than a million movements were recorded for the four vehicles. These movements included the date, time of day, acceleration, deceleration as well as speed profiles. This information was analysed for the selected videos but could be explored further to explain travel patterns. The GPS data could especially be valuable in generating information related to novice driver travel patterns. In order to fully maximise the potential of the image material, all the videos should be coded. This will enable a thorough understanding of the novice driver behaviour over the period of the three months. It will also ensure consistency

The data itself supported the need for an additional strategy to manage large databases of the magnitude as a four terabyte external hard drive was needed to store the data.

The amount of qualitative data generated could potentially be used in future research to investigate other types of behaviour, road environments, etc.

The study appeared to support the notion that a much larger ND study could provide valuable information related to novice and experienced drivers. It also proved that the ND methodology could be useful in a South African context.

A Naturalistic Driving Study is a useful tool which can assist researchers in understanding the events that led up to a crash (Dingus et al, 2011). In order to study crashes (rare events) a large sample of drivers and a lot of exposure to the data is needed. The more kilometres recorded, the higher the chance of getting actual crash or near-crash (exposure) data (Backer-Grøndahl et al. 2009).

The qualitative data should be further coded and quantitative data further explored. Acceleration and deceleration data as well as GPS have not been fully explored and the recommendation is that these data sets be explored further. These data sets could provide valuable information for planning and maintenance of infrastructure such as stop streets, traffic lights, etc. The acceleration and deceleration data will provide insight into congested areas, driver behaviour on specific roads, at specific locations, etc.

6.3.3. Research approach

If the resources were available it might be useful to include psychometric measurements in the 'before' study to determine attitudes and perceptions related to risk taking and hazards. The driver behaviour questionnaires could be used more effectively with a larger sample of drivers.

The development of a static hazard perception test should also be considered (Scalfia, 2012). In this study during the planning phase, only the novice drivers completed the behaviour questionnaires. However this meant that there was no real benchmark as to how these novice drivers perceived and reacted to risk. A static hazard perception test could provide an initial idea of the novice drivers' skills and abilities. It is recommended that the experienced drivers also complete such initial tests to provide information on their skills compared to the novices.

If the sample sizes are bigger, it could be useful to make use of focus group discussions to better understand the experiences the novice drivers went through.

6.3.4. Human resources

Although the literature indicated that this type of study is human resource intensive – this was really only fully appreciated once the study had started. A team of researchers should be appointed to work on a naturalistic driving study. For this study the whole process (from downloading and transcribing of data logger information, the identification and matching of video files, the coding, the matching of codes and vehicle movements) were conducted manually. Future research should perhaps focus on the automation of these processes.

The databases generated in this project are extremely large and future research could assist in managing and integrating the different databases.

6.3. Addressing the research questions

a) How are hazards perceived by novice drivers?

Both novice drivers indicated that they feel they are safe drivers, that they do not engage in risky behaviour and that they would not commit traffic offences willingly. The exceptions were barrier line offences and speeding behaviour. The video material analysed did not contain any examples of barrier line offences.

Speed profiles for the novice drivers indicated that in general novice drivers tended to keep to the speed limit. In fact novice drivers drove almost too slowly in some instances. As indicated earlier, novice drivers had however, higher average speeds on approaches to traffic lights and intersections which, coupled with their lack of scanning abilities, could potentially be dangerous. This might be an indication that the novice drivers do not yet recognise these locations as possible hazardous areas.

b) How do novice drivers react and adapt to those hazards?

As indicated earlier, no near-crash events or actual crashes were present in the image material analysed. It is therefore not possible to answer this question.

c) What differences exist between hazard perception in novice drivers and experienced drivers?

Differences in terms of behaviour only existed in terms of speed behaviour, behaviour on approach to intersections and right turns across intersections. Novice and experienced drivers displayed the same behaviour at stop streets, traffic lights and traffic circles.

However the time that novice and experienced drivers spent on different scanning tasks differ significantly. As indicated earlier, scanning left was neglected most of the time. The exception was on approach to stop streets where novice drivers did scan left and right possibly in anticipation of other vehicles that do not stop at the stop streets.

Both novice drivers engaged in red light running activities and both novice drivers engaged in cell phone activities while driving. Experienced drivers used cell phones while driving once for a very short period whereas the novice drivers tended to have long conversations while driving. Experienced drivers on the other hand were more likely to exceed speed limits whereas novice drivers tended to drive far below the posted speed limits observed in the image material.

In terms of the different pairs, it was interesting to note that the first participant group did not wear their seatbelts whereas participant group two always wore their seatbelts. As indicated earlier this might be indicative of the novice drivers following parental examples.

d) What are the differences in skills between novice drivers who have had previous driver school training or driving experience, compared with novice drivers whom have had little or no driver training before licensure?

As the novice drivers who were part of this study both had training and driving experience of driving prior to the study it was not possible to determine differences between the two novice drivers that would sufficiently answer this question.

6.4. Implications for training and education

From the findings it is clear that left scan behaviour is a neglected activity not only for novice drivers but for experienced drivers as well. A recommendation in terms of training would be that scanning behaviour to the left hand side should be better addressed.

In line with the literature review it is evident that mirror use is not as effective among novice drivers as it should be. Regular scanning of mirrors is important even if drivers are driving on familiar routes. Stopping at a traffic light or stop street means that drivers need to scan at least their rear-view mirror to be able to estimate the speed at which another vehicle may be approaching from the rear.

Attitudes and perception of risk could be included in training as it seems from the behavioural questionnaires that although novice drivers do not consider themselves transgressing the law they feel it is in order to uphold traffic rules and regulations that they deem to be “valid”. Training safe young drivers does not only revolve around the skill of driving a vehicle but should include attitudes towards safe participation in traffic.

6.5. Future considerations

The sample of drivers in this study was small and the participants not representative of different backgrounds, income groups or race. In future a larger, more demographically representative study might reveal more insights in novice drivers from different areas and backgrounds. The findings did however, indicate clearly that some differences were indeed noted between novice and experienced drivers. More observations, better selection criteria and a larger sample could potentially contribute to better insight in the differences in skill between novice and experience drivers.

If the ND methodology is used, it is recommended that the data be downloaded at predefined periods or at specific kilometres travelled. Popular routes that the participants travel on could be demarcated beforehand in order to make comparisons in terms of behaviour at specific hazardous locations as well as behaviour change over time.

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APPENDIXES

Appendix A: Example of the advertisement

Appendix B: Novice driver behaviour questionnaires

Appendix C: Consent forms

Appendix D: Overview of international NDS projects to date

Appendix E: Examples of coded behaviour

APPENDIX A:
EXAMPLE OF ADVERTISEMENT

PARTICIPATION IN A DRIVER BEHAVIOUR STUDY: FEBRUARY 2013

South Africa has one of the worst road safety records in the world with young and novice drivers being overrepresented in road accident statistics.

This research study is conducted by a Master's degree student in Civil Engineering at the University of Stellenbosch.

We are looking for four volunteers to participate in a Naturalistic Driving Study research project for a period of 2-3 months.

Who are we looking for? Two moms/dads/older brothers or sister (experienced drivers) anc a newly licensed driver (recently acquired a driver license) in the home. The experienced driver/s and newly licensed driver need to share a vehicle.

What does the research entail? The vehicle will be fitted with cameras and sensors that will be observing driver behaviour for a period of 2- 3 months. The purpose of this research is to investigate novice and experienced driver behaviour under normal everyday circumstances.

Will there be damage to my vehicle? No, the cameras and sensors are applied without any damage to your vehicle.

Will there be any costs involved? No, all the equipment and support is provided by the researcher.

What is in it for me? Each participant group will receive an incentive for participating in this research process.

If you are interested in participating or if you require more information please contact:

Karien Venter

Cell: 082 821 6474

E-mail: kventer@csir.co.za

APPENDIX B:
NOVICE DRIVER QUESTIONNAIRES

UNIVERSITEIT·STELLENBOSCH·UNIVERSITY
jou kennisvennoot • your knowledge partner

NDS Driver Behaviour Questionnaire (A)

Dear Participant,

This survey forms part of the Naturalistic Driving Studies research conducted for the completion of a master's degree in Civil Engineering at the University of Stellenbosch. This questionnaire is part 1 of two questionnaires that you will be requested to complete. The purpose of this questionnaire is to collect information that provides preliminary insight into your "everyday driving".

The second questionnaire will be administered on your completion of the two month NDS drive.

All the information that you provide will be treated as confidential. Please make use of your participant code (assigned to you after consent to participate in the study e.g. Participant a; b; c; d) to fill in the questionnaire. There is no need for you to fill in your name or any other identifiable information.

All information collected in this survey will be captured on a secure database. The information will be used in conjunction with the data collected from the NDS drive as well as the second questionnaire administered on completion of your participation in the study. This questionnaire should not take longer than 30 minutes to complete.

On completion of this questionnaire please send it back via e-mail kventer@csir.co.za. Should you not have access to internet or e-mail facilities please inform the researcher so that alternative arrangements can be made.

Please answer all the questions. Please answer the questions honestly.

Please do not hesitate to contact me on 082 821 6474 should you have any further queries.

Thank you for your participation.

Kind regards,
Karien Venter
Tel: 012 841 3856
Fax: 012 841 4044
E-mail: kventer@csir.co.za.

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Driver questionnaire

Novice and Experienced Driver Study

First of all I would like to thank you for participating in this study. Your contribution could in future influence the way in which young and new driver are trained in South Africa.

I would appreciate it if you could perhaps tell me about your experience. Please remember that your comments are confidential.

Novice driver 1		Novice driver 2		Experienced driver 1		Experienced driver 2	

1. How did you feel about driving around with the equipment in your vehicle?

2. When do you think you started to get comfortable with the equipment in the vehicle? (How long after installation?)

3. Did you ever completely forget about the equipment?

Yes		No	

4. Do you think that you driving behaviour changed over the study period?

Yes		No	

Please explain your answer:

5. What do you think are the most dangerous situations that you encountered on the road during the study period?

6. In general what do you think makes SA roads dangerous?

7. Do you feel that you have become a better driver during the past year?

Yes		No	

Please explain your answer:

8. If you would have to do the study again: what recommendations would have for the researchers? In other words what would you have differently?

Thank you for your time

APPENDIX C: CONSENT FORMS

Submitted as hard copies to protect the identity of participants.

APPENDIX D: OVERVIEW OF NATURALISTIC DRIVING PROJECTS TO DATE

Table 33: Summary of NDS projects (adapted from Regan et al., 2012 and Backer-Grøndahl et al., 2009)					
Topic	**Sub-topic/theme**	**Year**	**Author/s**	**Study**	**Findings**
Driver characteristics	Novice drivers Experience and skill	2011	Lee, Bruce, Simmons-Morton, Klauer, Quimet and Dingus	• Examined crashes and near-crashes involving novice teen drivers and experienced adult drivers • 42 teen and parent pairs were instrumented with DAS units that collected video and kinematic sensor data continuously, over a period of 18 months, commencing within three weeks of licensure for the teen drivers.	• Crash and near-crash rates were higher for the novice teen drivers than for the adults • Crash and near-crash rates among teen drivers were highest during the first 1-6 months of monitoring • Declined steadily and significantly during the following 12 months.
	Novice drivers Experience and skill	2010	Prato, Toledo, Lotan, and Taubman- Ben-Arid	• Examined teen drivers in 1st year after licensing in Israeli (GDL) program. Program is an accompanied driving period in the first three months after licensure • 62 novice drivers monitored in period of 12 months immediately following licensure, including 3 months accompanied driving & 9 months of solo driving. • Vehicles-DAS units that collected continuously driving data including speed,	• Higher sensation seeking tendencies more inclined to risky driving behaviour, • Most likely to exhibit such inclinations after being allowed to drive without supervision. • higher level of experience acquired in accompany period • led to lower risk taking behaviour when driving solo • Highlights the importance of GDL for

Table 33: Summary of NDS projects (adapted from Regan et al., 2012 and Backer-Grøndahl et al., 2009)					
Topic	**Sub-topic/theme**	**Year**	**Author/s**	**Study**	**Findings**
				acceleration, driver manoeuvres, and trip start and end times.	young drivers.
	Novice drivers Risk –behaviour	2007	McGehee, Raby, Carney, Lee and Reyes.	• Effects of feedback to novice young drivers and their parents for safe driving through video and graphical review feedback • 26 novice young drivers monitored over a period of 12 months • Vehicles equipped event triggered video that recorded 20 s when sensor values exceeded a safety limit threshold.	• Feedback -immediate • LED light that blinked threshold values >exceeded • weekly mentoring session involving parents in the form of graphical report cards and video reviews
	Novice drivers Risk –behaviour	2005	Lotan and Toledo	• Feedback to novice drivers using NDS data • 120 drivers DAS units monitored 8 months	• Feedback was provided in real time (SMS text • messages to parents/ vehicle displays, or off-line • in the form of a monthly driver report. • data showed feedback to novice young drivers and their parents reduced unsafe driving behaviours.
	Older drivers	2010	Blanchard,	• 61 older adult drivers over a one week	Same findings:

Table 33: Summary of NDS projects (adapted from Regan et al., 2012 and Backer-Grøndahl et al., 2009)					
Topic	**Sub-topic/theme**	**Year**	**Author/s**	**Study**	**Findings**
	skill		Myers and Porter	period. • DAS unit recorded continuously: • Driving trip information time of day, distance, duration, roadways, turns, and manoeuvres.	• Older drivers misestimate exposure and travel • patterns • May not regulate or adjust their driving as much as they indicate they do • Factors influencing exposure and travel patterns included: gender, season, weather and road conditions, self-ratings of driving comfort, and self-ratings of perceived driving • abilities
	Older drivers skill	2011	Myers AM, Trang A, Crizzle AM.	• 47 older adults • DAS monitor over two weeks.	
	Older drivers Performance and skill	2009	Silverstein et al. and Eby et al.	12 drivers with dementia for at least one month	• Determining the validity of the recommendations of clinicians, family, and self-screening for drivers with dementia.
Errors lapses and violations	Light vehicle motorists and motorcycles	2010	Uchida Kwakoshi, Tagawa, and Mochida.	• Instrumented vehicles to study accident causation in Japan • Incident data recorded/analysed for 60 drivers over 18 months 2years.	• Identify and examine key factors for incidents at intersections involving vehicles turning right and motorcycles going straight ahead

Table 33: Summary of NDS projects (adapted from Regan et al., 2012 and Backer-Grøndahl et al., 2009)					
Topic	**Sub-topic/theme**	**Year**	**Author/s**	**Study**	**Findings**
					• Drivers –near -crashes with motorcycles at intersections initiated the right turn despite there being obstructed view caused by an oncoming right turning vehicle. • Drivers' gaze longer directed away from motorcycles came from
	Professional (Truck) drivers	2008	Toledo, Musicant and Lotan	• 191 drivers compact pickup trucks monitored for eight weeks. • Vehicles were instrumented with sensors, accelerometers, and a data recording unit that continuously recorded speed, acceleration, location.	• Risk indices for drivers were associated with their actual accident history • Driving behaviour (measured as risk indices) changed following exposure to feedback.
	Light motor vehicle drivers	2010	Klauer, Guo, Sudweeks, and Dingus	• "100-Car NDS- 109 car drivers monitored 1 year in the seminal" In-vehicle data acquisition devices recorded sensor and video data continuously.	• 4 behaviours /states associated > risk of being involved in a crash or near-crash: • Inappropriate speeds, driving drowsy,

Table 33: Summary of NDS projects (adapted from Regan et al., 2012 and Backer-Grøndahl et al., 2009)					
Topic	**Sub-topic/theme**	**Year**	**Author/s**	**Study**	**Findings**
					eye glances away from the forward roadway >two seconds, and aggressive driving behaviours. • Older drivers were found to have lower risk of involvement in critical incidents than younger drivers.
Distraction	Light motor vehicle drivers	2006	Klauer	• "100-Car NDS- 109 car drivers monitored 1 year in the seminal" In-vehicle data acquisition devices recorded sensor and video data continuously.	• Engaging in complex secondary tasks and driving while drowsy increased a driver's crash and near-crash risk by two to six times, respectively, compared to normal baseline driving.
	Light motor vehicle drivers	2001	Stutts, Feaganes, Reinfurt, Rodgeman, Gish and Staplin	• Investigate occurrence and impact of events and activities that can draw a driver's attention away from activities critical for safe driving, • 70 drivers monitored for one week using a continuous in-vehicle video recording system	• Engaging in one or more potentially distracting activity - frequent occurrence in everyday driving. • Distractions negatively affect driving performance-higher rates: no hands on the steering wheel, eyes directed inside rather than outside the vehicle, and vehicles wandering and crossing lane lines
	Light motor	2011	Koppel, Charlton,	• Twelve drivers with young children were	• Engaging in one or more potentially

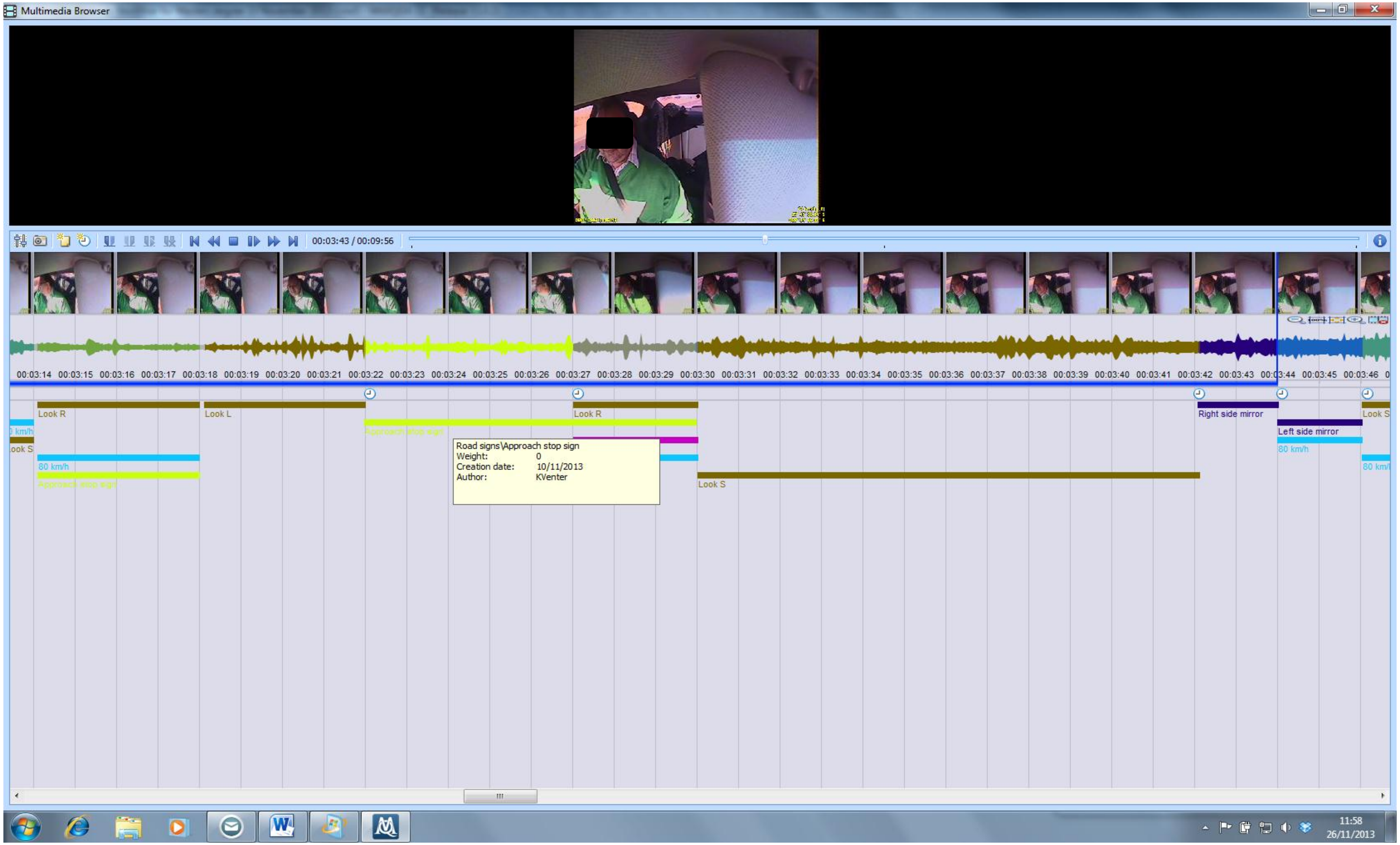
Table 33: Summary of NDS projects (adapted from Regan et al., 2012 and Backer-Grøndahl et al., 2009)					
Topic	**Sub-topic/theme**	**Year**	**Author/s**	**Study**	**Findings**
	vehicle drivers		Kopinatho, Taranto	monitored for 3 weeks-continuous recording	distracting activity - frequent occurrence in everyday driving. • Children and front seat passengers were found to be large sources of distraction to drivers; drivers were often distracted by child occupants for three seconds or more
	Truck driver	2003	Barr, Yang, and Ranney	• Truck driver distraction monitored six truck drivers for two weeks using a continuous in-vehicle video recording system,	• Engaging in potentially distracting activities more common for truck drivers than car drivers
	Truck driver	2005	Hanowski, Perez, and Dingus.	• Collected in-vehicle video and driving performance data from 33 truck drivers.	• Task characteristics e.g. frequency and duration of glances/ visual demand - contribute in combination to the prevalence of critical incidents
	Truck driver	2011	Olson, Hanowski, Hickman. and Bocanegra	• Reported data from two studies characterizing truck driver inattention in safety critical events, where 103 truck drivers were monitored for 12 weeks in the first study, and a separate group of 100 truck drivers were monitored for four	• Truck drivers engaging in any complex secondary task had an increased risk of being involved in a safety-critical event- effect true across different environmental/driving conditions

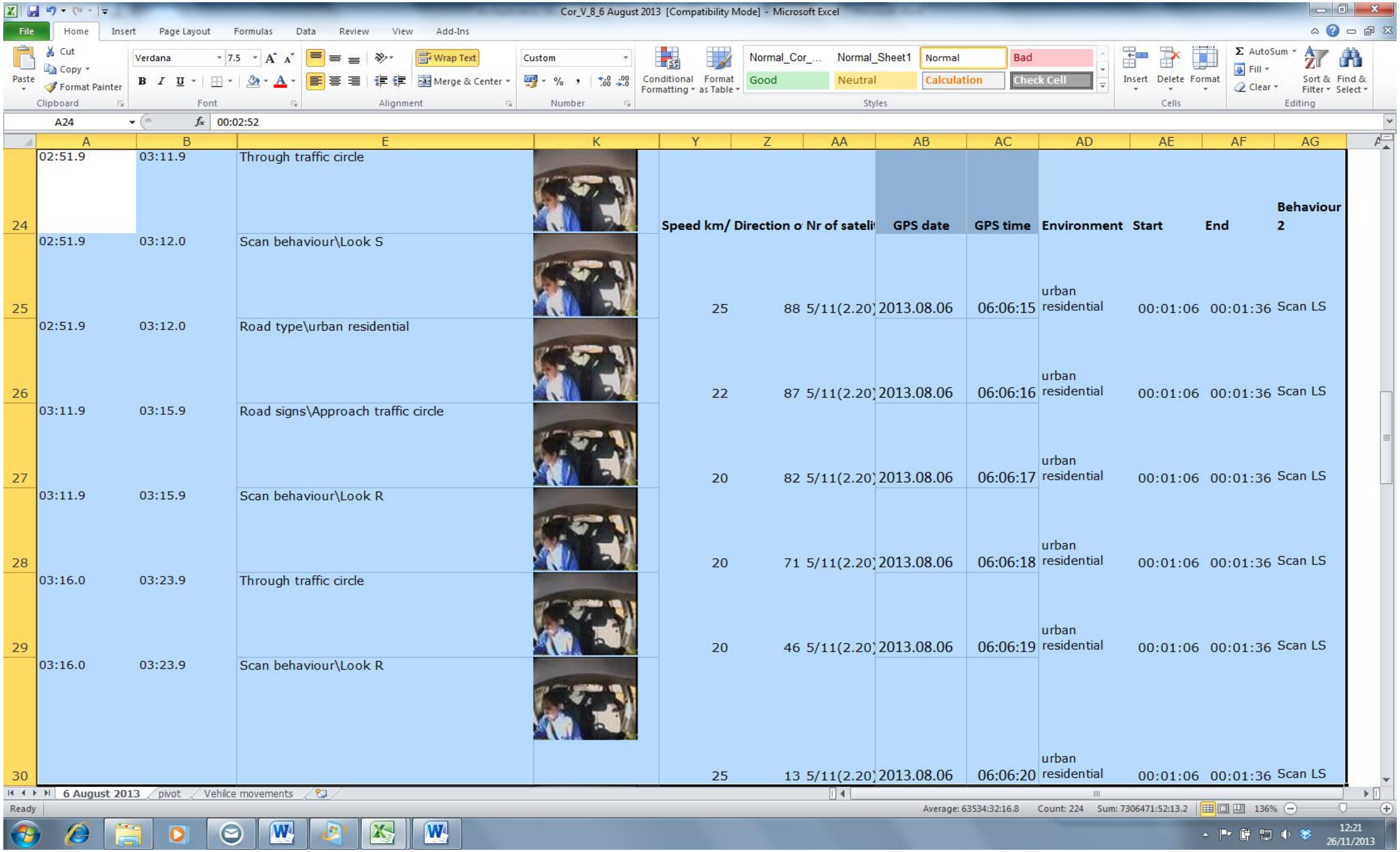
Table 33: Summary of NDS projects (adapted from Regan et al., 2012 and Backer-Grøndahl et al., 2009)					
Topic	**Sub-topic/theme**	**Year**	**Author/s**	**Study**	**Findings**
				weeks in the second study.	
Fatigue	Truck driver	2006	Dingus, Klauer, Neale, Petersen, Lee, Sudweeks, Perez, Hankey, Ramsey, Gupta, Bucher, Doerzaph, Jermeland, and Knipling.	• Assess safety-related fatigue issues among long haul (LH) truck drivers, in-vehicle devices were used to collect sensor and video data from 56 drivers, including 30 single drivers and 26 team drivers comprising 13 teams.	• Frequency of fatigue-related critical incidents varied significantly by hour of the day. • Largest number of cases of very drowsy single drivers occurred in the late afternoon and early evening hours, indicating that interaction with heavier traffic had a greater impact on the occurrence of incidents than did fatigue due to circadian rhythm effects.
	Truck driver	2007	Hanowski, Hickman, Fumero, Olson & Dingus	• Investigate effects of extended off-duty time on sleep quantity and involvement in critical incidents • 82 LH truck drivers monitored for 16 weeks using instrumented vehicles and sleep monitors	• Drivers appeared to be getting more sleep under the revised regulations. Fatigue-related critical incidents still occurred. • Period before a critical incident, driver sleep quantity was significantly less than the overall average, even for incidents where the driver was not at

Table 33: Summary of NDS projects (adapted from Regan et al., 2012 and Backer-Grøndahl et al., 2009)					
Topic	**Sub-topic/theme**	**Year**	**Author/s**	**Study**	**Findings**
					fault.
	Truck driver	2003	Hanowski, Hickman, Olson, & Bocanegra.	• Follow-up study: To determine if increase in risk associated with the increase in allowable driving time • 103 LH truck drivers monitored for 12 weeks	• 1st driving hour found associated with higher frequency of critical incidents relative to other driving hours • 2nd- 11th hours were not consistently different from each other.
	Truck driver	2006	Hanowski, Wierwille & Dingus	• Investigated fatigue among local/short-haul (SH) truck drivers. • 42 SH drivers were monitored for two weeks using in-vehicle devices that collected video data, a driver alertness measure, and driver attention and performance measures	• Majority of cases, drowsiness occurred during periods of extremely low driver workload, brought on by boredom and monotony.
	Light and heavy vehicle drivers		Hanowski, Olson, Hickman & Dingus.	• Interactions between light and heavy vehicles, one from the perspective of light vehicles • From the perspective of light vehicles, incident data involving interactions with	• Light vehicle driver initiated the critical incident (i.e., were at fault) in the majority of critical incidents involving light vehicle–heavy vehicle interactions • Smaller proportions of incidents where

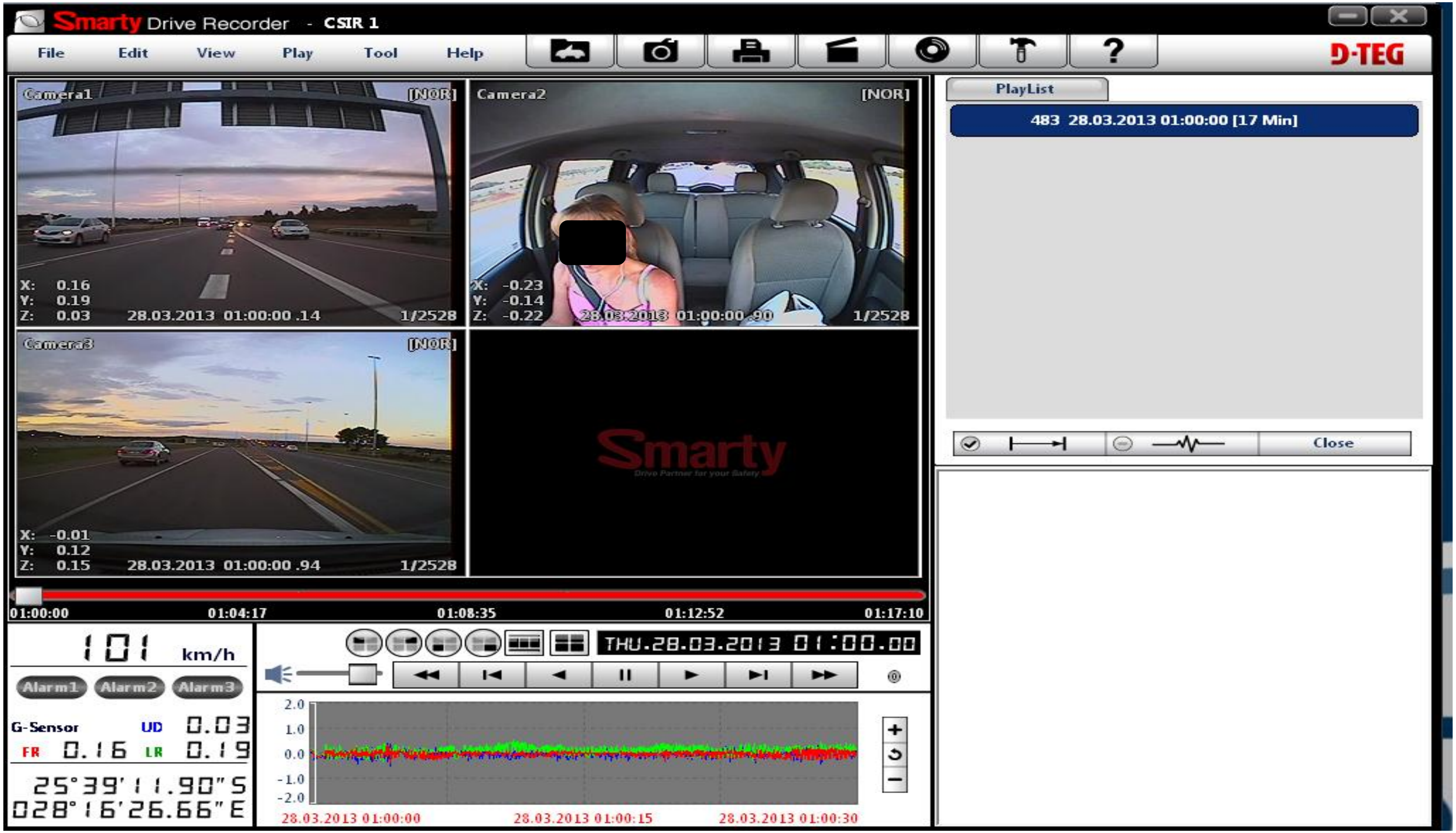
Table 33: Summary of NDS projects (adapted from Regan et al., 2012 and Backer-Grøndahl et al., 2009)					
Topic	**Sub-topic/theme**	**Year**	**Author/s**	**Study**	**Findings**
				heavy vehicles from the "100-Car NDS" were analysed	the heavy vehicle driver was at fault.
	Light and heavy vehicle drivers	2007	Hanowski, Hickman, Wierwille, W., & Keisler,	• Interactions between light and heavy vehicles, from the perspective of heavy vehicles. • From the perspective of the heavy vehicles, truck drivers, 48 LH and 42 SH drivers, were monitored using the same system of data collection devices as were used in the "100-Car NDS" - for between one and two weeks.	• Found that the light vehicle driver initiated the critical incident (i.e., were at fault) in the majority of critical incidents involving light vehicle–heavy vehicle interactions, while there were substantially smaller proportions of incidents where the heavy vehicle driver was at fault.

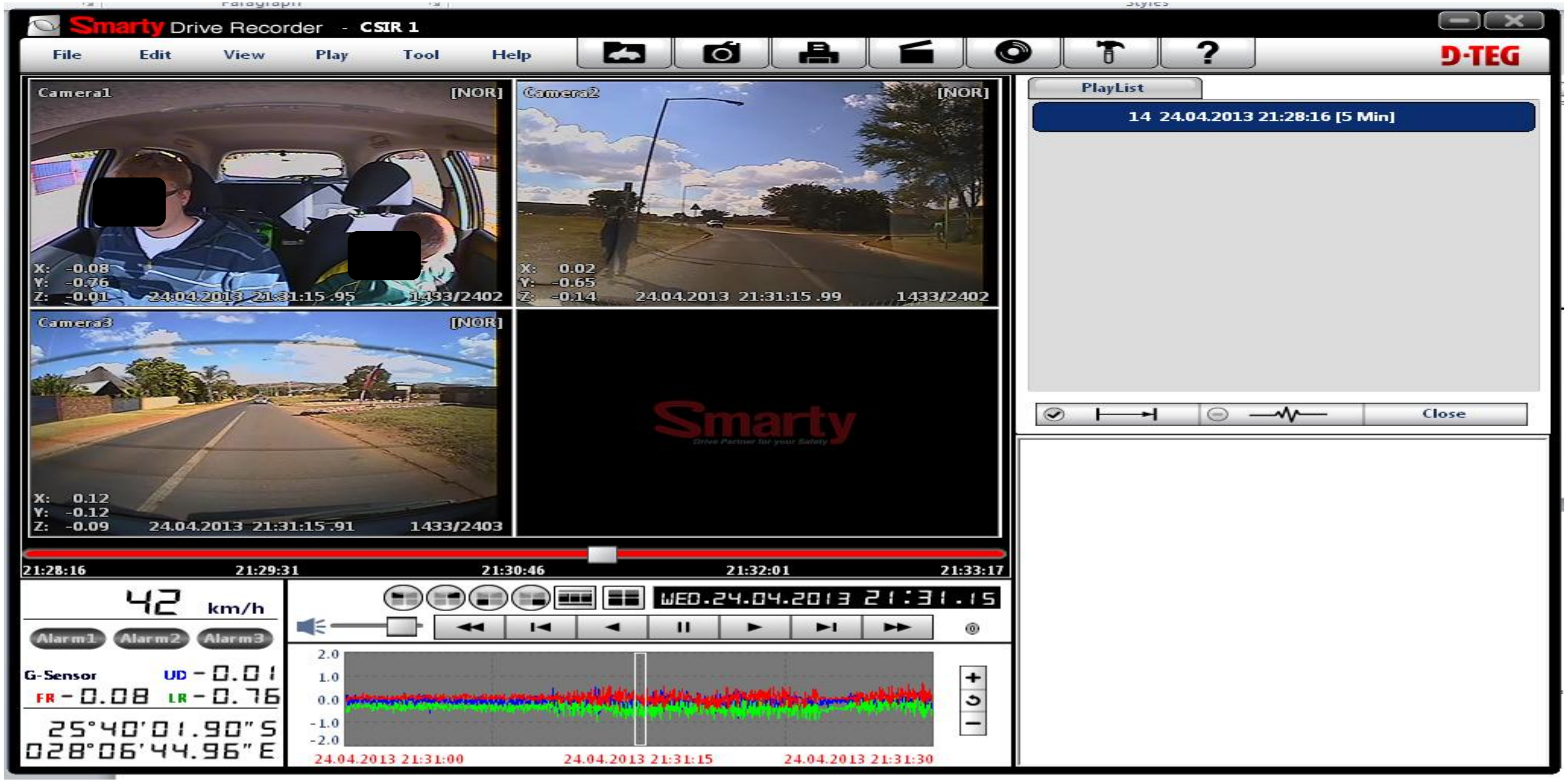
APPENDIX E
EXAMPLES OF CODING


Multimedia Browser
00:03:43 / 00:09:56
00:03:14 00:03:15 00:03:16 00:03:17 00:03:18 00:03:19 00:03:20 00:03:21 00:03:22 00:03:23 00:03:24 00:03:25 00:03:26 00:03:27 00:03:28 00:03:29 00:03:30 00:03:31 00:03:32 00:03:33 00:03:34 00:03:35 00:03:36 00:03:37 00:03:38 00:03:39 00:03:40 00:03:41 00:03:42 00:03:43 00:03:44 00:03:45 00:03:46
Look R
Look L
Look R
Right side mirror
Look S
Approach stop sign
Left side mirror
80 km/h
80 km/h
Approach stop sign
Road signs\Approach stop sign
Weight: 0
Creation date: 10/11/2013
Author: KVenter
Look S
80 km/h
80 km/h
11:58
26/11/2013



	A	B	E	K	Y	Z	AA	AB	AC	AD	AE	AF	AG
24	02:51.9	03:11.9	Through traffic circle		Speed km/	Direction o	Nr of satelit	GPS date	GPS time	Environment	Start	End	Behaviour 2
25	02:51.9	03:12.0	Scan behaviour\Look S		25	88	5/11(2.20)	2013.08.06	06:06:15	urban residential	00:01:06	00:01:36	Scan LS
26	02:51.9	03:12.0	Road type\urban residential		22	87	5/11(2.20)	2013.08.06	06:06:16	urban residential	00:01:06	00:01:36	Scan LS
27	03:11.9	03:15.9	Road signs\Approach traffic circle		20	82	5/11(2.20)	2013.08.06	06:06:17	urban residential	00:01:06	00:01:36	Scan LS
28	03:11.9	03:15.9	Scan behaviour\Look R		20	71	5/11(2.20)	2013.08.06	06:06:18	urban residential	00:01:06	00:01:36	Scan LS
29	03:16.0	03:23.9	Through traffic circle		20	46	5/11(2.20)	2013.08.06	06:06:19	urban residential	00:01:06	00:01:36	Scan LS
30	03:16.0	03:23.9	Scan behaviour\Look R		25	13	5/11(2.20)	2013.08.06	06:06:20	urban residential	00:01:06	00:01:36	Scan LS


Smarty Drive Recorder - CSIR 1
File
Edit
View
Play
Tool
Help
D-TEG
Camera1
[NOR]
X: 0.16
Y: 0.19
Z: 0.03
28.03.2013 01:00:00 .14
1/2528
Camera2
[NOR]
X: -0.23
Y: -0.14
Z: -0.22
28.03.2013 01:00:00 .90
1/2528
Camera3
[NOR]
X: -0.01
Y: 0.12
Z: 0.15
28.03.2013 01:00:00 .94
1/2528
Smarty
PlayList
483 28.03.2013 01:00:00 [17 Min]
Close
01:00:00
01:04:17
01:08:35
01:12:52
01:17:10
101 km/h
Alarm1
Alarm2
Alarm3
G-Sensor
UD 0.03
FR 0.16
LR 0.19
25°39'11.90"S
028°16'26.66"E
THU.28.03.2013 01:00.00
2.0
1.0
0.0
-1.0
-2.0
28.03.2013 01:00:00
28.03.2013 01:00:15
28.03.2013 01:00:30


Smarty Drive Recorder - CSIR 1
File
Edit
View
Play
Tool
Help
D-TEG
Camera1
[NOR]
X: -0.08
Y: -0.76
Z: -0.01
24.04.2013 21:31:15 .95
1433/2402
Camera2
[NOR]
X: 0.02
Y: -0.65
Z: -0.14
24.04.2013 21:31:15 .99
1433/2402
Camera3
[NOR]
X: 0.12
Y: -0.12
Z: -0.09
24.04.2013 21:31:15 .91
1433/2403
Smarty
PlayList
14 24.04.2013 21:28:16 [5 Min]
Close
21:28:16
21:29:31
21:30:46
21:32:01
21:33:17
42 km/h
Alarm1
Alarm2
Alarm3
G-Sensor
UD -0.01
FR -0.08
LR -0.76
25°40'01.90"S
028°06'44.96"E
WED.24.04.2013 21:31.15
2.0
1.0
0.0
-1.0
-2.0
24.04.2013 21:31:00
24.04.2013 21:31:15
24.04.2013 21:31:30